Article

Discovery Medicine 2026; 38(214): 3577–3586
https://doi.org/10.24976/Discov.Med.202638214.272

CONUT Score and CALLY Index as Independent Influencing Factors for Lymph Node Metastasis in Early Gastric Cancer

Xuejing Song[1], Yanan Duan[2], Rongguang Dang[2], Ye Yang[2,*]

[1]Department of Oncology (Fangbei), Shijiazhuang People's Hospital, 050000 Shijiazhuang, Hebei, China
[2]Department of Oncology I (Jianhua), Shijiazhuang People's Hospital, 050000 Shijiazhuang, Hebei, China
*Correspondence: 13930452596@163.com (Ye Yang)
Submitted: 21 July 2026 Revised: 16 September 2026 Accepted: 22 September 2026 Published: 25 November 2026

Background: Lymph node metastasis (LNM) is a critical determinant of recurrence and prognosis in early gastric cancer, yet current imaging approaches have limited sensitivity for detecting metastatic nodes, particularly micrometastases. Inflammation-nutrition composite biomarkers have shown promise for predicting tumor progression, but their utility specifically for LNM risk assessment remains underexplored. This study aimed to evaluate the utility of the Controlling Nutritional Status (CONUT) score and the C-reactive protein–albumin–lymphocyte (CALLY) index in predicting LNM in early gastric cancer, and to develop a multivariable predictive model for preoperative risk stratification to facilitate individualized risk assessment and inform surgical decision-making.

Methods: The clinical data of 255 patients with early gastric cancer confirmed by pathology in Shijiazhuang People's hospital from March 2022 to September 2025 were retrospectively collected. The patients were divided into the LNM group (61 cases) and the non-metastasis group (194 cases) according to whether LNM was detected on pathological examination. The general information, tumor-related data, and laboratory findings of the patients were collected, and the CONUT score and CALLY index were calculated. Univariate logistic regression followed by multivariate logistic regression with backward stepwise selection was used to identify independent predictors of LNM for model construction. Model discrimination, calibration, and clinical net benefit were evaluated using receiver operating characteristic (ROC) curves, calibration plots, and decision curve analysis (DCA), respectively.

Results: Multivariate logistic regression analysis showed that imaging lymph node status, CONUT score, and a lower CALLY index were independent factors for LNM of early gastric cancer. The area under the curve (AUC) of the combined prediction model based on the above three indicators was 0.77 (0.70–0.84), with a sensitivity of 0.61 and a specificity of 0.90. The calibration curve showed that the model had good calibration, and the DCA curve demonstrated a good net clinical benefit.

Conclusions: Radiologically suspicious lymph nodes, an elevated CONUT score, and a decreased CALLY index were identified as independent predictors of LNM in early gastric cancer. The combined prediction model based on the above indicators has good discrimination, calibration, and clinical net benefit, which may facilitate the identification of patients at high risk of LNM in early gastric cancer and provide a reference for the medical oncology department to formulate individualized systematic treatment and comprehensive treatment strategies. The CONUT score and CALLY index are simple and cost-effective inflammation-nutrition composite indices that have potential for clinical application.

Keywords: early gastric cancer; LNM; CONUT score; CALLY index

Introduction

Gastric cancer is globally recognized as a leading digestive malignancy, and its morbidity and mortality have long ranked at the forefront of malignant tumors. According to global cancer statistics, there are about 1.08 million new cases and 770,000 deaths from gastric cancer annually, posing a serious threat to human health [1,2]. Recurrence risk and long-term prognosis in gastric cancer patients are largely dictated by lymph node metastasis (LNM), which represents one of the most critical biological features of the disease [3].

Gastric cancer most frequently metastasizes through the lymphatic channels. The presence or absence of LNM directly influences the choice of surgical methods, the formulation of postoperative adjuvant treatment strategies, and the long-term prognosis of patients [4]. The 5-year survival rate of early gastric cancer declines from >90% in patients with node-negative disease to 50%–70% in those with node-positive disease. Therefore, accurate evaluation of LNM is essential for personalized treatment of gastric cancer and for avoiding inappropriate therapy [5]. At present, imaging examinations, such as computed tomog-

Copyright: © 2026 The Author(s). Published by Discovery Medicine. This is an open access article under the CC BY 4.0 license.
Note: *Discovery Medicine* stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

raphy (CT), magnetic resonance imaging (MRI), and endoscopic ultrasound, are the primary methods to evaluate LNM; however, their sensitivity and specificity have certain limitations [6,7].

