# Preoperative Controlling Nutritional Status (CONUT) Score Predicts Short-term Surgical Outcomes 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 useful in gastric cancer (GC) patients. The aim of our study was to assess the predictive ability of the preoperative CONUT score for short-term outcomes in GC patients undergoing laparoscopy-assisted gastrectomy.

**Methods**: We retrospectively reviewed the medical records of 309 patients who underwent curative laparoscopy-assisted gastrectomy. The patients were divided into two groups according to the optimal cut-off value of the CONUT score. The clinical characteristics and postoperative complications were evaluated and analysed in the low- and high-score groups. 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 (area under the curve (AUC)=0.718, Youden index=0.343) compared with other indexes, with an optimal cut-off value of 2.5. Patients with high CONUT scores had a higher incidence of overall complications ($P<0.001$) and mild complications ($P<0.001$). Univariate and multivariate analyses revealed that the CONUT score was independently associated with postoperative complications ($P=0.012$; odds ratio (OR)=2.433; 95% confidence interval (CI): 1.218-4.862).

**Conclusions**: The preoperative CONUT score is a reliable and useful nutritional assessment tool for predicting short-term outcomes in GC patients after laparoscopy-assisted gastrectomy.


# Introduction

Gastric cancer (GC) remains a major public health problem worldwide and is the fifth most common cancer and the third leading cause of cancer-related deaths[1]. Despite recent advances in the diagnosis and treatment of GC, the prognosis of patients remains poor. Adequate surgical resection is the main curative therapeutic option for GC[2, 3], which inevitably comes with some postoperative complications, leading to prolonged hospitalization, greater expenses, impaired quality of life, and delayed adjuvant chemotherapy treatment.

Patients with GC always have to endure unpleasant symptoms, such as early satiety, anorexia and dysphagia, caused by obstruction by the tumour mass and chronic anaemia due to malignant ulcers. These factors result in progressive weight loss, compromised immunity and ultimately malnutrition[4]. Malnutrition is a specific state resulting from the lack 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 outcomes of disease[5]. Malnutrition is quite common and severe among patients with GC, especially advanced GC.

Therefore, multiple nutritional assessment systems have emerged with the aim of identifying applicable parameters or tools, detecting malnutrition, and predicting the outcomes of patients with GC. Oh et al[6] analysed a study of patients with GC and confirmed that various perioperative nutritional parameters, including the Prognostic Nutritional Index (PNI) and albumin (ALB), were independent prognostic factors in GC patients. Sun et al[7] reported that ALB and neutrophils could predict postoperative overall survival (OS) in GC patients. Kim et al[8] observed the predictive ability of the platelet-to-lymphocyte ratio (PLR) for the prognosis of GC. In addition, other nutritional assessment tools have been reported for cancer patients, including the Nutritional Risk Screening (NRS), Skeletal Muscle Index (SMI), Naples Prognostic Score (NPS), modified Glasgow Prognostic Score (mGPS), and Malnutrition Universal Screening Tool (MUST)[9–13].

The Controlling Nutritional Status (CONUT) score was first reported by Ignacio de Ulíbarri J in 2005, as a nutritional tool for the early detection and continuous control of malnutrition[14]. It is calculated based on serum albumin, the total lymphocyte count and cholesterol level. In recent years, several studies have revealed that the CONUT score is a validated and effective nutritional assessment tool for predicting multiple cancer outcomes after surgery, including for colorectal cancer[15], hepatocellular carcinoma[16], oesophageal cancer[17], and GC[9, 18–22]. However, there has been little research on the CONUT score for evaluating postoperative complications in GC patients after radical gastrectomy. Therefore, the primary aim of our study was to assess the predictive ability of the preoperative CONUT score for short-term outcomes in GC patients who underwent laparoscopic radical gastrectomy.

