The relationship between Glasgow Prognostic Score and hospital duration in patients with inflammatory bowel diseases

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Running title: Glasgow Prognostic Score in IBD patients

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ABSTRACT

Background and Objectives: Both hypoalbuminemia and inflammation were common in patients with inflammatory bowel diseases (IBD), however, the combination of the two parameters on hospital duration remained unknown. **Methods and Study Design:** This is a retrospective two-centre study performed in two tertiary hospitals in Shanghai, China. Serum levels of C-Reactive Protein (CRP) and albumin (ALB) were measured within 2 days of admission. Glasgow prognostic score (GPS), based on CRP and ALB, was calculated as follows: point "0" as CRP <10 mg/L and ALB ≥35 g/L; point "1" as either CRP ≥10 mg/L or ALB <35 g/L; point "2" as CRP ≥10 mg/L and ALB <35 g/L. Patients with point "0" were classified as low-risk while point "2" as high-risk. Length of hospital stay (LOS) was defined as the interval between admission and discharge. **Results:** The proportion of low-risk and high-risk was 69.3% and 10.5% respectively among 3,009 patients (65% men). GPS was associated with LOS [β=6.2 d; 95% CI (confidence interval): 4.0 d, 8.4 d] after adjustment of potential co-variates. Each point of GPS was associated with 2.9 days (95% CI: 1.9 d, 3.9 d; p_{trend}<0.001) longer in fully adjusted model. The association was stronger in patients with low prealbumin levels, hypocalcaemia, and hypokalaemia relative to their counterparts. **Conclusions:** GPS was associated with LOS in IBD patients. Our results highlighted that GPS could serve as a convenient prognostic tool associated with nutritional status and clinical outcome.

Key Words: Glasgow Prognostic Score, inflammatory bowel diseases, length of stay, C-reactive protein, serum albumin

INTRODUCTION

Inflammatory bowel disease, including Crohn's disease and ulcerative colitis, keeps rising worldwide in recent decades and the trend is more pronounced in developing countries which experienced dramatic changes in diet and behaviour.[1-3] Bad nutritional status is associated with various complications, longer hospital stays, and higher healthcare costs.[4] Nutritional screening on admission, followed by a comprehensive nutritional assessment of those at risk, is the important step to decrease the risk of malnutrition and improve nutrition associated clinical outcomes in IBD patients.

The European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines recommend the use of validated nutritional risk screening tools for nutritional risk screening in patients with IBD such as NRS-2002 and MUST.[5, 6] Studies have shown that MUST could

serve as a nutritional screening tool for outpatient patients with IBD.[7, 8] NRS-2002 is another nutritional risk screening tool for hospitalized adult patients recommended by ESPEN, which focuses on weight changes, food intake, and disease severity.[9] Although studies have shown good agreement between NRS-2002 and malnutrition assessments and NRS-2002 have been shown to be associated with clinical outcomes.[10] However, NRS-2002 is unable to differentiate the severity of disease among IBD patients and does not take inflammatory status into consideration. GPS is the combination of serum CRP and ALB. This tool was originally used for prognostic analysis of non-small cell lung cancer with.[11] Many studies mainly focused on the prognosis assessment in patients with lung cancer, breast cancer, prostate cancer and gastrointestinal cancers,[12-16] and there were several studies on postoperative complications of IBD.[17-19]

We noted that the disease features of IBD, where inflammation and malnutrition often coexist, were well matched with the composition of GPS. In addition, LOS is an important and readily available parameter for clinical outcomes. Therefore, we conducted this retrospective study.

MATERIALS AND METHODS

This was a retrospective study. All the adult patients with IBD (n=3,305) admitted to two teaching hospital were potential participants. Patients with missing data were firstly excluded: age or sex (n=4), ALB or CRP (n=72), LOS≤1d (n=217). Then, we further excluded patients who died (n=3) (Details were shown in Figure 1). As a result, a total of 3,009 patients were included in the analysis. The study was approved by the Ethical Committee of Ren Ji Hospital, Shanghai Jiao Tong University School of Medicine (No. LY-2022-057-B) and Xin Hua Hospital, Shanghai Jiao Tong University School of Medicine (No. XHEC-C-2023-014-1). As a retrospective study, the above-mentioned ethics committee waived the patient's written informed consent.