The role of inflammation and nutritional status in the occurrence and development of tumors has attracted increasing attention. Tumor-associated inflammation drives cancer proliferation, invasion, and metastasis, whereas malnutrition impairs antitumor immunity and promotes disease progression [8]. C-reactive protein (CRP) is one of the most widely used acute-phase proteins in clinical practice. It is rapidly synthesized by hepatocytes and released into the blood under stress conditions such as infection, tissue injury, and inflammation, and its elevated levels are closely related to the severity of inflammation [9]. Elevated CRP has been repeatedly associated with adverse prognosis in gastric cancer [10]. However, CRP has certain limitations when used alone; for example, its levels can be influenced by non-infectious factors such as surgical trauma and tissue necrosis [11].

Prealbumin (PAB), also known as transthyretin, is a negative acute-phase protein synthesized by hepatocytes with a short half-life, which can sensitively reflect the nutritional status of proteins and changes in liver function [12]. In inflammatory states, PAB synthesis is inhibited, and its serum levels tend to decrease. Low PAB levels suggest malnutrition or chronic inflammatory states, both of which are predisposing factors for tumor progression [13]. Based on the above background, a series of composite indicators that comprehensively reflect inflammation and nutritional status have gradually emerged in recent years [14,15]. These indicators have shown good prognostic value across a variety of malignant tumors.

The Controlling Nutritional Status (CONUT) system quantifies nutritional status using albumin, cholesterol, and lymphocyte count (scale: 0–12, higher = poorer nutrition). This index is now widely employed for prognostic stratification in multiple tumor types [16,17,18]. The C-reactive protein–albumin–lymphocyte (CALLY) index is a novel inflammation-nutrition composite that reflects both inflammatory activity and immunonutritional status. Compared with a single indicator, the CALLY index combines CRP, which reflects the degree of inflammation, with albumin and lymphocyte count, which reflect nutritional and immune status, and theoretically enables a more comprehensive assessment of the patient's systemic status. Previous studies have confirmed that the CALLY index has a good predictive value for the prognosis of gastrointestinal tumors such as liver cancer and early gastric cancer [19,20]. However, few studies have examined the relationship between the CONUT score and CALLY index and the risk of LNM in early gastric cancer. Whether these two indices can be used as independent predictors of LNM in gastric cancer and whether a prediction model incorporating the CONUT score, CALLY index, and other factors has clinical utility still needs to be further explored and validated.

This study retrospectively enrolled 255 early gastric cancer patients to investigate LNM predictors, focusing on the CONUT score and CALLY index. A multivariable model integrating these markers was developed and evaluated using receiver operating characteristic (ROC), calibration, and decision curve analysis (DCA) for discrimination, calibration, and clinical utility, aiming to inform preoperative risk assessment.

Patients and Methods

Participants and Inclusion and Exclusion Criteria

We retrospectively reviewed 255 early gastric cancer cases treated at Shijiazhuang People's Hospital (March 2022–September 2025). Ethics approval was approved by the Ethics Committee of Shijiazhuang People's Hospital (Approval No.: 2026(147)), with informed consent waived. This study adhered to the ethical principles of the Declaration of Helsinki. Inclusion criteria: (1) early gastric cancer confirmed by postoperative pathology, defined as gastric cancer confined to the mucosa (T1a) or submucosa (T1b) according to the 8th edition of the American Joint Committee on Cancer (AJCC) tumor-node-metastasis (TNM) staging system and the Japanese Gastric Cancer Treatment Guidelines; (2) age ≥18 years; (3) complete clinical data. Exclusion criteria: (1) combined with other malignant tumors; (2) previous surgery, radiotherapy or chemotherapy related to gastric cancer; (3) complicated by severe cardiovascular and cerebrovascular diseases (New York Heart Association (NYHA) class III–IV heart failure, myocardial infarction); (4) complicated by severe infection or immunodeficiency diseases (such as human immunodeficiency virus infection); (5) long-term use of immunosuppressive agents; (6) combined with hematological diseases (such as leukemia, lymphoma). Using pathological findings as the diagnostic benchmark, patients were categorized into LNM-positive and LNM-negative groups based on the presence of cancer cells in perigastric nodes on histologic examination. The study ultimately comprised 255 eligible cases.