## Patients And Methods

# Study patients

There were 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 the Medical School of Zhejiang University, from January 2016 to June 2019. The inclusion criteria were as follows: (1) confirmed pathological diagnosis of gastric carcinoma by gastroscopic biopsy, (2) underwent curative laparoscopic gastrectomy, and (3) age > 18 y. The exclusion criteria were as follows: (1) received neoadjuvant chemotherapy before gastrectomy, (2)R1/2 resection, (3) diagnosed with gastric stump cancer, (4) combined with distant metastasis (liver, colon, ovary, etc.), (5) underwent extended or palliative surgery, and (6) incomplete data to follow-up at 30 days. Ultimately, 309 patients were enrolled in the retrospective analysis. The detailed flow-chart is shown in Fig. 1. Written informed consent for the usage of clinical records was granted by each patient, as required by the Institutional Review Board at the hospital and in accordance with ethical guidelines of the Declaration of Helsinki in 1964.

# Perioperative management

Routine case history collection, physical examination and preoperative laboratory measurements were performed. Abdominal enhanced computed tomography and endoscopy together with tissue biopsy were carried out for the overall assessment of gastric tumours. Standard surgical laparoscopic gastrectomy with a sufficient resection margin was performed in accordance with Japanese Gastric Cancer Treatment Guidelines 2014 (ver. 4)[3], which involved either total or distal gastrectomy coupled with systematic lymphadenectomy abiding by the D level criteria. The following alimentary tract reconstruction methods were usually employed: Roux-en-Y oesophagojejunostomy was performed after total gastrectomy, whereas Billroth I, Billroth II or Roux-en-Y gastrojejunostomy was selected after distal gastrectomy. For all patients, reasonable perioperative management was in line with the Enhanced Recovery After Surgery (ERAS) programme, including preoperative disease education, shrinking fasting time, the intraoperative use of minimally invasive techniques, and fluid restriction avoided from overload, postoperative early drain removal, off-bed mobilization and oral feeding until discharge[23–25]. Thereafter, patients diagnosed with advanced gastric carcinoma were recommended to receive subsequent adjuvant chemotherapy.

# Data collection

Clinical records of baseline characteristics, laboratory data, imaging scanning examinations and pathological diagnosis were collected from the database. Blood tests were performed within 3 days before surgery. The CONUT score was calculated according to Table 1. The PNI and PLR were calculated using the following formulas: PNI = 10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (per $mm^3$); PLR = platelet count/total lymphocyte count. Short-term outcomes were mainly postoperative complications that occurred within 30 days after surgery or before hospital discharge. Mortality was regarded as any death occurring from the date of operation up to 30 days after operation.

Table 1
Assessment of malnutritional status by the CONUT score.

| **Parameter** | **Malnutritional status** | | | |
|---|---|---|---|---|
| | Normal | Mild | Moderate | Severe |
| ALB (g/dl) | ≥ 3.5 | 3.0 ≤ ALB < 3.5 | 2.5 ≤ ALB < 3.0 | < 2.5 |
| Score | 0 | 2 | 4 | 6 |
| TLC (mg/ml) | ≥ 1600 | 1200 ≤ TLC < 1600 | 800 ≤ ALB < 1200 | < 800 |
| Score | 0 | 1 | 2 | 3 |
| TC (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 |
| ALB, albumin; TLC, total lymphocyte count; TC, total cholesterol. | | | | |

Based on the Clavien-Dindo classification system[26], grades I and II were defined as mild complications, and grades III to IV were defined as major complications. For major complications, severe active haemorrhage after surgery called for emergency treatment. When persistent fever and purulent drainage occurred, internal intra-abdominal abscess was considered. Other intractable major complications included anastomotic leakage, duodenal stump fistula, etc.

Data on cancer staging, including records of the primary and regional nodal extent of the tumour and the absence or presence of metastases, was evaluated based on the Tumour-Node-Metastasis (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

Data was statistically analysed using SPSS 21.0 (IBM Corp, Armonk, NY). Continuous variables are presented as the mean (standard deviation) or median (interquartile range), whereas categorical variables are presented as number (percentage). Student's t test or the Mann-Whitney U test/Kruskal-Wallis H test was utilized for continuous variables depending on the normality of the data distribution. The Pearson $\chi^2$ test or Fisher's exact test was applied for categorical variables, as appropriate. The predictive ability of factors, including the CONUT, PNI, ALB, and PLR, was evaluated by the receiver operating characteristic (ROC) curve. To identify independent risk predictors for postoperative complications, all significant associated factors ($P < 0.05$) in univariate analysis were assessed in multivariate analysis by logistic regression. The indicators of albumin, total lymphocyte count and cholesterol were excluded from multivariate analysis to avoid duplication. All P values < 0.05 were considered statistically significant.