GPS (the exposure)

All the measurements were completed in the Clinical Laboratory of Ren Ji Hospital and Xin Hua Hospital. Venous blood samples were drawn and transfused into vacuum tubes containing EDTA in the morning after patients were fasted for at least eight hours. Serum level of CRP was measured by immunoturbidimetric method (PA990 analyzer, Lifotronic Technology, Shenzhen, China). The lower limit of detection was 0.5 mg/L for CRP measurement and inter-assay variation was 12.5%. Serum level of ALB was measured by

enzyme-linked immunosorbent method (Roche 701 Bioanalyzer, Roche, United Kingdom). GPS was calculated based on both serum level of CRP and ALB. Briefly, the criteria of GPS were as follows: point " 0 " : CRP <10 mg/L AND ALB ≥35 g/L; point " 1 " : CRP ≥10 mg/L OR ALB <35 g/L; point " 2 " : CRP ≥10 mg/L AND ALB <35 g/L.11 Point "2" of GPS was defined as high-risk, point "1" as medium-risk, and point "0" as low-risk.

LOS (Outcome)

We obtained admission and discharge dates for each participant by reviewing medical records. LOS was defined as the interval between the admission date and data out of the hospital and recorded to the nearest day for further analysis.

Other information

Blood samples were prepared as mentioned above. Alanine transferase (ALT), aspartate aminotransferase (AST), total bilirubin (TBIL), Pre-albumin, and fasting blood glucose (FBG) were measured by enzyme-linked immunosorbent method (Roche 701 Bioanalyzer, United Kingdom). Estimated glomerular filtration rate (eGFR) was calculated by the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation.[20] Red blood cell count (RBC), white blood cell count (WBC), and haemoglobin (HB) were measured by an automatic haematology analyzer (XN-10, Sysmex, Japan). Serum calcium (Ca^{2+}) and phosphorus (P^{3+}) were measured by colorimetry method while serum sodium (Na^{+}) and potassium (K^{+}) by Ion Selective Electrode Method (Johnson & Johnson AU5800, The United States of America).

Body weight and height were measured by trained nurses at admission. BMI was calculated by body weight (kg) divided by height square (m^2). Sex, age, history of chronic diseases, surgery, and type of diseases (Crohn's disease and ulcerative colitis) were obtained from the medical records. Patients with chronic disease were defined as who had one or more of the following diseases: hypertension, diabetes, chronic kidney disease, cardiovascular disease, fatty liver, and dyslipidemia.

Statistical analysis

In terms of descriptive statistics, continuous variables with a non-normal distribution were presented as medians and inter-quartile range (IQR) while categorical variables as frequencies and proportions (%). Generalised linear model with stepwise adjustments for relevant confounders (sex, age, type of diseases and other clinical parameters) was used to investigate

the association between GPS and LOS. Potential confounders were adjusted in different models: model 1, adjusted for sex and age (y); model 2, adjusted for sex, age (y), type of diseases (Crohn's disease vs. ulcerative colitis), surgery (yes vs. no), anemia (yes vs. no), pre-albumin (mg/L), serum calcium (mmol/L), and serum potassium (mmol/L). Despite the potential risk of over-adjustments, in addition to the potential confounders in Model 2, we further adjusted for CRP (mg/L) in Model 3 and ALB (g/L) in Model 4 to determine whether these two factors had a combinative effect on LOS.

Besides, we performed a linear regression analysis to further explore the association between CRP, ALB and LOS. In order to assess the robustness of the results obtained from the main analysis, we performed the interaction between sex, age (y), type of diseases, surgery, anemia, Pre-albumin , serum calcium, serum potassium, and further performed five subgroup analyses: different types of diseases (Crohn's disease vs. ulcerative colitis), surgery (yes vs. no), Pre-albumin (≥200mg/L vs. <200mg/L), serum calcium (<2.25mmol/L, 2.25-2.60mmol/L, or ≥2.60mmol/L), and serum potassium (<3.5mmol/L, 3.5-5.5mmol/L, or ≥5.5mmol/L). In addition, a multiple linear regression model was established to evaluate the relationship between the parameters (type of diseases, surgery, ALB, CRP, Pre-albumin, Anemia, serum calcium and serum potassium) and LOS. All statistical analyses were performed with SAS version 9.4 at a significance level of $p<0.05$.

