Research Square

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Preoperative Controlling Nutritional Status (CONUT) Score Predicts Short-Term Surgical Prognosis in Patients with Gastric Cancer After Laparoscopy-Assisted Radical Gastrectomy

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Abstract

Background: The Controlling Nutritional Status (CONUT) score is an emerging nutrition assessment tool that is very useful in patients with gastric cancer who usually experience weight loss and malnutrition. The aim of our study was to assess the predictive ability of the preoperative CONUT score for short-term prognosis in patients with gastric cancer undergoing laparoscopy-assisted gastrectomy.

Methods: We retrospectively reviewed medical records of 309 patients who underwent curative laparoscopy-assisted gastrectomy. The patients were divided into two groups according to the optimal cutoff value of the CONUT score. The clinical association for the CONUT score, characteristics, and postoperative complications were evaluated and analyzed. The risk factors for complications were identified by univariate and multivariate analysis.

Results: The preoperative CONUT score showed a good predictive ability for postoperative complications (AUC=0.718，Youden index=0.343)，with an optimal cutoff value of 2.5. The patients with high CONUT scores had a higher incidence of overall complications (P<0.001) and mild complications (P<0.001). Univariate and multivariate analysis revealed that the CONUT score was independently associated with postoperative complications (P=0.012，OR=2.433，95%CI，1.218-4.862).

Conclusions：The preoperative CONUT score was identified as a reliable nutritional assessment tool for predicting short-term prognosis in patients with gastric cancer after laparoscopy-assisted gastrectomy.

Introduction

Worldwide，gastric cancer remains a major public health problem. Gastric cancer is fifth in incidence among new cases cancer and third in mortality[1]. Adequate surgical resection is the main curative therapeutic option for gastric cancer[2]，which inevitably carries some postoperative complications，leading to prolonged hospitalization，more expenses，impaired quality of life，and delayed adjuvant chemotherapy treatment.

Gastric cancer patients often suffer from malnutrition，which is usually associated with humoral and cellular immune dysfunction，inflammatory response alterations，and poor wound healing[3]. As an independent risk factor，malnutrition contributes to the occurrence of postoperative complications[4]， reduces the body response to antitumor treatment，and ultimately impairs long-term survival[5]. Several nutritional assessment scales or systems have been developed to detect the adverse condition of nutrition，such as the modified Glasgow Prognostic Score (mGPS)[6]，Prognostic Nutritional Index (PNI)[3]， Naples Prognostic Score (NPS)[7]，Platelet-Lymphocyte Ratio (PLR)[8]，Skeletal Muscle Index (SMI)[9]，or the Malnutrition Universal Screening Tool (MUST)[10] among others.

The Controlling Nutritional Status (CONUT) score was first reported and validated by Ignacio de Ulíbarri J in 2005，as a tool for early detection and continuous control of malnutrition. The formula of CONUT

comprises serum albumin，total lymphocyte count, and cholesterol (Table.1)[11]. Recently，previous studies reported that proactive assessment of nutritional status by the CONUT score could accurately predict long-term outcomes in patients with colorectal cancer[12]，hepatocellular carcinoma[13]，esophagus cancer[14]，and gastric cancer[9, 15-17]. However，little research work shed light on the CONUT score for short-term complications after radical gastrectomy. Therefore，the primary aim of our study was to assess the predictive ability of preoperative CONUT score for short-term prognosis in patients with gastric cancer， who underwent laparoscopic radical gastrectomy.

Patients And Methods

Study patients

We retrospectively reviewed a series of consecutive clinical records of 412 patients who underwent curative laparoscopic gastrectomy，at the Department of General Surgery of Sir Run Run Shaw Hospital， the affiliated hospital of medicine school of Zhejiang University，from January 2016 to June 2019. The inclusion criteria was as followed，(1)acquired pathological diagnosis confirmed with gastric carcinoma by gastroscopic biopsy，(2)underwent curative laparoscopic gastrectomy，(3)the age of patients>18 years old. The exclusion criteria was as followed，(1)received neoadjuvant chemotherapy before gastrectomy， (2)R1/2 resection，(3)diagnosed as gastric stump cancer，(4)combined with distant metastasis，liver， colon，ovary and etc.，，(5)underwent extended or palliative operation，(6)incomplete data to follow-up in 30 days. Ultimately，there were 309 patients enrolled in the retrospective analysis. The detailed flow-chart was shown in Figure.1. Written informed consent for usage of clinical records was granted by each patient，as required by the Institutional Review Board at hospital，in accordance with ethical guidelines from the Declaration of Helsinki in 1964.