# Results

## ROC curve of the CONUT score, PNI, ALB, and PLR

According to the inclusion and exclusion criteria, 309 patients were enrolled in the study. The ROC curves of the CONUT score, PNI, ALB, and PLR are depicted, and the areas under the curve (AUCs) were 0.718, 0.694, 0.680, and 0.635, respectively. The CONUT score was the most useful predictor. The demarcated values of the CONUT score that correlated with outcomes differed from those in previous studies[9, 15–20]. In our study, the optimal cut-off value for predicting postoperative complications was identified as 2.5. The Youden index of the CONUT score was 0.343, with a sensitivity of 0.549 and specificity of 0.794. The positive predictive value for postoperative complications was 52.3%, and the negative predictive value was 80.8%.

## Study population and baseline characteristics based on the cut-off value of the CONUT score

According to the cut-off value of the CONUT score, patients were subdivided into the low CONUT score group (score < 2.5, n = 214) and the high CONUT score group (score > 2.5, n = 95). The average age was significantly higher in the high CONUT score group than the low score group (62.2 ± 0.7 y vs 66.2 ± 1.2 y, p = 0.003). There was no significant difference in the ratio of males to females in these two groups (155/59 vs 73/22, p = 0.416). The body mass index (BMI) was significantly lower in patients with a CONUT score > 2.5 than in those with a CONUT score < 2.5 (21.9 ± 0.3 $kg/m^2$ vs 23.1 ± 0.2 $kg/m^2$, p < 0.001). The incidence of diabetes mellitus was significantly higher in the high CONUT score group (8.9% vs 20.0%, p = 0.006), but there was no significant difference in hypertension between these two groups (35.5% vs 43.2%, p = 0.201). Many more patients with a CONUT score > 2.5 had previously undergone abdominal surgery (18.7% vs 31.6%, p = 0.013). There were 193 (62.5%) patients who received distal gastrectomy and 116 (37.5%) patients who received total gastrectomy, with no significant difference between the two groups (131/83 vs 62/33, p = 0.498). The detailed clinical characteristics are summarized in Table 2.

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 | - | - | - | 0.416 |
| Male | 228 (73.8) | 155 (72.4) | 73 (76.8) | - |
| Female | 81(26.2) | 59(27.6) | 22(23.2) | - |
| 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 |

| Characteristics | All (N = 309) | CONUT < 2.5 (N = 214) | CONUT > 2.5 (N = 95) | P value |
|---|---|---|---|---|
| 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 | - | - | - | 0.498 |
| Distal gastrectomy | 193(62.5) | 131(61.2) | 62(65.3) | - |
| Total gastrectomy | 116(37.5) | 83(38.8) | 33(34.7) | - |
| 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 |

| Characteristics | All<br><br>(N = 309) | CONUT < 2.5 (N = 214) | CONUT > 2.5 (N = 95) | P value |
|---|---|---|---|---|
| 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. | | | | |

## Comparison of clinical characteristics in the low and high CONUT score groups

Compared to the low CONUT score group, the levels of preoperative haemoglobin (Hb) (132.5 ± 1.3 vs 104.5 ± 2.4, p < 0.001), ALB (40.9 ± 0.3 vs 34.6 ± 0.5, p < 0.001), red blood cells (RBCs) (4.38 ± 0.04 vs 3.60 ± 0.07, p < 0.001), platelets (PLTs) (221.4 ± 4.5 vs 206.5 ± 7.4, p < 0.001), total lymphocytes (1.79 ± 0.04 vs 1.04 ± 0.04, p < 0.001), and cholesterol (5.02 ± 0.07 vs 3.64 ± 0.08, p < 0.001) were lower and the C-reactive protein (CRP) level (3.2 ± 0.6 vs 9.6 ± 1.8, p < 0.001) was higher in the high CONUT score group. Regarding preoperative tumour biomarkers, there were significant differences in CA125 (p = 0.001) and CA199 (p = 0.016) but not in carcinoembryonic antigen (CEA) (p = 0.769) or AFP (p = 0.487)[27, 28]. Patients with low CONUT scores were more likely to have pathological stage I disease (37.4% vs 23.2%, p = 0.014), and patients with high CONUT scores were more likely to have stage III disease. The high CONUT score group suffered from significantly more postoperative complications (19.2% vs 52.6%, p < 0.001) and had a longer postoperative stay (11.6 ± 0.5 d vs 14.1 ± 0.7 d, p = 0.006) than the low CONUT score group. More detailed information is shown in Table 2.

