Preoperative Controlling Nutritional Status (CONUT) Score Predicts Short-Term Outcomes of Patients with Gastric Cancer after Laparoscopy-Assisted Radical Gastrectomy

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Research

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Abstract

Background: As an emerging prediction tool, the Controlling Nutritional Status (CONUT) score has shown good assessment ability of postoperative outcomes in cancer patients. This study assessed the role of the preoperative CONUT score in short-term outcomes of gastric cancer (GC) after laparoscopic gastrectomy.

Methods: Three hundred and nine patients undergoing laparoscopic gastrectomy from January 2016 to June 2019 were analyzed, retrospectively. GC patients were divided into two groups according to the optimal cut-off value of the CONUT. The clinical characteristics and postoperative complications were analyzed and evaluated in two groups. The risk factors of complications were identified by univariate and multivariate analysis.

Results: 309 patients received laparoscopic gastrectomy, and 91 (29.4%) patients suffered from postoperative complications. 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 score suffered a significantly higher incidence of overall complications (P<0.001). Age, haemoglobin level, C-reactive protein level, red blood cell level, CONUT scores, type of operative procedure, pathological TNM classification of T1, T4, N0, and N3, and pathological stage of I and III were associated with postoperative complications (P<0.05). Furthermore, preoperative CONUT score was identified as an independent risk predictor of postoperative complications (P=0.012; OR=2.433; 95% CI: 1.218-4.862) after multivariate analysis.

Conclusions: The preoperative CONUT score is a practical nutritional assessment for predicting short-term outcomes in patients with gastric cancer after laparoscopy-assisted gastrectomy.

Introduction

As one of major public health issues globally, gastric cancer (GC) is the third leading cause of cancer-related deaths\(^1\). Although there is recent progress in the diagnosis and treatment of GC, patient prognosis remains poor. The main curative therapeutic option for GC is surgical resection\(^2,3\), which inevitably comes with some postoperative complications, leading to longer hospitalization, greater expenses, poor quality of life, and delayed adjuvant chemotherapy therapy.

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\(^4\). The condition of malnutrition is quite common and severe among patients with GC, especially those with 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\(^5\) 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 predictors of complications. Sun et al\(^6\) reported that ALB and neutrophils could predict postoperative overall survival (OS) in patients with gastric cancer. Kim et al\(^7\) observed that the platelet-to-lymphocyte ratio (PLR) could predict 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), and so on\(^8\)–\(^12\).

The Controlling Nutritional Status (CONUT) score was initially reported as a useful assessment for the early detection and persistent monitoring of malnutrition in 2005\(^13\). The score consists serum ALB, the total lymphocyte count and cholesterol levels. In recent years, several studies have showed that the CONUT score is a validated and useful assessment of nutritional status for predicting multiple cancer outcomes after surgery, including for colorectal cancer\(^14\), hepatocellular carcinoma\(^15\), oesophageal cancer\(^16\), and GC\(^8\),\(^17\)–\(^21\). However, there has been little research on the CONUT score to predict postoperative outcomes in GC patients after radical gastrectomy. Therefore, this study aimed 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**

Consecutive clinical records of 412 patients undergoing laparoscopic gastrectomy from January 2016 to June 2019 were initially examined in this study. The inclusion criteria included: (1) gastric carcinoma was confirmed by pathological diagnosis from 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. Finally, 309 patients were enrolled in the retrospective analysis. The detailed flow-chart is shown in Fig. 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**

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 tumors. Standard surgical laparoscopic gastrectomy
with a sufficient resection margin was performed according to the guidelines, 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, which included preoperative disease education, shrinking fasting time, the intraoperative use of minimally invasive techniques, fluid restriction avoided from overload, postoperative early drain removal, off-bed mobilization and oral feeding until discharge. 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. The CONUT score was assessed according to Table 1. The PNI = 10 × serum ALB (g/dL) + 0.005 × total lymphocyte count (per mm³), and PLR = platelet count/total lymphocyte count. Short-term outcomes were mainly postoperative complications that occurred within 30 days after laparoscopic surgery or before hospital discharge.

| 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.