RESULTS

Patient characteristics

A total of 3,009 patients (1,958 men and 1,051 women) were included in the study. Of these, 2,314 (76.9%) were Crohn's disease and 695 (23.1%) were ulcerative colitis. The average age of participants was 35 years (IQR: 28 y, 47 y), and the average LOS was 7.0 days (IQR: 4.0 d, 12.0 d). The proportion of patients with high risk (GPS=2) was 10.5% while it was 69.3% for those with low risk (GPS=0). The differences in baseline characteristics among different GPS groups were statistically significant except age, BMI, surgery, chronic disease comorbidities, fasting blood glucose, serum potassium, and renal function (Table 1).

Multi-variate linear regression and subgroup analysis

GPS was associated with LOS after adjustment of sex and age, corresponding to a β value of 10.3 days (95% confidence interval [CI]: 8.5 d, 12.2 d; $p<0.001$) between the high-risk and low-risk group. After adjustment for covariates, including sex, age, type of diseases, and clinical parameters, the difference in LOS remained significant, with fully adjusted β value of

6.2 days (95% CI: 4.0 d, 8.4 d; p<0.001). Each point increment of GPS was associated with an increase in LOS by 2.9 days (95% CI: 1.9 d, 3.9 d; p_{trend}<0.001) with full adjustment of co-variates. Further adjustment of CRP increased this correlation, or further adjustment of ALB, weakened this correlation but did not change the trend (Table 2, model 3 and 4).

Serum CRP level was associated with an increase in LOS (β=3.0 days; 95% CI: 1.5 d, 4.5 d; p<0.001), and serum ALB level also had the similar association (β=4.3 d; 95% CI: 2.5 d, 6.1 d; p<0.001) (Supplementary Table 1).

Interaction test revealed that type of diseases (p<0.001), surgery (p<0.001), pre-albumin (p<0.001), serum calcium (p=0.02), and serum potassium (p=0.009) interacted with the association between GPS and LOS (Supplementary Table 2). The association was stronger in patients with hypo-prealbuminemia, hypocalcaemia, and hypokalaemia, relative to their counterparts (Table 3).

Multiple linear regression models showed that hypoalbuminemia, CRP elevation, hypo-prealbuminemia, anemia, and ulcerative colitis were significantly associated with LOS (Supplementary Table 3).

DISCUSSION

In this retrospective study, 3,009 hospitalized IBD patients were screened by GPS, and 10.5% of them were at high-risk (GPS=2). Furthermore, GPS was associated with LOS after adjustment of co-variates, and this association was more significant in those patients with hypo-prealbuminemia, hypocalcemia, and hypokalemia.

The prevalence of high-risk in IBD based on GPS

A study of 270 patients undergoing elective bowel resection for IBD-related complications found that the prevalence of patients with high-risk was 17.2% and 13.1% in CD and UC patients.[18] The patients included were relatively more severe, with lower BMI (18.29 kg/m^2 vs. 22.49 kg/m^2 in our study) and a high proportion of anemia (45.6% vs. 25.6% in our study), so it is not surprising that the proportion of high-risk was higher than that in our study. Zhu et al. 19 recruited 163 patients with CD who underwent elective intestinal resection, and the proportion of patients with high-risk was 19%, which was also higher than that in our study. It could be explained by following factors such as a lower BMI (18.95 kg/m^2) and a longer disease duration (5 years). Another study included 80 patients with ulcerative colitis underwent elective intestinal resection and 77.5% of them was classified as severe. The results showed that 55.0% of patients were at high-risk.[17] All three were single-center

retrospective studies conducted in China with similar ethnic backgrounds, however, the sample size was significantly smaller than that of our study.

GPS and LOS in IBD

There is growing interest in the role of GPS including serum CRP and ALB as a predictor of short-term complications after surgical procedures for IBD.[17-19, 21] A study of CD patients undergoing elective intestinal resection found that higher GPS was an important independent risk factor for postoperative intra-abdominal septic complications.[19] Another study also found that higher modified Glasgow Prognostic Score (mGPS) one day before elective bowel resection was associated with postoperative surgical site infections.[18] In a study of UC patients undergoing elective intestinal resection, UC patients with high GPS had a significantly higher incidence of infectious complications, including abdominal sepsis, pulmonary infection, urinary tract infection, and wound infection, within three months after surgery.[17] However, another study including 341 patients with CD who underwent intestinal resection (39 were emergency surgery) that mGPS was not associated with postoperative complications.[21] It was worth noting that the study underwent blood tests within 14 days before surgery, while CRP and ALB had a shorter half-life and might change shortly before surgery. Only two studies analyzed the association between GPS and LOS in IBD patients, and both suggesting that higher GPS in IBD patients undergoing elective surgery was associated with prolonged postoperative LOS.[18, 19] Our results also supported that GPS at admission was associated with LOS.

