Heliyon 10 (2024) e27202

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

# Study on the correlation between controlling nutritional status score and clinical biochemical indicators in patients with colorectal cancer

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ARTICLE INFO

*Keywords:*
CONUT score
Immunotrophic status
Colorectal cancer
Prognosis

ABSTRACT

*Purpose:* The controlling nutritional status (CONUT) score is an important tool for predicting the prognosis of colorectal cancer (CRC); however, its effectiveness is relatively insufficient. This study aimed to screen for more effective clinical indicators as supplements to the CONUT scoring system and improve the predictive value of CRC prognosis.

*Patients and methods:* Between 2014 and 2020, the clinical information of all CRC patients in our unit was retrospectively collected, and the CONUT scores were calculated based on the levels of serum albumin (ALB), lymphocytes (LC), and total cholesterol. The included patients were divided into the following three groups: normal nutrition (0–1), mild malnutrition (2–4), and moderate-to-severe malnutrition (5–12). The correlations between the CONUT score and baseline characteristics and clinical indicators were evaluated.

*Results:* This study ultimately included 5014 CRC patients. The nutritional status of patients with colon cancer (CC) was worse than that of rectal cancer (RC). The nutritional status was worse in men than in women. The older the patient, the poorer the nutritional status, and the poorer the nutritional status, the longer the hospital stay. In addition, poor nutritional status in patients is indicated by higher values of neutrophils (NE), monocytes (MC), eosinophils (EOS), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), carcinoembryogenic antigen (CEA), and lower values of white blood cells (WBC), basophils (BAS), haemoglobin (HB), total protein (TP), triglycerides (TG), low density lipoprotein (LDL), aspartate transaminase (AST), and blood urea nitrogen (BUN), which was statistically significant ($P < 0.05$). Indicators that significantly correlated with the CONUT score reflected the immune nutritional status, including WBC (odds ratio [OR] = 0.036, $P < 0.001$), NE (OR = 30.815, $P < 0.001$), MC (OR = 41.388, $P < 0.001$), EOS (OR = 27.577, $P < 0.001$), BAS (OR = 0.006, $P = 0.046$), and LDL (OR = 0.319, $P < 0.001$).

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https://doi.org/10.1016/j.heliyon.2024.e27202
Received 27 November 2023; Received in revised form 24 February 2024; Accepted 26 February 2024
Available online 5 March 2024

*Conclusion:* Additional variables such as WBC, NE, MC, EOS, BAS, and LDL may be used as supplementary indicators in the CONUT scoring system to more effectively predict the clinical prognosis of CRC patients.

## 1. Introduction

Colorectal cancer (CRC) is the third most commonly diagnosed cancer (10.0% of total diagnosed cases), and the second leading cause of cancer-related death worldwide (9.4% of the total cancer deaths) in both sexes [1]. Although advancements in clinical diagnosis and treatment modalities have effectively improved the five-year survival rate of CRC patients, the case fatality rate is increasing annually [2]. Tumour recurrence and metastasis is commonly implicated in mortality of CRC patients, and effective targets for evaluating the prognosis of CRC patients is currently lacking [3,4]. Therefore, more effective biological targets for survival and prognosis of CRC patients, early intervention, enhanced treatment, and strict follow-up is imperative to improve their prognosis.

The nutritional level and inflammatory status of cancer patients are two important indicators for predicting their survival outcomes, and the prognostic nutrition index (PNI) and the controlling nutritional status (CONUT) are the common evaluation criteria that comprehensively reflect these two indicators [5–7]. The PNI, derived from serum albumin (ALB) levels and lymphocyte (LC) counts, was first established by Onodera et al. This index was originally used to assess the nutritional and immune status of patients undergoing gastrointestinal surgery, predict surgical risk, and determine prognosis. In recent years, the PNI has evolved as a new indicator for evaluating tumour prognosis [8,9]. The serum total cholesterol (TC) level was additionally included in the CONUT, which better reflects the nutritional and immune status of patients. Therefore, the CONUT score can be used as an independent prognostic factor before or after surgery for various malignant tumours, including CRC and breast cancer [7,10].

The CONUT score was calculated based on serum ALB, LC count, and TC levels. Because of the ease of operation and inclusion of valid data, the CONUT tool plays a critical role in the prognosis of CRC [11–13]. The higher the CONUT score, the poorer the nutritional status, treatment response, and survival prognosis of patients [14,15]. However, the specificity and sensitivity of the CONUT score in the prognosis analysis of CRC patients are still insufficient, and inconsistency in results were observed. Therefore, we screened the clinical information of all CRC patients in our unit between 2014 and 2020, and investigated the correlation between CONUT scores, baseline characteristics, and other clinical biochemical indicators of CRC; and attempted to incorporate more effective nutritional and immune indicators to improve the predictive value of prognosis in CRC patients.