## Postoperative complications in patients with low and high CONUT scores

The incidence of postoperative complications in patients with a CONUT score < 2.5 was significantly lower than that in patients with a CONUT score > 2.5 (19.2% vs 52.6%, p < 0.001) (Table 3). The incidence of mild complications was significantly higher in patients with high CONUT scores than low CONUT scores (7.9% vs 26.3%, p < 0.001). The incidence of major complications was also significantly higher in high CONUT group than low CONUT group (18.7% vs 31.6%, p = 0.013) (Table 3). Only 1 patient died from severe cachexia and multiple organ dysfunction syndrome (MODS) after surgery. With regard to surgical site infection (SSI), there were 5 (1.6%) cases of surface incisional infection and 20 (6.5%) cases of deep space infection. The incidence of SSIs in high CONUT score group was almost significantly higher than in low CONUT score group (6.1% vs 12.6%, p = 0.051).

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°C 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 |

| Postoperative complications | All (N = 309) | CONUT < 2.5 (N = 214) | CONUT > 2.5 (N = 95) | P value |
|---|---|---|---|---|
| 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.

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

In univariate analysis, age ($p < 0.001$); preoperative Hb ($p < 0.001$); CRP ($p < 0.001$); RBCs ($p < 0.001$); CONUT scores ($p < 0.001$); type of operative procedure ($p = 0.043$); pathological TNM classification of T1 ($p < 0.001$), T4 ($p = 0.004$), N0 ($p = 0.012$), N3 ($p < 0.001$); and pathological stage of I ($p = 0.003$) and III ($p < 0.001$) were found to be risk factors. Furthermore, age ($p = 0.037$; odds ratio (OR) = 2.237; 95% confidence interval (CI): 1.048–4.774), preoperative RBCs ($p = 0.003$; OR = 0.356; 95% CI: 0.180–0.707), and CONUT scores ($p = 0.012$; OR = 2.433; 95% CI: 1.218–4.862) were found to be independent risk factors for short-term complications in patients with GC after laparoscopic gastrectomy (Table 4).

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 | | | |

| Characteristics | Postoperative complications (N = 91) | No postoperative complications (N = 218) | P value | Multivariate | | |
|---|---|---|---|---|---|---|
| | | | | OR | 95%CI | P value |
| 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 | | | | | | |

| Characteristics | Postoperative complications (N = 91) | No postoperative complications (N = 218) | P value | Multivariate | | |
|---|---|---|---|---|---|---|
| | | | | OR | 95%CI | P value |
| 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.

# Discussion

A clinical database with a consecutive patient cohort was reviewed to determine whether the preoperative CONUT score effectively predicted postoperative complications for GC patients who underwent laparoscopic gastrectomy. The findings showed that the preoperative CONUT score served as a significant predictor of short-term outcomes for patients with GC.

The prognosis of cancer is not only related to tumour factors but is also associated with patient status, especially nutritional status[29, 30]. The CONUT score was originally proposed by Ignacio de Ulíbarri J in 2005[14] as an integrated scale for assessing the nutritional status of inpatients. The CONUT score is calculated by parameters that are easy to acquire, including serum albumin, the total lymphocyte count and cholesterol level, which reflect protein reserves, immune function and lipid metabolism, respectively. The condition of hypoalbuminemia suggests that the body is in a stage of hypercatabolism, which is prevalent among cancer patients, especially with cachexia. Lymphocytes are important cellular components of the human immune response system that help to fight tumours by inhibiting cancer cell proliferation, invasion and migration[31]. Saka et al[32] reported that the exhaustion of T cells was closely associated with poor prognosis in cancer. Cholesterol plays a vital role in modulating the activity of membrane proteins, which may be associated with the initiation and progression of cancer and interactions with the immune system. Yang et al[33] reported that cholesterol inhibited hepatocellular carcinoma invasion and metastasis by promoting CD44 localization in lipid rafts. Therefore, this assessment scale is able to provide an integrated, rapid and low-cost nutritional evaluation of patients.