Subgroup analysis

Subgroup analysis showed that the association between GPS and LOS was stronger in the hypo-prealbuminemia, hypocalcemia, and hypokalemia groups. The half-life of prealbumin in plasma was 24-48 h, which was much shorter than ALB, and only sufficient energy and protein intake (more than 65% required) helped to synthesize prealbumin.[22, 23] Therefore, prealbumin better reflected recent dietary intake and was a good parameter reflecting changes in nutritional status.[22-25] Studies showed that prealbumin level was well consistent with protein-energy malnutrition and patients at high nutritional risk, and was associated with LOS.[25, 26] Patients with IBD were at risk for protein-energy malnutrition and sarcopenia. Furthermore, they were also at risk for micronutrient deficiencies.[27] These deficiencies largely depended on disease activity, dietary intake and supplementation, and vitamin D deficiency and hypocalcemia were founded to be more common in patients with CD and UC,[28-31] and the

presence of acute intestinal inflammation such as diarrhea could also exacerbate electrolyte abnormalities such as hypokalemia.[32] The results of subgroup analysis showed that IBD patients with hypo-prealbuminemia, hypocalcemia, and hypokalemia had relatively more severe disease and worse nutritional status, requiring more medical treatments and nursing interventions during hospitalization, and that surgical inpatients might require more complex surgery or more postoperative complications, thus further prolonging LOS.

Limitations

This study has some limitations. First, as a retrospective study, there was a possibility of bias. Further, disease severity, medical treatment, specific intestinal inflammatory markers (e.g. fecal calprotectin, endoscopic performance), parenteral and enteral nutrition therapy, and dietary intake were not recorded, which could also interact with the association between GPS and LOS.[27, 33-36] However, this study included some clinical parameters in the statistical model trying to alleviated it. Second, the data in this study were from two large tertiary hospitals in Shanghai, China, which might not be representative of the general situation. Nonetheless, the advantage of our study was that the larger sample size improved the reliability of the results of this study to a certain extent. Finally, only LOS was included in this study, which limits the clinical use of GPS. Future studies can include more secondary clinical outcomes, such as medical costs and incident infections, and compare the predictive performance of other inpatient nutritional screening tools to further validate the specificity and sensitivity of GPS in nutritional screening of IBD patients. The above problems still require a well-designed prospective study to replicate our results.

Advantages

This study also has some advantages. First, CRP and ALB are routine clinical lab examination biomarker for admitted patient, so GPS is more convenient than common nutritional screening tools, without additional questionnaires and physical examination. In addition, GPS combines two indicators related to inflammation and nutrition, CRP and ALB, which are consistent with the common disease characteristics of inflammation and malnutrition in IBD patients, and has certain advantages as a nutritional risk screening tool.

Conclusion

In conclusion, GPS was associated with LOS in hospitalized IBD patients. GPS might be a useful and convenient screening tool associated with nutritional status and clinical outcome.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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Table 1. Demographical characteristics in 3,009 Chinese adult patients with inflammatory bowel diseases (IBD)[†]