## 2. Patients and methods

### 2.1. Study population and data collection

We retrospectively collected the baseline data and clinical biochemical indicators of all hospitalised CRC patients at Nanjing First Hospital between January 2014 and December 2020. The baseline data included sex, age, length of hospital stay, and pathological diagnoses. Biochemical indicators include ALB level, LC count and TC level, in addition to white blood cell (WBC) count, red blood cell (RBC) count, neutrophil (NE) count, hemoglobin (HB) level, platelet (PLT) count, monocyte (MC) count, eosinophil (EOS) count, basophil (BAS) count, alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP), γ-glutamic transferase (GGT), lactate dehydrogenase (LDH), total protein (TP), triglycerides (TG), low-density lipoprotein (LDL), total bilirubin (TBIL), indirect bilirubin (IBIL), direct bilirubin (DBIL), total bile acid (TBA), creatine kinase (CK), blood urea nitrogen (BUN), serum creatinine (SCR), uric acid (UA), carcinoembryonic antigen (CEA), thioredox protease (TR), and $CD4^+/CD8^+$ T cell ratio. All patients included in this study were aged > 18 years with histologically confirmed CRC. Patients with other histological types and missing data, such as ALB, LC, or TC, were excluded. Informed consent was obtained from all the patients, and the study was approved by the Ethics Committee of Nanjing First Hospital (KY20230424-02-KS-01).

**Table 1**
CONUT scoring criteria.

| Parameters | Normal | Light | Moderate | Severe |
|---|---|---|---|---|
| ALB (g/1) | ≥35 | 30–34.9 | 25–29.9 | <25 |
| Score | 0 | 2 | 4 | 6 |
| LC (count/1) | ≥1.6 | 1.2–1.59 | 0.8–1.19 | <0.8 |
| Score | 0 | 1 | 2 | 3 |
| TC (mmol/1) | ≥4.65 | 3.62–4.64 | 2.59–3.61 | <2.59 |
| Score | 0 | 1 | 2 | 3 |
| CONUT score | 0–1 | 2–4 | | 5–12 |
| Assessment | Low | Intermediate | | High |

CONUT, controlling nutritional status; ALB, albumin; LC, lymphocyte; TC, total cholesterol.

### 2.2. CONUT scoring

Fasting blood samples were obtained from all study participants on the second day after admission, and all necessary biochemical investigation were performed. The CONUT score for each patient was calculated based on the values of the ALB, LC, and TC indicators (Table 1). The CONUT score reflects the patient's immune and nutritional status. Based on the CONUT scores, all patients were divided into the following three groups: normal nutrition (0–1, low score), mild malnutrition (2–4, intermediate score), and moderate to severe malnutrition (5–12, high score). Finally, a comparative analysis was conducted on the baseline data and clinical biochemical indicators of the three patient groups.

### 2.3. Statistical analyses

All statistical analyses were performed using the SPSS 26.0 software (IBM SPSS Inc., Chicago, IL, USA). The measurement data are represented as mean ± standard deviation, and the counting data are represented as case numbers and constituent ratios. In the univariate analysis, the F-test was used to compare the means, and the chi-square test was used to compare the constituent ratios to study the correlation between the CONUT score and patients' baseline characteristics and clinical biochemical indicators. To further explore the relationship between nutritional status and clinical-related indicators in CRC patients, multivariate analysis was performed using an ordered logistic regression analysis with the CONUT score as the dependent variable and meaningful indicators from the analysis of variance or chi-square test as the independent variables. A $P$-value $<$ than 0.05 indicated statistical significance.