Perioperative management

Elaborate case history analysis，normative physical examination and routine preoperative laboratory measurements were performed. All elder patients above 50 years old would have to take in ultrasonic cardiogram and pulmonary function test，to evaluate cardiopulmonary condition before surgery. Abdominal enhanced computed tomography and endoscopy together with tissue biopsy were carried out for overall assessment of gastric tumor. The standard surgical laparoscopic gastrectomy ensured with sufficient resection margin was performed followed by Japanese gastric cancer treatment guidelines 2014，ver.4，[18]，which was either total or distal gastrectomy coupled with systematic lymphadenectomy abiding by the D level criteria. The alimentary tract reconstruction methods were usually employed as following，We performed Roux-en-Y esophagojejunostomy after total gastrectomy，with regard to distal gastrectomy we selected one of three gastrointestinal methods including Billroth I gastroduodenostomy， Billroth II gastrojejunostomy and Roux-en-Y gastrojejunostomy. Based on preoperative and intraoperative condition，patients were transferred to intensive care unit for postoperative treatment when necessary. For all of patients，reasonable perioperative management was in line with the Enhanced Recovery After Surgery (ERAS) program，including preoperative disease education，shrinking fasting time，intraoperative

utility of minimally invasive techniques，fluid restriction avoided from overload，postoperative early drainage removing，off-bed mobilization and oral feeding until discharged[19-21]. Thereafter，patients received with pathological diagnosis of advanced gastric carcinoma were recommended to adopt subsequent adjuvant chemotherapy.

Data Collection

We retrospectively collected clinical records of baseline characteristics，laboratory data，imaging scanning examination and pathological diagnosis from the database. Preoperative CONUT score was calculated from precise records of serum albumin level，total lymphocyte count and cholesterol level， whose blood samples were obtained within 3 days before surgery. Short-term prognosis was chiefly considerated as postoperative complications that occurred within 30 days after surgery or before hospital discharge. Based on the Clavien-Dindo classification system[22]，we ranged postoperative complications from Grade I to Grade V，with Grade I and II defined as mild complications，Grade III to Grade V defined as major complications. Among mild complications，abdominal or pelvic effusion was diagnosed via ultrasonic testing or computed tomography scan，excluding the case of intra-abdominal infection. When the patients developed nontransient fever over 38.5°C after surgery，we highly suspected there existed infection and adopted effective antibiotic therapy. Delayed flatus and defecation denoted sluggish resuscitation of gastrointestinal function，and we had to prolong the usage of TPN(total parenteral nutrition). As for major complications，severe active hemorrhage after surgery called for emergency treatment. When persistent fever and purulent drainage came out，we considered there was intra-abdominal abscess inside. Other intractable major complications included anastomotic leakage， duodenal stump fistula and etc. Mortality was regarded as any death occurring from the date of operation up to 30 days after operation. Each individual data of cancer staging involving records of the primary and regional nodal extent of tumor and the absence or presence of metastases was evaluated based on TNM Classification of Malignant Tumors，8th Edition，published in affiliation with the Union for International Cancer Control (UICC) and the American Joint Committee on Cancer(AJCC).

Statistical Analysis

All of the data was statistically analyzed using SPSS 21.0 (IBM Corp，Armonk，NY). Continuous variables were presented as mean (standard deviation) or median (interquartile range)，whereas categorical variables were presented as number (percentage). The Student t test or Mann-Whitney U test/ Kruskal-Wallis H test was utilized for continuous variables depending on the normality of data distribution. The Pearsonχ^2 test or Fisher exact test was applied for categorical variables as appropriate. The predictive ability of potential factors for postoperative complications was evaluated by the Receiver Operating Characteristic curve. We elaborately chose the optimal cut-off value with reference to Youden index， which was set as the value maximizing the sum of sensitivity and specificity. To identify independent risk predictors for postoperative complications，all significant associated factors ($P < 0.05$) on univariate analysis were assessed for multivariate analysis by logistic regression. All of P value < 0.05 was considered as statistical significance.

Results

Receiver operating characteristic curve of CONUT score and the optimal cutoff value identified

The demarcated values of CONUT score correlated with prognosis differed in recent studies[9, 12-17]. Therefore，we elaborately plotted the receiver operating characteristic curve of CONUT score，based on postoperative overall complications (Figure.2). The area under the curve(AUC) was 0.718，with sensitivity of 0.549 and specificity of 0.794. The positive predictive value was 52.3%，and negative predictive value was 80.8%. Youden index was 0.343，and the optimal cutoff value was identified as 2.5.

Study population and baseline characteristics

According to the inclusion and exclusion criteria，309 patients were enrolled in the retrospective analysis，including 228(73.8%) men and 81(26.2%) women，with an average age of 63.4±0.6 years old and a mean BMI of 22.8±0.2 kg/m^2. There were 38(12.3%) patients diagnosed with diabetes mellitus and 117(37.9%) patients as hypertension when hospitalized. 70(22.7%) patients admitted the history of abdomen surgery. 193(62.5%) patients received distal gastrectomy，and the remaining 116(37.5%) patients received total gastrectomy. Based on the 8th edition of malignant tumors TNM classification，102(33.0%)，51(16.5%)，148(47.9%)，and 8(2.6%) patients were in stages I，II，III，IV，respectively. Statistically，91(29.4%) patients in total withstood postoperative complications and the average length of stay after surgery was 13.6±0.5 days. The detailed clinical characteristics are summarized in Table.2.