Parameter and group	GPS groups[‡]			
	0 (n=2,084)	1 (n=608)	2 (n=317)	*p* value
Age, y				0.092
N/A	35 (28, 47)	34 (27, 47)	37 (29, 50)	
BMI, kg/m^2				0.322
N/A	22.3 (20.0, 24.6)	22.6 (20.0, 24.9)	22.5 (20.2, 25.4)	
Sex, n (%)				0.004
Men	1,371 (70.0%)	407 (20.8%)	180 (9.2%)	
Women	713 (67.9%)	201 (19.1%)	137 (13.0%)	
Surgery, n (%)				0.203
Yes	725 (67.3%)	233 (21.6%)	120 (11.1%)	
No	1,359 (70.4%)	375 (19.4%)	197 (10.2%)	
Type of diseases, n (%)				0.024
CD	1,603 (69.3%)	484 (20.9%)	227 (9.8%)	
UC	481 (69.2%)	124 (17.8%)	90 (13.0%)	
Combined with chronic disease				0.235
Yes	89 (66.4%)	25 (18.7%)	20 (14.9%)	
No	1,995 (69.4%)	583 (20.3%)	297 (10.3%)	
LOS, d				<0.001
N/A	6 (3, 9)	10 (6, 15)	15(10, 21)	
ALT, IU/L				<0.001
N/A	15 (10, 22)	11 (8, 15)	9 (6, 17)	
AST, U/L				<0.001
N/A	18 (15, 22)	14 (12,18)	13 (10, 18)	
ALP, U/L				0.033
N/A	75 (61, 89)	77 (64, 94)	74 (60, 93)	
GGT, U/L				
N/A	17 (12, 26)	19 (13, 29)	19 (13, 33)	<0.001
TBil, μmol/L				<0.001
N/A	8.9 (6.5, 12.4)	6.8 (5.0, 9.1)	6.0 (4.4, 8.2)	
DBil, μmol/L				<0.001
N/A	3.1 (2.3, 4.1)	2.5 (1.9, 3.3)	2.3 (1.8, 3.4)	
eGFR-EPI, mL/min per 1.73 m^2				0.175
N/A	120.4 (106.5, 131.9)	121.6 (107.2, 133.8)	121.3 (108.0, 133.0)	
FBG, mmol/L				0.149
N/A	4.9 (4.3, 5.9)	4.8 (4.3, 5.7)	4.8 (4.3, 5.9)	
Hemoglobin, g/L				<0.001
N/A	135 (121, 147)	121 (107, 134)	103 (89, 115)	
CRP, mg/L				<0.001
N/A	0.6 (0.5, 2.6)	17.5 (10.5, 30.4)	39.4 (23.7, 68.9)	
WBC, 10^9/L				<0.001
N/A	5.76 (4.74, 7.00)	6.65 (5.32, 8.37)	7.19 (5.54, 9.03)	
Albumin, g/L				<0.001
N/A	43.8 (40.8, 46.7)	37.8 (35.3, 40.9)	31.5 (28.4, 33.3)	
Pre-albumin, mg/L				<0.001
N/A	238.2 (207.8, 272.6)	172.4 (144.3, 203.8)	118.0 (88.1, 153.3)	
Ca^{2+}, mmol/L				<0.001
N/A	2.18 (2.13, 2.23)	2.22 (2.16, 2.28)	2.24 (2.18, 2.30)	
P^{3+}, mmol/L				0.049
N/A	1.12 (0.99, 1.26)	1.13 (0.99, 1.27)	1.09 (0.94, 1.27)	
Na^+, mmol/L				<0.001
N/A	141 (139, 142)	140 (138,142)	139 (137, 141)	
K^+, mmol/L				0.068
N/A	3.5 (3.3, 3.7)	3.4 (3.2, 3.7)	3.4 (3.1, 3.7)	

GPS, Glasgow Prognostic Score; LOS, length of hospital stay; ALT, alanine transferase; AST, aspartate transaminase; ALP, alkaline phosphatase; GGT, gamma glutamyl-transferase; TBIL, total bilirubin; DBIL, direct bilirubin; eGFR-EPI, estimated glomerular filtration rate calculated by Chronic Kidney Disease Epidemiology Collaboration equation; FBG, fasting blood glucose; WBC, white blood cell count; Ca, calcium; P, phosphorus; Na, sodium; K, potassium; CD, Crohn's disease; UC, ulcerative colitis; CRP, C-reactive protein; N/A, not applicable.

[†]If continuous variable was in abnormal distribution, data was shown as median (IQR). Categorical data was shown as proportion.

[‡]The criteria of GPS: point "0": C-reactive protein <10 mg/L AND albumin ≥35 g/L; point "1": C-reactive protein ≥10 mg/L OR albumin <35 g/L; point "2": C-reactive protein ≥10 mg/L AND albumin <35 g/L

Table 2. The association between GPS and length of hospital stay: multivariate linear regression model