## 3. Results

### 3.1. Relationship between CONUT score and clinical factors

Based on the inclusion and exclusion criteria, this study ultimately included 5014 CRC patients (3199 men [63.80%] and 1815 women [36.20%]), including 1841 and 3173 patients with colon cancer (CC) (36.72%) and rectal cancer (RC) (63.28%), respectively (detailed information can be found in the Supplementary Material). According to the CONUT score, 1555 patients (31.01%) had a normal nutritional status (CONUT-low group), 2378 patients (47.43%) had mild malnutrition (CONUT-intermediate group), and 1081 patients (21.56%) had moderate to severe malnutrition (CONUT-high group). The statistical results indicate that the proportion of malnutrition in CC patients is significantly higher than that in RC patients ($\chi^2 = 15.53$, $P < 0.01$). The proportion of malnutrition is significantly higher in men than in women ($\chi^2 = 8.40$, $P = 0.02$). In addition, the average age of all participants was 64.64 years; higher the age, the poorer the nutritional status (F = 127.27, $P < 0.01$). The average length of hospital stay was 10.19 days; the more severe the degree of malnutrition, the longer the length of hospital stay (F = 103.66, $P < 0.01$). Table 2 presents the results of the study.

### 3.2. Correlation between CONUT score and clinical biochemical indicators

Clinical biochemical indicators of all CRC patients, including immune, inflammatory, and nutrition-related indicators; liver, kidney, and heart organ function indicators; and tumour indicators were collected. Nutritional status was grouped according to the CONUT score, and changes in clinical indicators were analysed among the three groups. The univariate analysis results showed that in addition to $CD4^+/CD8^+$ T cell ratio (F = 1.46, $P = 0.23$), ALT (F = 0.83, $P = 0.41$), CK (F = 0.90, $P = 0.41$), and TR (F = 0.44, $P = 0.55$), other immune nutrition related indicators (Table 3) which included WBC, NE, MC, PLT, EOS, BAS, RBC, HB, TP, TG, LDL, and other liver function indicators (including AST, GGT, ALP, TBIL, DBIL, IBIL, and TBA), kidney function indicators (including BUN, SCR, and UA), cardiac function indicators (LDH), and tumour indicators (CEA) showed significant differences among the three groups of CONUT (Table 4). This indicates that the CONUT score of CRC patients is closely related to various other clinical indicators that collectively determine their nutritional status.

### 3.3. Correlation analysis of influencing factors on CONUT score in CRC patients

An ordered logistic regression analysis was conducted using the CONUT score of CRC patients as the dependent variable (low = 0, intermediate = 1, high = 2) and clinical parameters with statistical differences in the univariate analysis as the independent variable.

**Table 2**
Comparison of clinical baseline data of CRC patients grouped according to CONUT score.

| CONUT score | low (n = 1555) | intermediate (n = 2378) | high (n = 1081) | χ [2]/F | *P* |
|---|---|---|---|---|---|
| CC n(%) | 544 (29.55%) | 845 (45.90%) | 452 (24.55%) | 15.53 | <0.01 |
| RC n(%) | 1011 (31.86%) | 1533 (48.31%) | 629 (19.82%) | | |
| Male n(%) | 951 (29.73%) | 1529 (47.80%) | 719 (22.48%) | 8.40 | 0.02 |
| Female n(%) | 604 (33.28%) | 849 (46.78%) | 362 (19.94%) | | |
| Age (M±SD, year) | 62.26 ± 11.04 | 64.09 ± 11.59 | 69.3 ± 11.29 | 127.27 | <0.01 |
| Hospitalization days (M±SD, day) | 8.75 ± 6.81 | 9.65 ± 7.92 | 13.43 ± 11.75 | 103.66 | <0.01 |

Low, Low CONUT score (0–1) group; Intermediate, intermediate CONUT score (2–4) group; High, high CONUT score (5–12) group; CRC, colorectal cancer; CC, colon cancer; RC, rectal cancer. *$P < 0.05$, statistically significant.