Correlations of the CONUT score and clinical characteristics

On account of the optimal CONUT score cutoff value，all of patients were subdivided into the low CONUT group(score<2.5，N=214) and the high CONUT group(>2.5，N=95)(Table.2). Compared with the low CONUT group，preoperative laboratory measurements of the high CONUT group performed worse in Hb(P<0.001)，albumin(P<0.001)，CRP(P<0.001)，RBC(P<0.001)，platelets(P<0.001)，total lymphocytes(P<0.001) and cholesterol(P<0.001). As regards preoperative tumor biomarkers，there was no significant difference observed with carcino-embryonic antigen(CEA)(P=0.769)，which was reported specifically associated with gastric cancer[23, 24]. Furthermore，there were higher proportions of pathological stage I(P=0.014) and II(P=0.059) in the low CONUT group，and lower proportions of pathological stage III(P<0.001) and IV(P=0.975) yet. Patients with high CONUT score had longer postoperative stay(P=0.006) and higher incidence of postoperative complications(P<0.001).

Distribution statistics of postoperative complications after laparoscopic gastrectomy with low and high CONUT score

Next，we conducted distribution statistics of postoperative complications for patients undergoing laparoscopic gastrectomy(Table.3). The overall amount of complications was 41(19.2%) in the low CONUT group，and 50(52.6%) in the high CONUT group(P<0.001). Postoperative complications were classified from Grade I to V，based on the Clavien-Dindo classification system[22]，and defined as mild or

major complications in accordance with criteria. The incidence rate of mild complications was significantly higher in malnutritional patients with high CONUT score(18，8.4%，33，34.7%，P<0.001)， including fever with temperature over 38.5℃ after surgery(P=0.204)，incision infection (P=0.347)， persistent utilization of total parenteral nutrition exceeding 2 weeks (P=0.091)，postoperative blood transfusion more than 2 U (P=0.347)，gastroplegia (P=0.521)，abdominal or pelvic effusion(P=0.264)， early postoperative bowel obstruction(P=0.091)，urinary tract infection(P=0.307). A total of 40 patients suffered major complications with higher proportion of malnutritional group(24，11.2%，16，16.8%， P=0.174)，including postoperative active hemorrhage(P=0.548)，intra-abdominal abscess(P=0.676)， anastomotic leakage (P=0.591)，anastomotic stenosis (P=0.802)，duodenal stump fistula (P=0.864)， emergency second operation (P=0.219)，shift to ICU for custody (P=0.419)，septic shock(P=0.028)，single organ dysfunction (P=0.768)，and MODS (P=0.307). There was only 1 case who died from severe cachexia and MODS after surgery. With regard to Surgical Site Infection (SSI)，5 (1.6%) cases of surface incisional infection (P=0.347) and 17 (5.5%) cases of deep space infection (P=0.676) occurred.

Univariate and multivariate analysis of risk factors associated with short-term outcomes

With the univariate analysis for patients with gastric cancer after surgery，we identified potential risk factors associated with postoperative complications，including age(P<0.001)，preoperative Hb(P<0.001)， CRP(P<0.001)，RBC(P<0.001)，CONUT score(P<0.001)，types of operative procedure(P=0.043)，the pathological TNM classification of T1(P<0.001)，T4(P=0.004)，N0(P=0.012)，N3(P<0.001)，the pathological stage I(P=0.003)，III(P<0.001). Furthermore，the multivariate analysis was performed which validated age(P=0.037，OR=2.237，95%CI，1.048-4.774)，preoperative RBC(P=0.003，OR=0.356，95%CI， 0.180-0.707)，and CONUT score(P=0.012，OR=2.433，95%CI，1.218-4.862) as independent risk factors for predicting short-term complications in patients with gastric cancer after laparoscopic gastrectomy. The detail was shown in Table 4.

Discussion

Malnutrition is defined as “a state resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease”[25]. Among patients with cancer，the condition of low BMI and weight loss causing by inadequate nutritional intake with independent prognostic significance[26]，is quite common and may be severe. Meanwhile，the depletion of skeletal muscle as the main aspect of cancer-associated malnutrition，a hallmark of cancer cachexia，also does damage to physical function and treatment tolerance[27, 28]. The systemic inflammation syndrome is frequently activated，which varies in degree but impacts all relevant metabolic pathways including protein，carbohydrate and lipid metabolism[29]. The circumstance of malnutrition is particularly common among patients with gastric cancer，especially advanced gastric cancer. They always have to endure unwell symptoms such as early satiety，anorexia and dysphagia，caused by chronic obstruction of tumor

mass and hemorrhagic anemia of malignant ulcers，which ultimately leads to progressive weight loss， compromised immunity and perishing malnutrition[30].