Group	GPS groups, b (95% CI)[†]				Per point (95% CI)	*p*-trend
	0 (n=2,084)	1 (n=608)	2 (n=317)	*p* value		
Model 1[‡]	Ref (0)	4.6 (3.2, 6.0)	10.3 (8.5, 12.2)	<0.001	5.0 (4.2, 5.8)	<0.001
Model 2[§]	Ref (0)	2.2 (0.6, 3.8)	6.2 (4.0, 8.4)	<0.001	2.9 (1.9, 3.9)	<0.001
Model 3[¶]	Ref (0)	2.7 (-0.2, 5.5)	6.8 (3.0, 10.5)	<0.001	3.6 (1.7, 5.4)	<0.001
Model 4[††]	Ref (0)	2.0 (0.3, 3.7)	5.3 (1.6, 8.9)	0.011	2.3 (0.7, 3.8)	0.004

GPS, Glasgow Prognostic Score.
[†]The criteria of GPS: point "0": C-reactive protein <10 mg/L AND albumin ≥35 g/L; point "1": C-reactive protein ≥10 mg/L OR albumin <35 g/L; point "2": C-reactive protein ≥10 mg/L AND albumin <35 g/L.
[‡]Model 1: adjusted for sex (men vs. women) and age (<40y, 40-65y, and ≥65y).
[§]Model 2: adjusted for sex (men vs. women), age (<40y, 40-65y, and ≥65y) , type of diseases (CD vs. UC), surgery (yes vs. no), anemia (yes vs. no), pre-albumin (≥200mg/L vs. <200mg/L), Ca^{2+} (<2.25mmol/L 2.25-2.60mmol/L, and ≥2.25mmol/L), and K^{+} (<3.5mmol/L, 3.5-5.5mmol/L, ≥5.5mmol/L).
[¶]Model 3: adjusted for variables in model 2 and further C-reactive protein (mg/L).
[††]Model 4: adjusted for variables in model 2 and further albumin (g/L).

Table 3. The association between GPS and length of hospital stay: subgroup analysis[†]

Parameter (n)	Model 1 GPS groups, b (95% CI)[‡]				Model 2 GPS groups, b (95% CI)[§]			
	0	1	2	*p* value	0	1	2	*p* value
Type of diseases								
CD (2,314)	Ref (0)	4.9 (3.5, 6.3)	9.7 (7.8, 11.6)	<0.001	Ref (0)	2.0 (0.4, 3.6)	5.1 (2.7, 7.4)	<0.001
UC (695)	Ref (0)	4.0 (0.1, 7.8)	11.4 (7.0, 15.8)	<0.001	Ref (0)	1.9 (-2.3, 6.3)	8.7 (3.2, 14.1)	0.007
Surgery								
Yes (1,078)	Ref (0)	3.9 (3.0, 4.9)	8.5 (7.2, 9.8)	<0.001	Ref (0)	2.6 (1.6, 3.7)	6.0 (4.5, 7.5)	<0.001
No (1,931)	Ref (0)	5.2 (3.1, 7.3)	11.8 (8.9, 14.4)	<0.001	Ref (0)	1.9 (-0.6, 4.3)	6.3 (3.0, 9.7)	0.001
Pre-albumin, mg/L								
<200 (1,161)	Ref (0)	3.2 (0.8, 5.7)	8.0 (5.3, 10.7)	<0.001	Ref (0)	2.4 (0.0, 4.9)	5.7 (2.8, 8.7)	<0.001
≥200 (1,848)	Ref (0)	1.8 (-0.3, 3.9)	4.7 (-1.4, 10.9)	0.080	Ref (0)	1.7 (-0.4, 3.8)	4.2 (-2.0, 10.5)	0.138
Ca^{2+}, mmol/L								
<2.25 (2,278)	Ref (0)	4.0 (2.4, 5.5)	10.5 (8.4, 12.7)	<0.001	Ref (0)	2.0 (0.3, 3.7)	6.8 (4.3, 9.3)	<0.001
2.25-2.60 (638)	Ref (0)	4.7 (1.2, 8.2)	8.7 (4.5, 12.8)	<0.001	Ref (0)	2.2 (-1.8, 6.1)	4.9 (-0.4, 10.1)	0.184
≥2.60 (93)	Ref (0)	5.2 (2.5, 7.9)	8.5 (5.2,11.8)	<0.001	Ref (0)	3.4 (-0.6, 7.4)	6.6 (1.8, 11.3)	0.028
K^{+}, mmol/L								
<3.5 (2,179)	Ref (0)	3.8 (2.2, 5.5)	9.5 (7.2, 11.8)	<0.001	Ref (0)	2.1 (0.3, 4.0)	6.4 (3.7, 9.1)	<0.001
3.5-5.5 (828)	Ref (0)	5.5 (3.0, 8.0)	10.9 (7.9, 14.0)	<0.001	Ref (0)	1.8 (-1.1, 4.7)	5.1 (1.3, 8.9)	0.03
≥5.5 (2)	Ref (0)	N/A	N/A	N/A	Ref (0)	N/A	N/A	N/A