**Table 3**
The relationship between CONUT score and immune nutritional indicators.

| CONUT score | low (n = 1555) | intermediate (n = 2378) | high (n = 1081) | F | *P* |
|---|---|---|---|---|---|
| WBC (10^9/L) | 5.92 ± 2.03 | 5.33 ± 2.67 | 6.51 ± 4.66 | 57.96 | <0.01 |
| NE (10^9/L) | 3.42 ± 1.82 | 3.54 ± 2.44 | 5.01 ± 4.38 | 123.10 | <0.01 |
| MC (10^9/L) | 0.42 ± 0.19 | 0.41 ± 0.22 | 0.45 ± 0.29 | 8.67 | <0.01 |
| PLT (10^9/L) | 197.63 ± 70.24 | 180.45 ± 72.81 | 193.23 ± 104.91 | 24.00 | <0.01 |
| BAS (10^9/L) | 0.03 ± 0.02 | 0.02 ± 0.02 | 0.02 ± 0.02 | 57.06 | <0.01 |
| EOS (10^9/L) | 0.15 ± 0.14 | 0.13 ± 0.13 | 0.11 ± 0.13 | 36.41 | <0.01 |
| $CD4^+/CD8^+$ T cell | 3.45 ± 2.83 | 3.76 ± 3.31 | 4.01 ± 2.94 | 1.46 | 0.23 |
| RBC (10^12/L) | 4.28 ± 0.50 | 3.95 ± 0.57 | 3.45 ± 0.64 | 662.17 | <0.01 |
| HB (g/L) | 129.36 ± 16.82 | 117.70 ± 18.81 | 98.18 ± 20.68 | 893.84 | <0.01 |
| TP (g/L) | 69.41 ± 6.28 | 66.18 ± 6.67 | 58.59 ± 8.12 | 803.71 | <0.01 |
| TG (mmol/L) | 1.84 ± 1.56 | 1.56 ± 1.14 | 1.21 ± 0.65 | 88.56 | <0.01 |
| LDL (mmol/L) | 3.05 ± 0.80 | 2.58 ± 0.95 | 2.13 ± 1.21 | 293.07 | <0.01 |

WBC, white blood cell; NE, neutrophil; MC, monocyte; PLT, platelet; BAS, basophil; EOS, eosinophil; RBC, red blood cell; HB, hemoglobin; TP, total protein; TG, triglycerides; LDL, low-density lipoprotein. *$P < 0.05$, statistically significant.

**Table 4**
Comparison of liver, kidney, heart function indicators and tumor indicators in CONUT grouping.

| CONUT score | low (n = 1555) | intermediate (n = 2378) | high (n = 1081) | F | *P* |
|---|---|---|---|---|---|
| AST (U/L) | 25.57 ± 14.64 | 26.27 ± 19.64 | 33.97 ± 109.55 | 9.07 | <0.01 |
| ALT (U/L) | 24.54 ± 22.00 | 22.69 ± 21.43 | 23.97 ± 82.87 | 0.83 | 0.41 |
| GGT (U/L) | 43.80 ± 51.63 | 57.56 ± 99.03 | 79.04 ± 145.11 | 39.56 | <0.01 |
| ALP (U/L) | 85.96 ± 43.68 | 97.81 ± 69.33 | 132.15 ± 169.06 | 78.83 | <0.01 |
| TBIL (umol/L) | 11.93 ± 6.25 | 12.40 ± 16.55 | 18.80 ± 50.25 | 26.93 | <0.01 |
| DBIL (umol/L) | 3.22 ± 1.79 | 4.26 ± 11.28 | 9.95 ± 35.31 | 49.32 | <0.01 |
| IBIL (umol/L) | 8.67 ± 4.78 | 8.11 ± 6.15 | 8.86 ± 15.69 | 3.34 | 0.03 |
| TBA (umol/L) | 7.11 ± 7.70 | 7.55 ± 11.08 | 10.51 ± 25.14 | 19.93 | <0.01 |
| BUN (mmol/L) | 5.54 ± 2.59 | 5.61 ± 2.84 | 7.05 ± 5.85 | 67.81 | <0.01 |
| SCR (umol/L) | 70.29 ± 34.28 | 72.43 ± 55.81 | 86.38 ± 91.22 | 24.96 | <0.01 |
| UA (umol/L) | 311.41 ± 89.49 | 306.25 ± 100.27 | 286.58 ± 128.15 | 19.10 | <0.01 |
| CK (U/L) | 77.91 ± 68.72 | 73.26 ± 87.13 | 76.62 ± 176.29 | 0.90 | 0.41 |
| LDH (U/L) | 223.72 ± 123.95 | 263.09 ± 309.38 | 344.17 ± 464.99 | 46.35 | <0.01 |
| CEA ( ng/ml ) | 37.28 ± 152.58 | 120.89 ± 599.33 | 247.76 ± 1161.47 | 26.44 | <0.01 |
| TR (U/ml) | 7.97 ± 2.51 | 8.03 ± 2.61 | 7.82 ± 2.81 | 0.44 | 0.55 |

AST, aspartate transaminase; ALT, alanine transaminase; GGT, γ-glutamic transferase; ALP, alkaline phosphatase; TBIL, total bilirubin; DBIL, direct bilirubin; IBIL, indirect bilirubin; TBA, total bile acid; BUN, blood urea nitrogen; SCR, serum creatinine; UA, uric acid; CK, creatine kinase; LDH, lactate dehydrogenase; CEA, carcinoembryonic antigen; TR, thioredox protease. *$P < 0.05$, statistically significant.