As of today，several nutritional assessments have been established with aim at identifying applicable parameters of malnutrition status，such as NRS(Nutritional Risk Screening)，MNA(Mini Nutritional Assessment)，MUST(Malnutrition Universal Screening Tool)，SGA(Subjective Global Assessment)，from the consensus scheme of criteria proposed by the Global Leadership Initiative on Malnutrition(GLIM)[31]. The CONUT score was originally proposed to assess nutritional status of inpatients by Ignacio de Ulíbarri J in 2005[11]，precisely calculated with serum albumin，total lymphocyte count and cholesterol level，which subsequently was deemed to be a validated nutritional assessment approach for predicting multiple cancer outcomes in recent years[9, 12-17, 32, 33].

We carried out this retrospective cohort study to cast attentions to the role of CONUT score played in predicting the prognosis of patients with gastric cancer，to be specific，short-term prognosis. The correlation between CONUT score and postoperative complications was estimated with data from electronic medical record.

Despite prolonged operating time and fewer harvested lymph nodes，laparoscopy-assisted gastrectomy is associated with minimally invasive incision，less blood loss，earlier healing，and shorter time to oral intake and hospital stay，compared with open surgery[34]. Previous studies indicated that laparoscopic gastrectomy was likely to be an alternative procedure for patients with gastric cancer，with the non-inferiority of short-term and long-term outcomes[35, 36]. Recently，an open-label，multicentre，non-inferiority， phase III randomized controlled trial in Japan supported the non-inferiority of laparoscopy-assisted distal gastrectomy compared with open distal gastrectomy for clinical stage I gastric cancer relapse-free survival[37]. Our study involved clinical records of 309 patients who underwent laparoscopy-assisted radical gastrectomy with written informed consent. A certain part of patients with gastric cancer started with laparoscopic exploration，and then transferred to open gastrectomy，extended or palliative operation according to the surgeon’s judgement，due to gross tumor volume，deep tumor location or visible existence of tumor invasion or peritoneal metastasis，which was deliberately excluded from our analysis.

Based on the receiver operating characteristic curve，we identified the optimal cutoff value as CONUT score of 2.5 to distinguish patients at disparate risk for postoperative complications. The preoperative parameters constituting CONUT score revealed an authentic and steady nutrition status of patients，and it was reasonable for preoperative assessment. When patients underwent operation，various factors including surgical trauma，intraoperative hemorrhage，venous fluid utilization，postoperative TPN support might influence their blood components and hemodynamics，and bring about the variations of laboratory measurements for nutritional assessment.

In order to explore potential risk factors associated with postoperative complications，we conducted univariate and multivariate analysis with preoperative parameters. Consistent with what we supposed， the CONUT score served as an integrated nutritional index，was significantly associated with

postoperative complications in patients with gastric cancer undergoing laparoscopic surgery(P=0.012，OR=2.433，95%CI，1.218-4.862). In addition，we also identified age(P=0.037，OR=2.237，95%CI，1.048-4.774)，preoperative RBC(P=0.003，OR=0.356，95%CI，0.180-0.707) as independent risk factors for complications. Generally speaking，elderly patients，anemia and malnutrition played adverse roles in short-term prognosis with patients after radical gastrectomy for cancer，which was parallel to prior studies[38, 39]. By the way，we excluded albumin，total lymphocyte count and cholesterol from multivariate analysis so as to avoid duplication.

Based on the Clavien-Dindo classification system[22]，we ulteriorly performed stratified statistics of postoperative complications with low and high CONUT score. As a matter of fact，some patients who suffered severe complications usually underwent multiple collateral complications. One patient got a sudden bellyache and subsequent fever，with abdominal tenderness and rebound tenderness，for example，as a result of duodenal stump rupture，developed grievous intra-abdominal abscess fleetly，and had to suffer second laparotomy with suture，irrigation and drainage. Our detailed analysis indicated that higher scale of gastric cancer patients with high CONUT score developed postoperative complications，especially mild complications. The condition of hypoalbuminemia，decreased lymphocytes，hypocholesterolemia was prevalent among malnourished patients with complications，which meant delayed wound healing，increased susceptibility to infection，and prolonged parenteral nutrition support. That helped to explain why the percentage of patients with mild complications was significantly higher in high CONUT score group. Statistic difference was not present at patients group with major complications，which needed larger scale of patients to further validation. Surgical site infections(SSIs) are infections of the incision or organ or space that occur after surgery，combined with complex comorbidities and antimicrobial-resistant pathogens，which increase the challenge and expenses of treatment[40]. Our analysis showed that there was no significant difference about SSIs whether located at surface incision or deep space. The respiratory complications after surgery contained pneumonia，hydrothorax，which occurred more frequently in the high CONUT group，as same as Song Ryo et al reported[15]. We believed that was blamed for long stay in bed and infrequent cough and sputum of malnourished patients. Therefore，the CONUT score acted to furnish an evaluation strategy for precise risk stratification oriented at short-term outcomes before surgery，which allowed to implement active nutritional intervention for malnourished patients.