Previous studies have proposed diversified prognostic predictors for GC, such as the PNI[6, 19, 34–37], PLR[8, 38, 39], etc. These nutrition score scales are based on routine parameters from blood examinations and are applied to assess the prognosis of cancer patients. In our study, we analysed the assessment capability of these scales for predicting postoperative complications with ROC curves, and the CONUT score showed the best performance. In addition, we identified age and RBC counts as independent risk factors for complications. In other words, old age, anaemia and malnutrition had an adverse effect on short-term outcomes in patients after gastrectomy for GC, which was consistent with prior studies[40, 41].

In previous studies, most researchers focused on the long-term survival associated with the CONUT score among GC patients[9, 18–22], with little focus on postoperative complications. Ryo et al[18] mentioned the incidence of some complications, such as anastmostic leakage and intra-abdominal abscess, in relation to the CONUT score. Huang et al[40] reported that the CONUT score was a significant risk factor for total complications and one-year survival in elderly GC patients. In our study, stratified analysis of postoperative complications was further performed comparing low and high CONUT scores. Sometimes some patients suffered multiple complications. For example, after surgery, one patient suffered a sudden stomach ache and subsequent fever, with abdominal tenderness and rebound tenderness as a result of duodenal stump rupture, rapidly developed grievous intra-abdominal abscess, and had to undergo a second operation with suturing, irrigation and drainage. Our analysis indicated that a higher ratio of patients with a high CONUT score developed postoperative complications. We speculated that patients with hypoalbuminemia, decreased lymphocytes and hypocholesterolaemia were more likely to experience negative conditions with slow tissue repair and delayed wound healing, increasing their susceptibility to infection, prolonging their reliance on parenteral nutrition support, and increasing their probability of abdominal effusion. SSIs are infections of the incision, organ or nearby space that occur after surgery, which can be combined with complex comorbidities and antimicrobial-resistant pathogens, and increase the challenges and expenses of treatment[42]. There was almost significant difference in SSIs between two groups in this study. The respiratory complications after surgery included pneumonia and hydrothorax, which occurred more frequently in the high CONUT score group, as Song Ryo et al reported[18]. We considered that long stays in bed and infrequent cough and sputum may be to blame. In summary, the CONUT score acts as an evaluation strategy for precise risk stratification for postoperative complications, which allows doctors to implement active nutritional interventions for GC patients.

Despite our findings, there were still some limitations of the present study. First, this single-centre study included a homogeneous cohort of patients with a fixed surgical team. Second, a retrospective study cannot rule out selection bias. Finally, follow-up assessments of the CONUT score after surgery were not available, which resulted in a lack of dynamic observations of the nutrition status. Therefore, prospective multi-center studies should be warranted to confirm the predictive significance of the CONUT score for GC patients, to validate the effectiveness of preoperative nutritional interventions and to compare the CONUT score with other commonly used nutritional assessments.

# Conclusion

As a simple and feasible nutrition assessment tool, the CONUT score reliably predicts postoperative complications for patients with GC after laparoscopic gastrectomy, allowing precise risk stratification and preoperative nutritional interventions before surgery.

# Abbreviations

CONUT: Controlling Nutritional Status; GC: Gastric Cancer; AUC: area under the curve; CI: confidence interval; PNI: Prognostic Nutritional Index; ALB: albumin; OS: overall survival; PLR: Platelet-to-Lymphocyte Ratio; NRS: Nutritional Risk Screening; SMI: Skeletal Muscle Index; NPS: Naples Prognostic Score; mGPS: modified Glasgow Prognostic Score; MUST: Malnutrition Universal Screening Tool; ERAS: Enhanced Recovery After Surgery; TNM: Tumour-Node-Metastasis; UICC: Union for International Cancer Control; AJCC: American Joint Committee on Cancer; ROC: receiver operating characteristic; BMI: Body Mass Index; Hb: haemoglobin; RBC: red blood cell; PLT: platelet; CRP: C-reactive protein; CEA: carcinoembryonic antigen; MODS: Multiple Organ Dysfunction Syndrome; SSI: Surgical Site Infection; OR: odds ratio; TPN: Total Parenteral Nutrition.