The independent variables included CRC category (CC = 0, RC = 1), sex (male = 0, female = 1), age, number of hospitalization days, and biochemical indicators (WBC, NE, MC, PLT, EOS, BAS, RBC, HB, TP, TG, LDL, AST, GGT, ALP, TBIL, DBIL, IBIL, TBA, BUN, SCR, UA, LDH, and CEA). Multivariate analysis showed that patient age, length of hospital stay, and some biochemical indicators (NE, MC, EOS, ALP, LDH, and CEA) were positively correlated with the CONUT score. Categories of CRC, sex, and biochemical indicators (WBC, BAS, HB, TP, TG, LDL, AST, and BUN) were negatively correlated with the CONUT score. Other indicators, including PLT, RBC, GGT, TBIL, DBIL, IBIL, TBA, SCR, and UA, were not correlated with the CONUT score (Table 5). An odds ratio [OR] value > 10 or < 0.5 was used as the cutoff value to determine a significant correlation indicator. The results showed that the indicators NE (OR = 30.815, $P < 0.001$), MC (OR = 41.388, $P < 0.001$), and EOS (OR = 27.577, $P < 0.001$) showed a significant positive correlation, whereas WBC (OR = 0.036, $P < 0.001$), BAS (OR = 0.006, $P = 0.046$), and LDL (OR = 0.319, $P < 0.001$) demonstrated a significant negative correlation (Table 5).

## 4. Discussion

The CONUT scoring system is based on the basic biochemical indicators (ALB, LC, and TC levels), which are not affected by subjective factors and can quickly and objectively reflect the patient's nutritional and immune status [16]. The CONUT score is used to evaluate the clinical prognosis of various disease states, including postoperative complications, heart failure, liver transplantation, and malignant tumours [7,17–19]. The occurrence and prognosis of CRC are closely related to the body's immune and nutritional status [20]. The CONUT scoring tool has gained recent attention for assessing immune nutritional status in the analysis of the survival prognosis of CRC patients. The higher the CONUT score, the poorer the treatment effect and clinical prognosis of CRC patients [5,7,21,22]. However, in practice, inconsistencies between the CONUT score and the prognosis of CRC patients were observed; therefore, it is imperative to improve their predictive values. Comprehensive evaluation of a patient's immunonutritional status before treatment, early detection, and intervention will greatly improve the survival outcomes of CRC patients [23,24].

In this study, we included 5014 CRC patients, collected their baseline characteristics and clinical biochemical indicators, and

**Table 5**
Ordered logistic regression analysis of factors related to CONUT score.

| Parameter | SE | wald | *P* | OR | 95% confidence interval of OR | |
|---|---|---|---|---|---|---|
| | | | | | Lower limit | Upper limit |
| CRC category | 0.090 | 4.801 | 0.028 | 0.821 | 0.688 | 0.979 |
| SEX | 0.099 | 15.776 | <0.001 | 0.676 | 0.557 | 0.820 |
| Age | 0.004 | 18.886 | <0.001 | 1.017 | 1.010 | 1.025 |
| Hospitalization days | 0.005 | 14.965 | <0.001 | 1.020 | 1.010 | 1.030 |
| WBC | 0.115 | 837.477 | <0.001 | 0.036 | 0.029 | 0.045 |
| NE | 0.118 | 844.614 | <0.001 | 30.815 | 24.459 | 38.823 |
| MC | 0.273 | 185.730 | <0.001 | 41.388 | 24.240 | 70.739 |
| EOS | 0.380 | 76.183 | <0.001 | 27.577 | 13.092 | 58.090 |
| BAS | 2.553 | 3.987 | 0.046 | 0.006 | 0.000 | 0.910 |
| PLT | 0.001 | 0.805 | 0.370 | 1.001 | 0.999 | 1.002 |
| RBC | 0.122 | 0.002 | 0.967 | 0.995 | 0.783 | 1.265 |
| HB | 0.004 | 52.710 | <0.001 | 0.971 | 0.964 | 0.979 |
| TP | 0.006 | 181.864 | <0.001 | 0.918 | 0.907 | 0.930 |
| TG | 0.042 | 24.106 | <0.001 | 0.812 | 0.748 | 0.882 |
| LDL | 0.056 | 420.727 | <0.001 | 0.319 | 0.285 | 0.355 |
| AST | 0.001 | 5.979 | 0.014 | 0.997 | 0.994 | 0.999 |
| GGT | 0.001 | 0.022 | 0.883 | 1.000 | 0.999 | 1.001 |
| ALP | 0.001 | 20.157 | <0.001 | 1.004 | 1.002 | 1.005 |
| TBIL | 0.108 | 1.788 | 0.181 | 0.865 | 0.700 | 1.069 |
| DBIL | 0.109 | 3.308 | 0.069 | 1.219 | 0.985 | 1.508 |
| IBIL | 0.108 | 0.990 | 0.320 | 1.114 | 0.900 | 1.377 |
| TBA | 0.004 | 1.914 | 0.167 | 0.995 | 0.987 | 1.002 |
| BUN | 0.021 | 9.768 | 0.002 | 0.936 | 0.898 | 0.975 |
| SCR | 0.001 | 2.769 | 0.096 | 1.002 | 1.000 | 1.004 |
| UA | 0.000 | 0.101 | 0.751 | 1.000 | 0.999 | 1.001 |
| LDH | 0.000 | 19.419 | <0.001 | 1.001 | 1.001 | 1.001 |
| CEA | 0.000 | 5.039 | 0.025 | 1.000 | 1.000 | 1.000 |