Despite of our findings，there were still some limitations of our present study. First，the single-center study took in a homogeneous cohort of patients with a fixed surgery team. Second，a retrospective study could not reject selection bias. At last，the follow-up assessments of CONUT score after surgery were absent，which resulted in the lack of dynamic observation of nutrition status. Therefore，prospective multi-center studies should be warranted to confirm predictive significance of the CONUT score for short-term and long-term prognosis，to validate the effectivity of preoperative nutritional intervention，involving with the comparison of other commonly used and well considered nutritional assessments.

Conclusion

As a simple and feasible nutrition assessment tool the CONUT score plays a reliable role in predicting postoperative complications for patients with gastric cancer after laparoscopy-assisted gastrectomy which allows precise risk stratification and preoperative nutritional intervention before surgery.

Abbreviations

CONUT: Controlling Nutritional Status; PNI: Prognostic Nutritional Index; mGPS: modified Glasgow Prognostic Score; NPS: Naples Prognostic Score; PLR: Platelet-Lymphocyte Ratio; SMI: Skeletal Muscle Index; MUST: Malnutrition Universal Screening Tool; ERAS: Enhanced Recovery After Surgery; TPN: Total Parenteral Nutrition; AUC: Area Under the Curve; BMI: Body Mass Index; SSI: Surgical Site Infection.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Sir Run Run Shaw Hospital. Written informed consent was obtained from all participants.

Consent

Written informed consent was obtained from all patients enrolled in the investigation. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and the guidelines of the regional ethical committees of Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, China.

Competing interests

The authors declare that they have no competing interests.

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Author’s contributions

Y.Q. and H.Y.L. contributed to study conception and design, X.L.G., Y.Q., J.H.P., J.Q.G. and H.Y.L. contributed to acquisition of data, W.H.Y., J.M.L. and J.F.Y. contributed to analysis and interpretation of data, Y.Q., X.L.G. and H.Y.L. contributed to drafting of manuscript, X.L.G., W.Z. and X.F.W. contributed to critical revision. All authors read and approved the final manuscript.

Availability of data and materials

Access to the data and the calculation method can be obtained from the authors by email (gxlnjumed09@126.com).

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Tables

Table.1 Assessment of malnutritional status by the CONUT score.

Parameter	Malnutritional status			
	Normal	Mild	Moderate	Severe
Albumin (g/dl)	≥ 3.5	3.0 ≤ alb < 3.5	2.5 ≤ alb < 3.0	< 2.5
score	0	2	4	6
Total lymphocyte count (mg/ml)	≥ 1600	1200 ≤ TLC < 1600	800 ≤ TLC < 1200	< 800
Score	0	1	2	3
Cholesterol (mg/dl)	≥ 180	140 ≤ TC < 180	100 ≤ TC <140	< 100
Score	0	1	2	3
Total score	0 1	2 4	5 8	9 12

Table.2 Study population and baseline characteristics of the patients sorted by the CONUT score.

Characteristics	All (N=309)	CONUT<2.5 (N=214)	CONUT>2.5 (N=95)	P value
Age, years	63.4±0.6	62.2±0.7	66.2±1.2	0.003
Gender				
Male	228 (73.8)	155 (72.4)	73 (76.8)	0.416
Female	81(26.2)	59(27.6)	22(23.2)	0.416
BMI, kg/m^2	22.8±0.2	23.1±0.2	21.9±0.3	<0.001
Comorbidities				
Diabetes mellitus	38 (12.3)	19 (8.9)	19 (20.0)	0.006
Hypertension	117 (37.9)	76 (35.5)	41 (43.2)	0.201
History of abdomen surgery	70 (22.7)	40 (18.7)	30 (31.6)	0.013
Preoperative laboratory measurements				
Hb, g/L	123.9±1.4	132.5±1.3	104.5±2.4	<0.001
Albumin, g/L	39.0±0.3	40.9±0.3	34.6±0.5	<0.001
CRP, mg/L	5.2±0.7	3.2±0.6	9.6±1.8	<0.001
WBC, x10^9/L	5.87±0.09	5.99±0.10	5.61±0.21	0.064
RBC, x10^{12}/L	4.14±0.04	4.38±0.04	3.60±0.07	<0.001
Platelets, x10^9/L	216.8±3.8	221.4±4.5	206.5±7.4	<0.001
Total lymphocytes, x10^9/L	1.56±0.04	1.79±0.04	1.04±0.04	<0.001
Cholesterol, mmol/L	4.60±0.06	5.02±0.07	3.64±0.08	<0.001
Preoperative tumor biomarkers				
CA125, u/ml	13.6±0.8	11.8±0.9	17.4±1.7	0.001
CA199, u/ml	27.9±4.6	20.4±2.8	43.9±13.0	0.016
CEA, ng/ml	5.8±1.6	6.1±2.3	5.1±1.2	0.769
AFP, μg/L	8.9±5.8	11.7±8.4	3.0±0.5	0.487
Types of operative procedure				
Distal gastrectomy	193(62.5)	131(61.2)	62(65.3)	0.498