According to the Clavien-Dindo classification system, mild complications included grades I and II and major complications included grades III to IV as previously described. 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. Other postoperative events included respiratory complications, cardiovascular complications and surgical site infections (SSIs). Data on cancer staging was evaluated based on the Tumour-Node-Metastasis (TNM) Classification of Malignant Tumours.

### Statistical analysis

Data were statistically analysed using SPSS 23.0. Quantitative variables were presented as the mean ± SD. Qualitative variables were presented as numbers (percentage). Student’s t test or Mann-Whitney U test was utilized for quantitative data. Pearson χ² test was applied for qualitative data. The receiver operating characteristic (ROC) was performed to analyze the predictive ability of factors, including the CONUT score, PNI, ALB, and PLR. To identify independent risk predictors for postoperative complications, factors with p value less than 0.05 in univariate analysis were assessed in the multivariate analysis. The indicators of serum ALB, total lymphocyte count and cholesterol were excluded from the multivariate analysis to avoid duplication. Significance was defined as P values less than 0.05.

### Results

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

Depend on the criteria of inclusion and exclusion in this study, 309 patients were enrolled finally. The ROC curves of the CONUT score, PNI, ALB, and PLR are depicted, and the areas under the curve (AUC) 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. In our study, the cut-off value in prediction of 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 CONUT score cut-off value

According to the cut-off value of CONUT score, 214 patients with score less than 2.5 were in the low CONUT score group and 95 patients with score more than 2.5 were in the high CONUT score group. The average age of patients in the low CONUT score group was much lower than those in the high score group (62.2 ± 0.7 y vs 66.2 ± 1.2 y, P = 0.003). Comparison in the ratio of males to females in these two groups was no significant difference (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/m² vs 23.1 ± 0.2 kg/m², P < 0.001). The rate of diabetes mellitus was significantly higher in the high CONUT score group (8.9% vs 20.0%, P = 0.006), however, no significant difference was found in hypertension (35.5% vs 43.2%, P = 0.201). The high CONUT score group experienced much more previous 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 was found in patient with high and low score (131/83 vs 62/33, P = 0.498).

**Comparison of clinical characteristics between patients with a low and high CONUT score**

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 carbohydrate antigen 125 (CA125) (P = 0.001) and carbohydrate antigen 199 (CA199) (P = 0.016) but not in carcinoembryonic antigen (CEA) (P = 0.769) or alpha fetoprotein (AFP) (P = 0.487). Patients with low CONUT scores were more likely to have pathological stage I disease (37.4% vs 23.2%, P = 0.014), while 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 details are shown 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

| Characteristics                  | All (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.

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

The rate of postoperative complications in patients with a CONUT score < 2.5 was significantly lower than in patients with a CONUT score > 2.5 (19.2% vs 52.6%, P < 0.001) (Table 3). The rate of mild complications, including sustained fever with a temperature over 38.5 °C, incision infection, persistent utilization of total parenteral nutrition exceeding 2 weeks, postoperative blood transfusion, gastroplegia, abdominal or pelvic effusion, early postoperative bowel obstruction, and urinary tract infection, was significantly higher in the high CONUT score group (8.4% vs 34.7%, P < 0.001). A total of 40 patients suffered major complications, including postoperative active haemorrhage, intra-abdominal abscess, anastomotic leakage, duodenal stump fistula, septic shock, and single organ dysfunction, though there was not a significant difference between the two groups (11.2% vs 16.8%, P = 0.174) (Table 3). Only 1 patient died from severe cachexia and multiple organ dysfunction syndrome (MODS) after surgery. With regard to SSIs, there were 5 (1.6%) cases of surface incisional infection and 17 (5.5%) cases of deep space infection, with no significant difference between the two groups (0.9% vs 3.2%, P = 0.347; 5.1% vs 6.3%, P = 0.676).
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)           | 42(13.6)       | 17(7.9)                 | 25(26.3)              | < 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   |
| 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 IV)        | 70(22.7)       | 40(18.7)                | 30(31.6)              | 0.013   |
| Postoperative active hemorrhage              | 16(5.2)        | 10(4.7)                 | 6(6.3)                | 0.548   |
| Abdominal/Pelvic effusion                    | 7(2.3)         | 3(1.4)                  | 4(4.2)                | 0.264   |
| 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   |
| 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                 | 25(8.1)        | 13(6.1)                 | 12(12.6)              | 0.051   |
| Surface incisional infection                 | 5(1.6)         | 2(0.9)                  | 3(3.2)                | 0.347   |
| Deep space infection                         | 20(6.5)        | 11(5.1)                 | 9(9.5)                | 0.153   |
| 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 complications | All (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   |