*$P < 0.05$, statistically significant.

calculated the CONUT scores for all patients based on the levels of ALB, LC, and TC. The study participants were divided into three groups according to their corresponding CONUT scores: normal nutritional status (low-score group), mild malnutrition (intermediate-score group), and moderate-to-severe malnutrition (high-score group). The results of the univariate analysis demonstrated that the CONUT score was correlated with sex, age, and hospitalization days in CRC. In addition, we collected 27 clinical biochemical indicators from CRC patients, including routine blood tests, liver and kidney function, myocardial enzymes, and immune and tumour indicators. The results showed that, except for the $CD4^+/CD8^+$ T cell ratio, ALT, CK, and TR, all other indicators showed statistically significant differences from the CONUT score. Furthermore, an ordered logistic regression analysis revealed that the nutritional status was worse in CC patients than in RC patients, and the nutritional status was worse in men than in women; the higher the age, the poorer the nutritional status, and the poorer the nutritional status, the longer the hospitalization. In addition, nutritional status was poor in patients with elevated levels of NE, MC, EOS, ALP, LDH, and CEA. In contrast, patients with decreased WBC, BAS, HB, TP, TG, LDL, AST, and BUN values had poorer nutritional status. Indicators with an OR value $> 10$ or $< 0.5$ as the cutoff value are considered significantly correlated. The results showed that the significantly correlated indicators reflected the patient's immunonutritional status, including WBC, NE, MC, EOS, BAS, and LDL.

This study had certain limitations. First, this was a retrospective, single-centre study. Second, the study did not rule out factors that may affect the patients' immune and nutritional status, such as immune drugs, hormone use, enteral and parenteral nutrition support, and comorbidities with underlying diseases.

## 5. Conclusion

This study explored the factors influencing the immune nutritional status of CRC patients based on the CONUT score. Finally, WBC, NE, MC, EOS, BAS, and LDL levels were selected as supplementary indicators for the CONUT scoring system to provide a more effective prediction of the clinical prognosis for CRC patients. These indicators can be included in future analyses to further explore their potential relationship with the survival and prognosis of CRC patients.

## Ethics statement

This study was reviewed and approved by the Ethics Committee of Nanjing First Hospital, with the approval number: KY20230424-02-KS-01. All participants/patients (or their proxies/legal guardians) provided informed consent to participate in the study. All participants/patients (or their proxies/legal guardians) provided informed consent for the publication of their anonymised case details, including ages, sexes, hospitalization days, biochemical indicators.

## Data availability statement

All data supporting the findings of this study are available within the article and its supplementary files. Data associated with the study has not been deposited into a publicly available repository, it will be made available on request from the corresponding author.

## Funding

This study was supported by the National Natural Science Foundation of China (82203182), and the foundation of Xinghuo Talent Program of Nanjing First Hospital.

## CRediT authorship contribution statement

**Zhi Wang:** Writing – original draft, Data curation. **Jin Bian:** Writing – review & editing, Validation. **Jiayan Yuan:** Writing – original draft, Investigation, Formal analysis. **Sunyan Zhao:** Writing – original draft, Methodology. **Shijia Huang:** Methodology, Investigation. **Rong Wu:** Investigation, Formal analysis, Data curation. **Fei Fei:** Writing – review & editing, Writing – original draft, Funding acquisition, Conceptualization.