Total gastrectomy	116(37.5)	83(38.8)	33(34.7)	0.498
Intraoperative fluid utilization, ml	2161±35.7	2209±41.1	2042±69.4	0.034
Operative time, min	271.8±3.0	273.4±3.6	268.4±5.8	0.444
Estimated blood loss, ml	106.1±7.3	103.0±9.3	112.9±11.2	0.531
T factor				
T1	91(29.4)	78(36.4)	13(13.7)	<0.001
T2	35(11.3)	22(10.3)	13(13.7)	0.384
T3	42(13.6)	23(10.7)	19(20.0)	0.029
T4	141(45.6)	91(42.5)	50(52.6)	0.100
N factor				
N0	118(38.2)	94(43.9)	24(25.3)	0.002
N1	44(14.2)	30(14.0)	14(14.7)	0.868
N2	53(17.2)	38(17.8)	15(15.8)	0.672
N3	94(30.4)	52(24.3)	42(44.2)	<0.001
pTNM stage				
I	102(33.0)	80(37.4)	22(23.2)	0.014
II	51(16.5)	41(19.2)	10(10.5)	0.059
III	148(47.9)	88(41.1)	60(63.2)	<0.001
IV	8(2.6)	5(2.3)	3(3.2)	0.975
Postoperative stay, days	13.6±0.5	11.6±0.5	14.1±0.7	0.006
Postoperative complications	91 (29.4)	41 (19.2)	50 (52.6)	<0.001
Values in parentheses are percentages unless indicated otherwise; the other values are mean±Sd. BMI, body mass index; Hb, Hemoglobin; CRP, C-reactive protein; WBC, White blood cells; RBC, Red blood cells.				

Table 3. Comparison of postoperative complications in gastric cancer undergoing laparoscopic surgery with low and high CONUT score.

Postoperative complications	All (N=309)	CONUT<2.5 (N=214)	CONUT>2.5 (N=95)	P value
Overall complications	91(29.4)	41(19.2)	50(52.6)	<0.001
Mild complications（Grade I to II）	51(16.5)	18(8.4)	33(34.7)	<0.001
Fever>38.5℃ after surgery	9(2.9)	4(1.9)	5(5.3)	0.204
Incision infection	5(1.6)	2(0.9)	3(3.2)	0.347
TPN> 2 weeks	10(3.2)	4(1.9)	6(6.3)	0.091
Postoperative blood transfusion> 2U	5(1.6)	2(0.9)	3(3.2)	0.347
Gastroplegia	2(0.6)	1(0.5)	1(1.1)	0.521
Abdominal/Pelvic effusion	7(2.3)	3(1.4)	4(4.2)	0.264
Early postoperative bowel obstruction	10(3.2)	4(1.9)	6(6.3)	0.091
Urinary tract infection	1(0.3)	0(0.0)	1(1.1)	0.307
Major complications（Grade III to Grade V）	40(12.9)	24(11.2)	16(16.8)	0.174
Postoperative active hemorrhage	16(5.2)	10(4.7)	6(6.3)	0.548
Intra-abdominal abscess	17(5.5)	11(5.1)	6(6.3)	0.676
Anastomotic leakage	9(2.9)	5(2.3)	4(4.2)	0.591
Anastomotic stenosis	4(1.3)	3(1.4)	1(1.1)	0.802
Duodenal stump fistula	9(2.9)	6(2.8)	3(3.2)	0.864
Emergency second operation	13(4.2)	7(3.3)	6(6.3)	0.219
Shift to ICU for custody	8(2.6)	4(1.9)	4(4.2)	0.419
Septic shock	3(1.0)	0(0.0)	3(3.2)	0.028
Single organ dysfunction	4(1.3)	2(0.9)	2(2.1)	0.768
MODS	1(0.3)	0(0.0)	1(1.1)	0.307
Dead cases（Grade V）	1(0.3)	0(0.0)	1(1.1)	0.307
Surgical Site Infection（SSI	22(7.1)	13(6.1)	9(9.5)	0.284
Surface incisional infection	5(1.6)	2(0.9)	3(3.2)	0.347
Deep space infection	17(5.5)	11(5.1)	6(6.3)	0.676
Respiratory complications	20(6.5)	8(3.7)	12(12.6)	0.003

Cardiovascular complications	7(2.3)	3(1.4)	4(4.2)	0.264
Postoperative stay, days	13.6±0.5	11.6±0.5	14.1±0.7	0.006

Values in parentheses are percentages unless indicated otherwise; the other values are mean±Sd; TPN, total parenteral nutrition; ICU, Intensive Care Unit; MODS, multiple organ dysfunction syndrome; SSI, Surgical Site Infection; Postoperative complications were classified from Grade I to V based on the Clavien-Dindo classification system, with Grade I to II defined as mild complications, Grade III to IV defined as major complications.