GPS, Glasgow Prognostic Score.
[†]The criteria of GPS: point "0": C-reactive protein <10 mg/L AND albumin ≥35 g/L; point "1": C-reactive protein ≥10 mg/L OR albumin <35 g/L; point "2": C-reactive protein ≥10 mg/L AND albumin <35 g/L.
[‡]Model 1: adjusted for sex (men vs. women) and age (<40y, 40-65y, and ≥65y).
[§]Model 2: adjusted for sex (men vs. women), age (<40y, 40-65y, and ≥65y), type of diseases (CD vs. UC), surgery (yes vs. no), anemia (yes vs. no), Pre-albumin (≥200mg/L vs. <200mg/L), Ca^{2+} (<2.25mmol/L, 2.25-2.60mmol/L, and ≥2.60mmol/L), and K^{+} (<3.5mmol/L, 3.5-5.5mmol/L, and ≥5.5mmol/L).

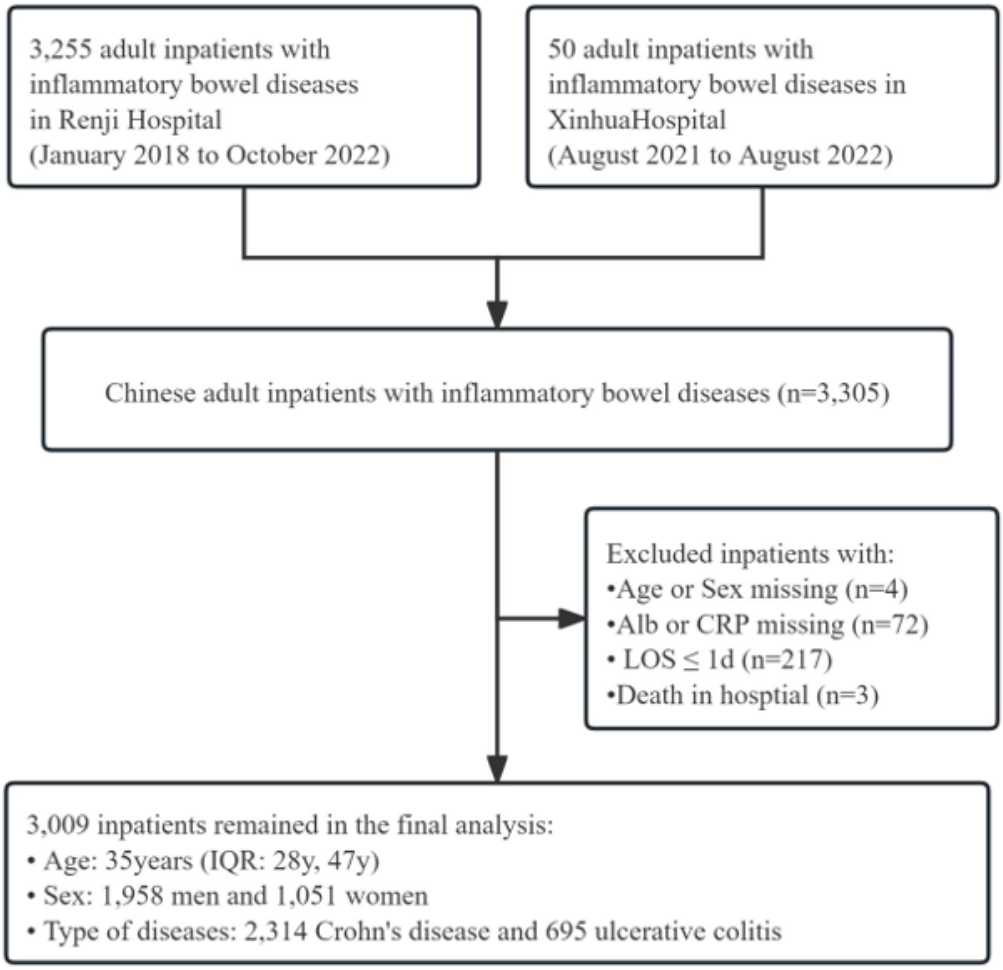

Figure 1. Flow chart of participant recruitment. CRP, C-reactive protein; LOS, length of hospital stay.