## Declaration of competing interest

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

## Acknowledgments

We are grateful for the data support provided by the Information Department of Nanjing First Hospital, and we also express our sincere gratitude to the patients included in this study. We acknowledge Elsevier's Language Editing services for the manuscript language edit.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e27202.

## Abbreviations

| | |
|---|---|
| CRC | Colorectal cancer |
| PNI | prognostic nutrition index |
| CONUT | controlling nutritional status |
| ALB | albumin |
| LC | lymphocyte |
| TC | total cholesterol |
| WBC | white blood cell |
| RBC | red blood cell |
| NE | neutrophil |
| HB | hemoglobin |
| PLT | platelet; |
| MC | monocyte |
| EOS | eosinophil |
| BAS | basophil |
| ALT | alanine transaminase |
| AST | aspartate transaminase |
| ALP | alkaline phosphatase |
| GGT | γ-glutamic transferase |
| LDH | lactate dehydrogenase |
| TP | total protein; TG, triglycerides |
| LDL, | low-density lipoprotein |
| TBIL, | total bilirubin |
| IBIL, | indirect bilirubin |
| DBIL, | direct bilirubin |
| TBA | total bile acid |
| CK | creatine kinase |
| BUN | blood urea nitrogen |

| | |
|---|---|
| SCR | serum creatinine; |
| UA | uric acid |
| CEA | carcinoembryonic antigen |
| TR | thioredox protease |
| CC | colon cancer |
| RC | rectal cancer |

## References


[1] H. Sung, J. Ferlay, R. Siegel, M. Laversanne, I. Soerjomataram, A. Jemal, F. Bray, Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries, CA: a cancer journal for clinicians 71 (3) (2021) 209–249.

[2] R. Siegel, N. Wagle, A. Cercek, R. Smith, A. Jemal, Colorectal Cancer Statistics, 2023, a cancer journal for clinicians, CA, 2023.

[3] S. Foersch, C. Glasner, A. Woerl, M. Eckstein, D. Wagner, S. Schulz, F. Kellers, A. Fernandez, K. Tserea, M. Kloth, et al., Multistain deep learning for prediction of prognosis and therapy response in colorectal cancer, Nat. Med. 29 (2) (2023) 430–439.

[4] A. Misiewicz, V. Dymicka-Piekarska, Fashionable, but what is their real clinical usefulness? NLR, LMR, and PLR as a promising indicator in colorectal cancer prognosis: a systematic review, J. Inflamm. Res. 16 (2023) 69–81.

[5] H. Kim, D. Shin, J. Lee, E. Cho, H. Lee, S. Shin, E. Park, S. Baik, K. Lee, J. Kang, Combining prognostic nutritional index (PNI) and controlling nutritional status (CONUT) score as a valuable prognostic factor for overall survival in patients with stage I-III colorectal cancer, Front. Oncol. 13 (2023) 1026824.

[6] L. Chen, P. Bai, X. Kong, S. Huang, Z. Wang, X. Wang, Y. Fang, J. Wang, Prognostic nutritional index (PNI) in patients with breast cancer treated with neoadjuvant chemotherapy as a useful prognostic indicator, Front. Cell Dev. Biol. 9 (2021) 656741.

[7] K. Takagi, S. Buettner, J. Ijzermans, Prognostic significance of the controlling nutritional status (CONUT) score in patients with colorectal cancer: a systematic review and meta-analysis, Int. J. Surg. 78 (2020) 91–96.

[8] T. Onodera, N. Goseki, G. Kosaki, [Prognostic nutritional index in gastrointestinal surgery of malnourished cancer patients], Nihon Geka Gakkai zasshi 85 (9) (1984) 1001–1005.

[9] M. Dai, Q. Sun, Prognostic and clinicopathological significance of prognostic nutritional index (PNI) in patients with oral cancer: a meta-analysis, Aging 15 (5) (2023) 1615–1627.

[10] M. Zhu, L. Chen, X. Kong, X. Wang, Y. Ren, Q. Liu, X. Li, Y. Fang, J. Wang, Controlling nutritional status (CONUT) as a novel postoperative prognostic marker in breast cancer patients: a retrospective study, BioMed Res. Int. 2022 (2022) 3254581.

[11] R. Tokunaga, Y. Sakamoto, S. Nakagawa, M. Ohuchi, D. Izumi, K. Kosumi, K. Taki, T. Higashi, Y. Miyamoto, N. Yoshida, et al., CONUT: a novel independent predictive score for colorectal cancer patients undergoing potentially curative resection, Int. J. Colorectal Dis. 32 (1) (2017) 99–106.