Table. 4 Univariate and multivariate analysis of risk factors associated with postoperative complications in patients with gastric cancer undergoing laparoscopic surgery.

Characteristics	Postoperative complications (N=91)	No postoperative complications (N=218)	P value	Multivariate		
				OR	95%CI	P value
Age, year	68.2±1.1	61.4±0.7	<0.001	2.237	1.048-4.774	0.037
Gender						
Male	70 (76.9)	158 (72.5)	0.418			
Female	21(23.1)	60(27.5)	0.418			
BMI, kg/m^2	22.2±0.3	23.0±0.2	0.059			
Comorbidities						
Diabetes mellitus	14 (15.4)	24 (11.0)	0.286			
Hypertension	39 (42.9)	78 (35.8)	0.242			
History of abdomen surgery	20 (22.0)	50 (22.9)	0.855			
Preoperative laboratory measurements						
Hb, g/L	113.6±2.9	128.2±1.4	<0.001	0.521	0.219-1.237	0.139
CRP, mg/L	9.0±1.8	3.5±0.6	<0.001	1.193	0.500-2.849	0.691
WBC, x10^9/L	5.85±0.19	5.88±0.11	0.881			
RBC, x10^{12}/L	3.78±0.08	4.29±0.04	<0.001	0.356	0.180-0.707	0.003
Platelets, x10^9/L	216.0±7.5	217.2±4.5	0.887			
CONUT score	3.7±0.3	1.6±0.1	<0.001	2.433	1.218-4.862	0.012
Albumin, g/L	36.4±0.6	40.1±0.3	<0.001			
Total lymphocytes, x10^9/L	1.33±0.06	1.66±0.05	<0.001			
Cholesterol, mmol/L	4.20±0.13	4.77±0.07	<0.001			
Preoperative tumor biomarkers						

CA125, u/ml	15.5±1.4	12.8±1.0	0.129			
CA199, u/ml	38.7±13.5	23.3±3.2	0.126			
CEA, ng/ml	6.2±1.5	5.6±2.2	0.869			
AFP, μg/L	22.5±19.4	3.3±0.3	0.128			
Types of operative procedure				1.345	0.740-2.444	0.331
Distal gastrectomy	49(53.8)	144(66.1)	0.043			
Total gastrectomy	42(46.2)	74(33.9)	0.043			
Intraoperative fluid utilization, ml	2082±66.6	2195±42.1	0.148			
Operative time, min	272.7±5.3	271.5±3.7	0.853			
Estimated blood loss, ml	124.2±11.8	98.5±9.1	0.110			
T factor						
T1	14 (15.4)	77 (35.3)	<0.001	1.131	0.353-3.622	0.836
T2	8 (8.8)	27 (12.4)	0.364			
T3	16 (17.6)	26 (11.9)	0.186			
T4	53 (58.2)	88 (40.4)	0.004	1.402	0.643-3.058	0.396
N factor						
N0	25(27.5)	93(42.7)	0.012	2.596	0.810-8.317	0.108
N1	14(15.4)	30(13.8)	0.710			
N2	10(11.0)	43(19.7)	0.063			
N3	42(46.2)	52(23.9)	<0.001	1.903	0.936-3.868	0.075
pTNM stage						
I	19(20.9)	83(38.1)	0.003	1.141	0.302-4.311	0.846
II	10(11.0)	41(18.8)	0.092			
III	60(65.9)	88(40.4)	<0.001	2.897	0.986-8.511	0.053
IV	2(2.2)	6(2.8)	0.780			

Postoperative stay, days	20.7±1.4	10.2±0.2	<0.001

Values in parentheses are percentages unless indicated otherwise; the other values are mean±Sd. BMI, body mass index; Hb, Hemoglobin; CRP, C-reactive protein; WBC, White blood cells; RBC, Red blood cells; CONUT, Controlling Nutritional Status.