# 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

Yun Qian and Huaying Liu contributed to study conception and design, Xiaolong Ge, Yun Qian, Junhai Pan, Jiaqi Gao and Huaying Liu contributed to acquisition of data, Weihua Yu, Jiemin Lv and Jiafei Yan contributed to analysis and interpretation of data, Yun Qian, Xiaolong Ge and Huaying Liu contributed to drafting of manuscript, Xiaolong Ge, Wei Zhou and Xianfa Wang 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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# Figures

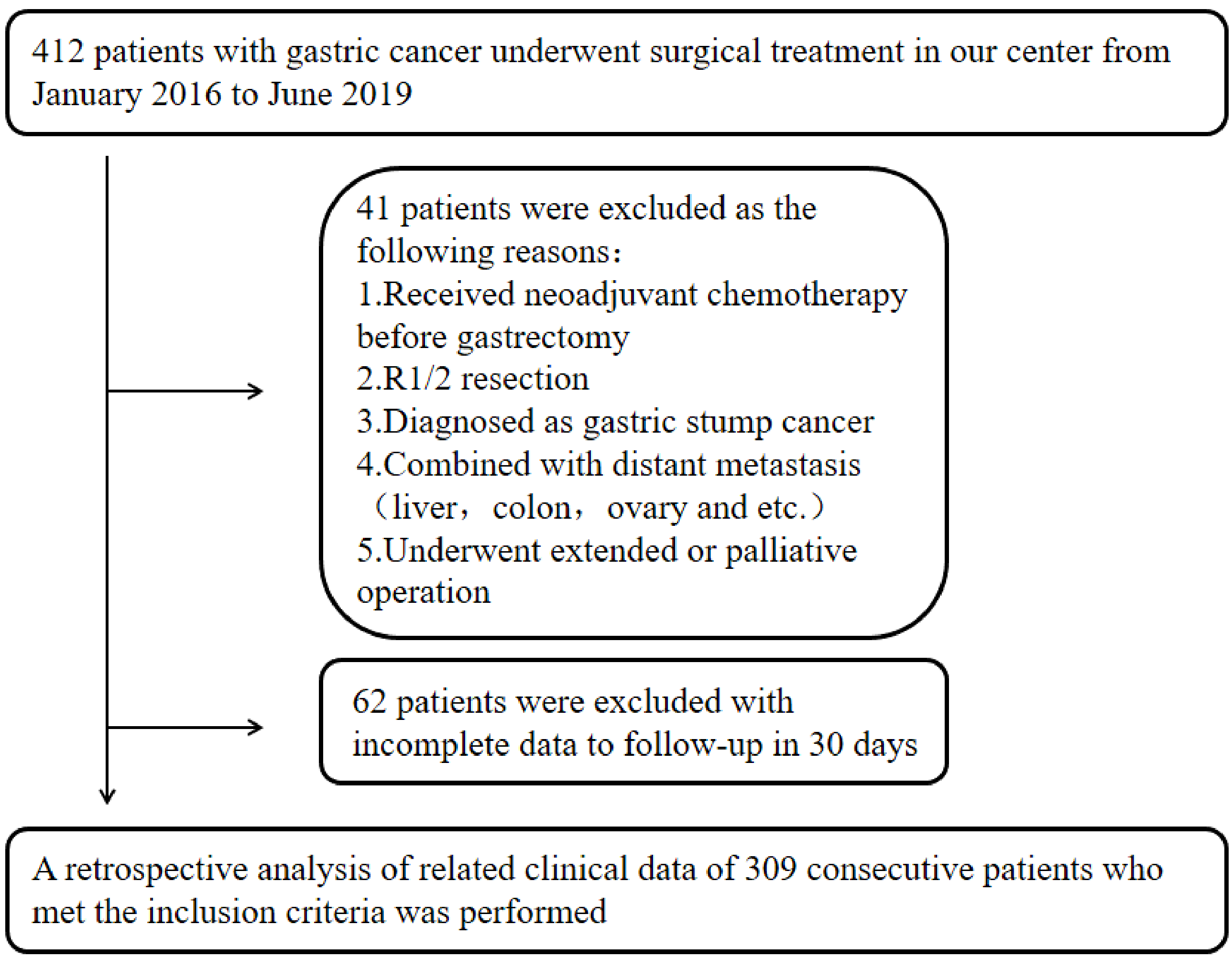
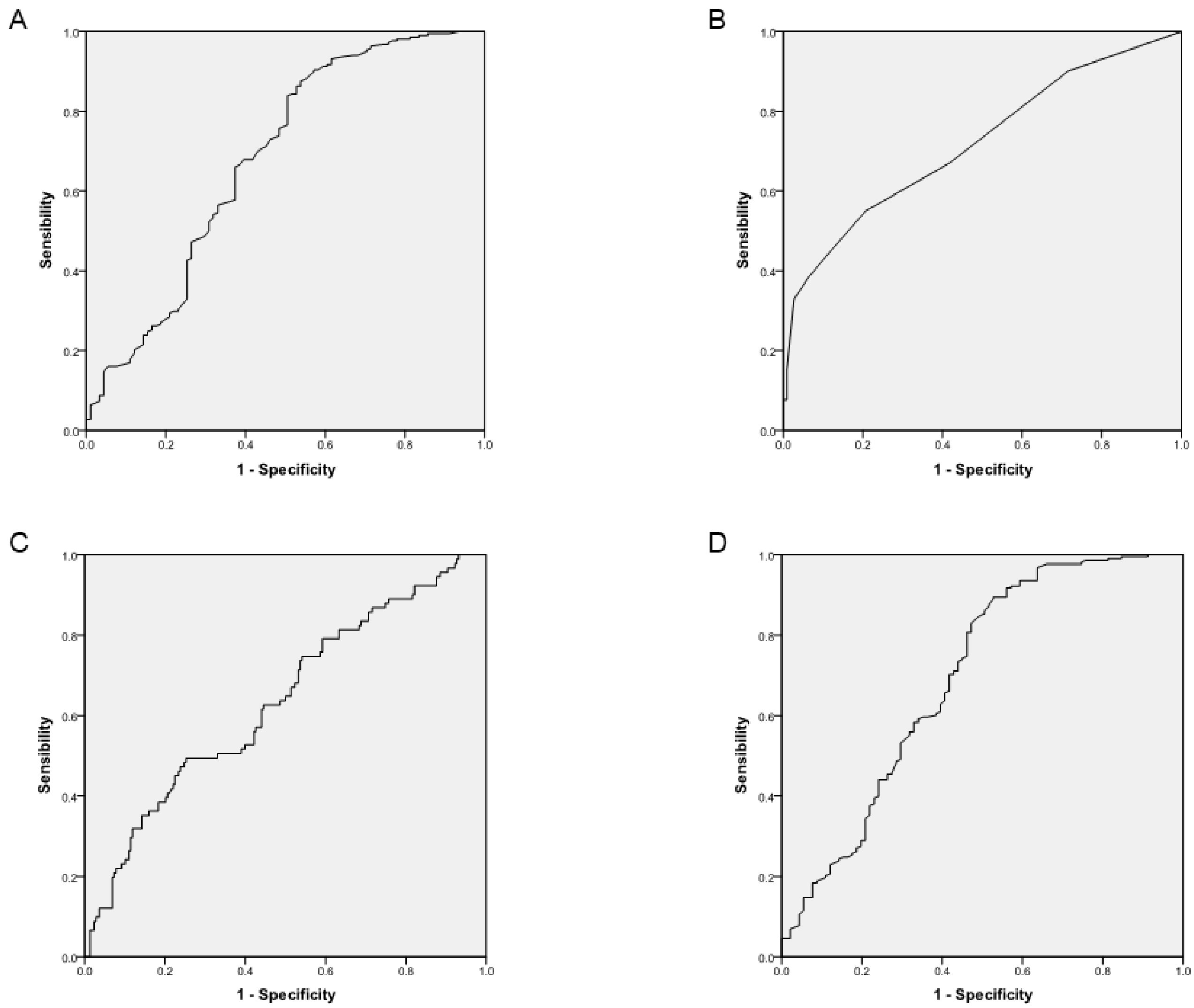



**Figure 1**

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




## Figure 2

Receiver Operating Characteristic curve showing the capacity of ALB (A), CONUT score (B), PLR (C), and PNI (D) for predicting postoperative overall complications.