[12] Y. Takamizawa, D. Shida, N. Boku, Y. Nakamura, Y. Ahiko, T. Yoshida, T. Tanabe, A. Takashima, Y. Kanemitsu, Nutritional and inflammatory measures predict survival of patients with stage IV colorectal cancer, BMC Cancer 20 (1) (2020) 1092.

[13] G. Galizia, E. Lieto, A. Auricchio, F. Cardella, A. Mabilia, V. Podzemny, P. Castellano, M. Orditura, V. Napolitano, Naples prognostic score, based on nutritional and inflammatory status, is an independent predictor of long-term outcome in patients undergoing surgery for colorectal cancer, Dis. Colon Rectum 60 (12) (2017) 1273–1284.

[14] Y. Fukui, N. Aomatsu, K. Sai, R. Naka, S. Kurihara, K. Kuroda, J. Nishimura, K. Sakurai, T. Nishii, A. Tachimori, et al., [Prognostic analysis of colorectal cancer patients by the controlling nutritional status(CONUT)score], Gan to kagaku ryoho Cancer & chemotherapy 48 (13) (2021) 1975–1977.

[15] Z. Güç, C. Altay, H. Özgül, H. Ellidokuz, T. Yavuzşen, GNRI and conut scores: simple predictors of sarcopenia in metastatic colorectal cancer patients, Support. Care Cancer : official journal of the Multinational Association of Supportive Care in Cancer 30 (10) (2022) 7845–7852.

[16] H. Liu, X. Yang, D. Liu, C. Tong, W. Wen, R. Chen, Clinical significance of the controlling nutritional status (CONUT) score in gastric cancer patients: a meta-analysis of 9,764 participants, Front. Nutr. 10 (2023) 1156006.

[17] Y. Cai, X. Li, X. Ye, X. Li, Y. Fu, B. Hu, H. Li, J. Miao, Preoperative controlling nutritional status score (CONUT) predicts postoperative complications of patients with bronchiectasis after lung resections, Front. Nutr. 10 (2023) 1000046.

[18] T. Kato, H. Yaku, T. Morimoto, Y. Inuzuka, Y. Tamaki, E. Yamamoto, Y. Yoshikawa, T. Kitai, R. Taniguchi, M. Iguchi, et al., Association with controlling nutritional status (CONUT) score and in-hospital mortality and infection in acute heart failure, Sci. Rep. 10 (1) (2020) 3320.

[19] G. Spoletini, F. Ferri, A. Mauro, G. Mennini, G. Bianco, V. Cardinale, S. Agnes, M. Rossi, A. Avolio, Q. Lai, CONUT score predicts early morbidity after liver transplantation: a collaborative study, Front. Nutr. 8 (2021) 793885.

[20] Liu Y, Meng Y, Zhou C, Liu Y, Tian S, Li J, Dong W: Creation and Validation of a Survival Nomogram Based on Immune-Nutritional Indexes for Colorectal Cancer Patients. Journal of oncology 2022, 2022:1854812.

[21] C. Yang, C. Wei, S. Wang, S. Han, D. Shi, C. Zhang, X. Lin, R. Dou, B. Xiong, Combined features based on preoperative controlling nutritional status score and circulating tumour cell status predict prognosis for colorectal cancer patients treated with curative resection, Int. J. Biol. Sci. 15 (6) (2019) 1325–1335.

[22] T. Hayama, T. Ozawa, Y. Okada, M. Tsukamoto, Y. Fukushima, R. Shimada, K. Nozawa, K. Matsuda, S. Fujii, Y. Hashiguchi, The pretreatment Controlling Nutritional Status (CONUT) score is an independent prognostic factor in patients undergoing resection for colorectal cancer, Sci. Rep. 10 (1) (2020) 13239.

[23] Beukers K, Voorn M, Trepels R, van de Wouw Y, Vogelaar J, Havermans R, Janssen-Heijnen M: Associations between outcome variables of nutritional screening methods and systemic treatment tolerance in patients with colorectal cancer: A systematic review. Journal of geriatric oncology 2022, 13(8):1092-1102.

[24] S. Xiang, Y. Yang, W. Pan, Y. Li, J. Zhang, Y. Gao, S. Liu, Prognostic value of systemic immune inflammation index and geriatric nutrition risk index in early-onset colorectal cancer, Front. Nutr. (2023) 10.