Supplementary Table 1. The association between C-reactive protein, albumin and length of hospital stay: multivariate linear regression

Parameter	n	Model 1†		Model 2‡	
		b (95% CI)	*p* value	b (95% CI)	*p* value
CRP (mg/L)					
<10 (Ref)	2,214	Ref (0)	N/A	Ref (0)	N/A
≥10	795	6.5 (5.3, 7.8)	<0.001	3.0 (1.5, 4.5)	<0.001
Alb (g/L)					
≥35 (Ref)	2,568	Ref (0)	N/A	Ref (0)	N/A
<35	441	8.2 (6.7, 9.8)	<0.001	4.3 (2.5, 6.1)	<0.001

CRP, C-reactive protein.
†Model 1: adjusted for sex (men vs. women) and age (<40y, 40-65y, and ≥65y).
‡Model 2: adjusted for sex (men vs. women), age (<40y, 40-65y, and ≥65y) , type of diseases (CD vs. UC), surgery (yes vs. no), anemia (yes vs. no), pre-albumin (≥200mg/L vs. <200mg/L), Ca^{2+} (<2.25mmol/L 2.25-2.60mmol/L, and ≥2.25mmol/L), and K^{+} (<3.5mmol/L, 3.5-5.5mmol/L, ≥5.5mmol/L).

Supplementary Table 2. Interactions between clinical parameters and the association between GPS and length of hospital stay†

Parameter	Interaction‡	*p* value
Length of hospital stay	GPS*sex	0.588
	GPS*age	0.195
	GPS*type of diseases	<0.001
	GPS*surgery	<0.001
	GPS*hemoglobin	0.062
	GPS*Pre-albumin	<0.001
	GPS*Ca^{2+}	0.022
	GPS*K^{+}	0.009

GPS, Glasgow Prognostic Score
†The criteria of GPS: point "0": C-reactive protein <10 mg/L AND albumin ≥35 g/L; point "1": C-reactive protein ≥10 mg/L OR albumin <35 g/L; point "2": C-reactive protein ≥10 mg/L AND albumin <35 g/L.
‡The interaction terms: (men vs. women), age (<40y, 40-65y, and ≥65y) , type of diseases (CD vs. UC), surgery (yes vs. no), anemia (yes vs. no), pre-albumin (≥200mg/L vs. <200mg/L), Ca^{2+} (<2.25mmol/L 2.25-2.60mmol/L, and ≥2.25mmol/L), and K^{+} (<3.5mmol/L, 3.5-5.5mmol/L, ≥5.5mmol/L).

Supplementary Table 3. The association between variables and length of hospital stay: multivariate linear regression model

Parameter		LOS	
	n	b (95% CI)	*p* value
Type of diseases			
CD (Ref)	2,314	Ref (0)	N/A
UC	695	3.7 (2.4, 5.0)	<0.001
Alb, g/L			
≥35 (Ref)	2,568	Ref (0)	N/A
<35	441	3.8 (2.0, 5.6)	<0.001
Pre-albumin, mg/L			
≥200 (Ref)	1,848	Ref (0)	N/A
<200	1,161	3.1 (1.7, 4.4)	<0.001
Ca^{2+}, mmol/L			
2.25-2.60 (Ref)	638	Ref (0)	N/A
<2.25	2,278	-2.6 (-3.9, -1.2)	<0.001
≥2.60	93	-1.4 (-4.7, 1.9)	0.400
Surgery			
No (Ref)	1,931	Ref (0)	N/A
Yes	1,078	-3.4 (-4.5, -2.3)	<0.001
CRP, mg/L			
<10 (Ref)	2,214	Ref (0)	N/A
≥10	795	2.3 (0.8, 3.8)	0.003
Anemia[†]			
No (Ref)	2,238	Ref (0)	N/A
Yes	771	1.7 (0.3, 3.1)	0.020
K^+, mmol/L			
3.5-5.5 (Ref)	828	Ref (0)	N/A
<3.5	2,179	-2.3 (-3.5, -1.1)	<0.001
≥5.5	2	N/A	N/A

LOS, length of hospital stay
[†]The definition of anemia: hemoglobin<120g/L in men or <110g/L in women.