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 of short-term outcomes in GC

In the univariate analysis, age, Hb, CRP, RBCs, CONUT scores, type of operative procedure, pathological TNM classification of T1, T4, N0, and N3, and pathological stage of I and III were found to be risk factors with p value less than 0.05. Furthermore, age (P = 0.037; odds ratio (OR) = 2.237; 95% confidence interval (CI): 1.048–4.774), 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 identified as independent risk indicators for postoperative complications in gastric cancer 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/m²                             | 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

| 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 analyzed to explain whether the preoperative CONUT score could effectively predict postoperative complications for GC patients after laparoscopic gastrectomy. This study found that the preoperative CONUT score could be an independent risk factor in predicting postoperative complications in gastric cancer after surgery.

The prognosis of cancer is not only associated with tumor factors but also is associated with patient status, especially nutritional status\(^{28,29}\). The CONUT score was originally proposed as an integrated scale for assessing the nutritional status of inpatients by Ignacio de Ulibarri J in 2005\(^{13}\). The CONUT score can 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 those 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\(^{30}\). Saka et al\(^{31}\) 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 occurrence and development of cancer and interactions with the body immune system. Yang et al\(^{32}\) 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\(^5,18,33–36\), PLR\(^7,37,38\), etc. These nutritional 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 count 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\textsuperscript{39,40}.

In previous studies, most researchers focused on the long-term survival associated with the CONUT score among GC patients\textsuperscript{8,17–21}, with little focus on postoperative complications. Ryo et al\textsuperscript{17} mentioned the incidence of some complications, such as anastomotic leakage and intra-abdominal abscess, as related to the CONUT score. Huang et al\textsuperscript{39} 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 to compare low and high CONUT scores. Sometimes 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, especially mild 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. However, there was no significant difference between the two groups in terms of major complications despite the trend of higher incidence in the high CONUT score group. A larger number of patients is needed for further validation. 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\textsuperscript{27}. There was no significant difference in SSIs located at the surface incision or deep space. The respiratory complications after surgery included pneumonia and hydrothorax, which occurred more frequently in the high CONUT score group, as reported by Song Ryo et al\textsuperscript{17}. 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 of 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 multicentre studies are warranted to confirm the predictive significance of the CONUT score for GC patients compared with other commonly used nutritional assessments and to validate the effectiveness of preoperative nutritional interventions.

**Conclusion**
As a simple and feasible nutritional 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; PNI: Prognostic Nutritional Index; ALB: albumin; PLR: Platelet-to-Lymphocyte Ratio; NRS: Nutritional Risk Screening; Hb: haemoglobin; 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 for publication**

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.

**Availability of data and materials**

All the data can be obtained from the author by email (gxlmed@zju.edu.cn).

**Competing interests**

No other conflict of interests.

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**Author’s contributions**

Y.Q. and H.Y.L. contributed to the manuscript writing. X.L.G., Y.Q., J.H.P., J.Q.G. and H.Y.L. contributed to date collection. W.H.Y., J.M.L. and J.F.Y. contributed to analysis of data. Y.Q. and H.Y.L. were involved in manuscript editing. X.L.G., W.Z. and X.F.W. contributed to the trial design and critical revision.

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