Figures

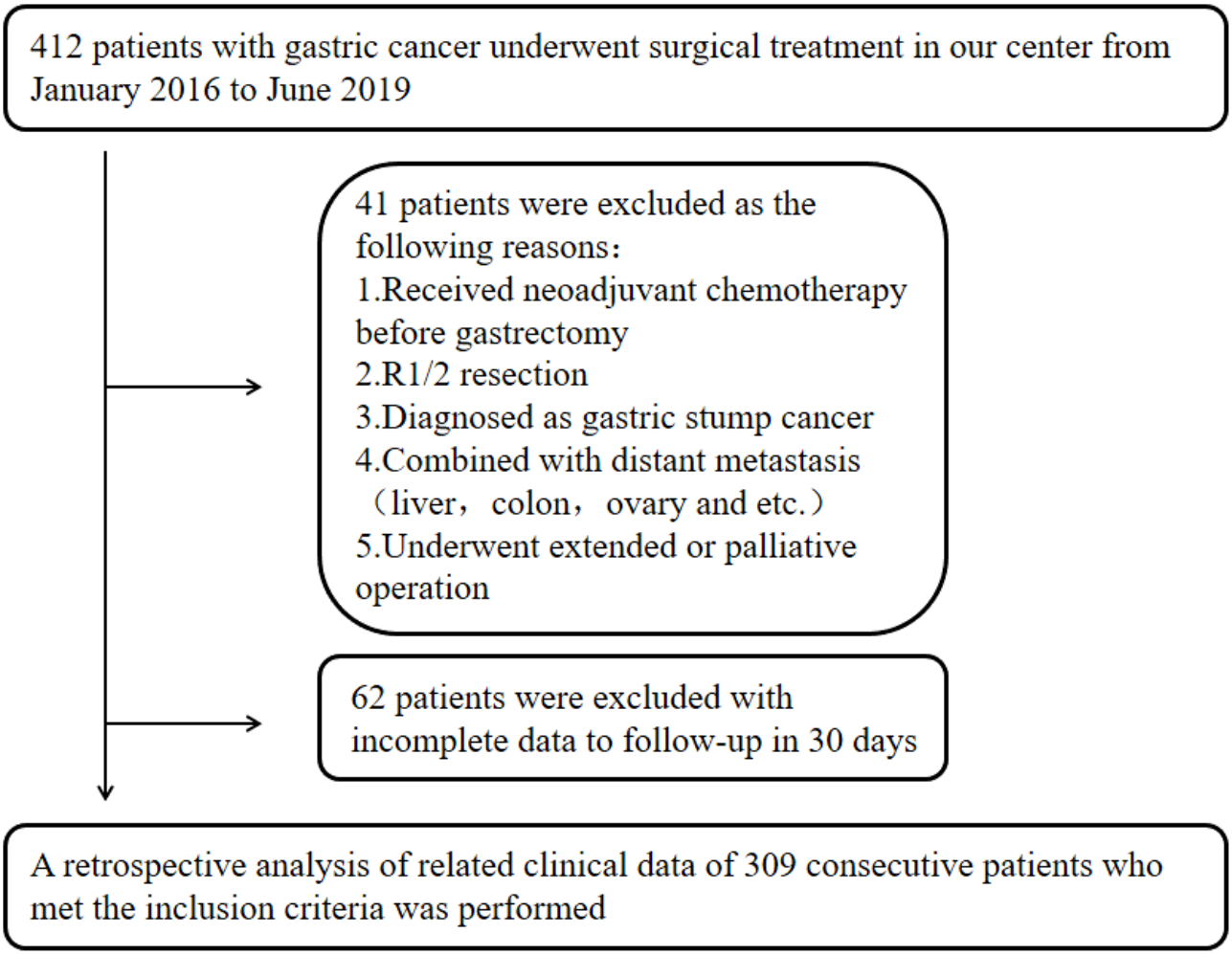
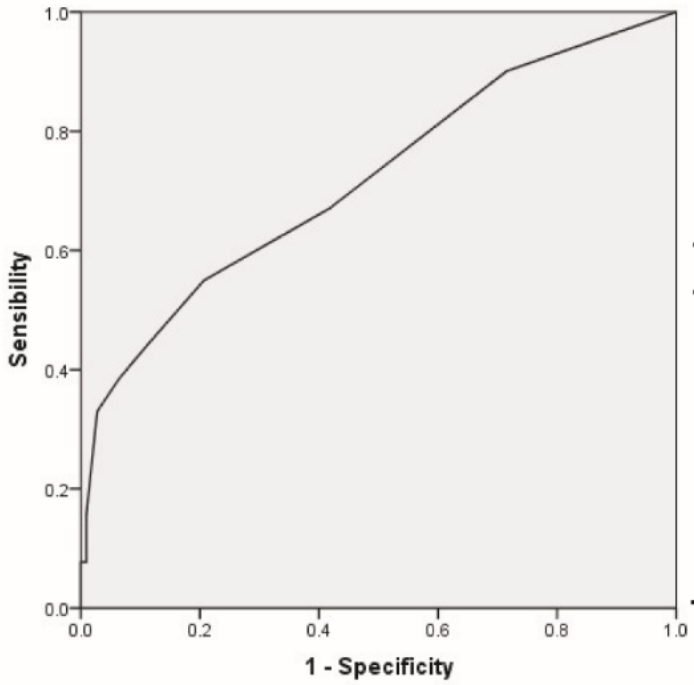


Figure 1

A flow chart of the inclusion process for patients with gastric cancer.



	CONUT score
Cutoff point	2.5
AUC	0.718
Sensitivity	0.549
Specificity	0.794
Positive predictive value	52.3%
Negative predictive value	80.8%
Youden index	0.343

Figure 2

Receiver operating characteristic curve showing the capacity of CONUT score for predicting postoperative overall complications.