Collection of Clinical Data

Clinical data were retrospectively collected from electronic records. The recorded data included age, sex, hypertension, diabetes, and family history. Tumor-related data included tumor location (upper/lower middle), gross type (depressed/elevated/superficial), imaging lymph node status (positive/negative), and Helicobacter pylori (Hp) infection status. The clinical symptoms included anemia, melena, hematemesis, dyspepsia, and abdominal distension. Preoperative peripheral venous blood samples were collected within 1 week before surgery for measurement of serum carcinoembryonic antigen (CEA), along with calculated CONUT and CALLY indices. The CONUT score was

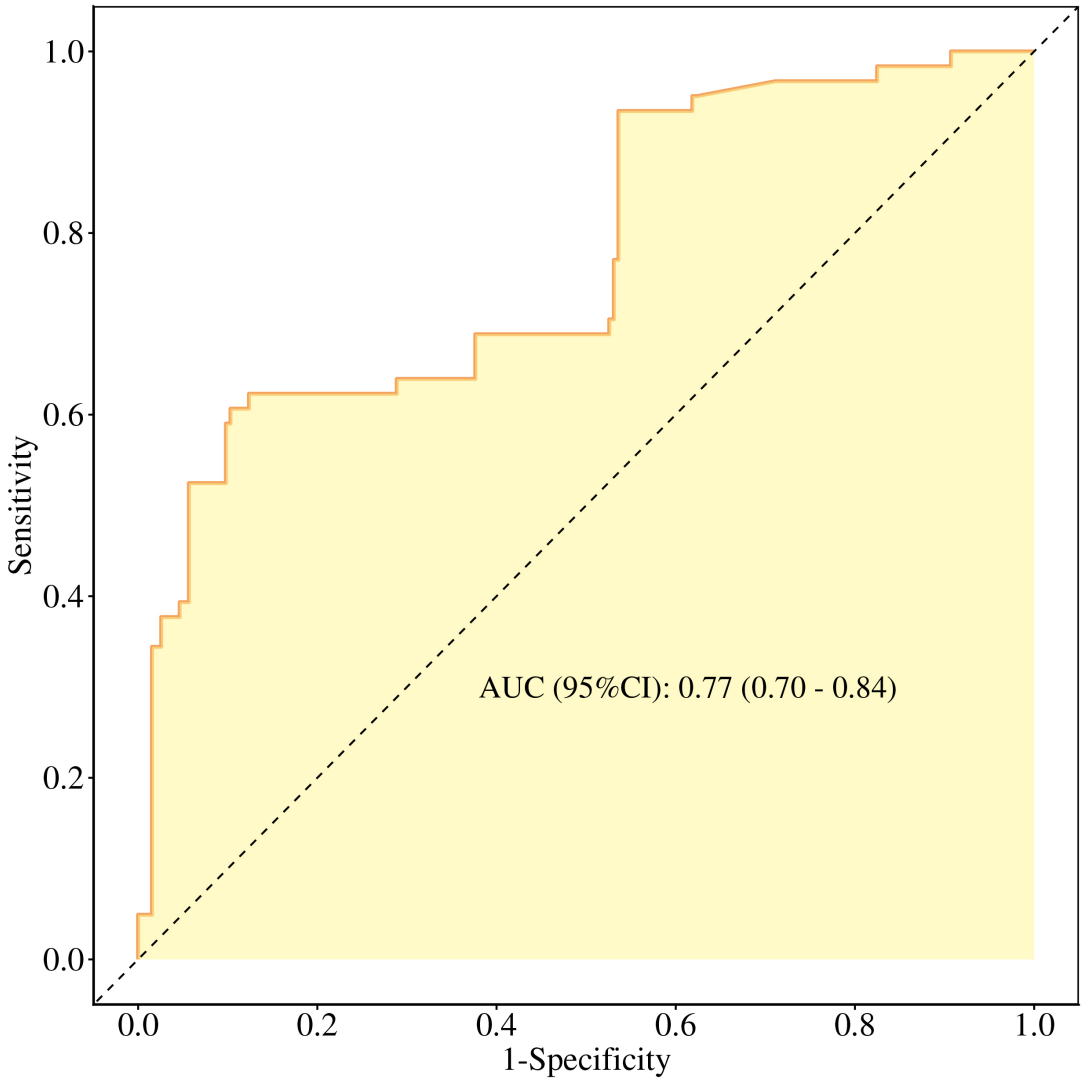


Fig. 1. Receiver operating characteristic (ROC) curve analysis of the prediction model.

calculated based on three laboratory parameters: serum albumin (g/dL), total lymphocyte count ($\times 10^9$/L), and total cholesterol (mg/dL). The scoring criteria were as follows: serum albumin ≥3.5 g/dL (score 0), 3.0–3.49 g/dL (score 2), 2.5–2.99 g/dL (score 4), and <2.5 g/dL (score 6); total lymphocyte count ≥1.60 $\times 10^9$/L (score 0), 1.20–1.59 $\times 10^9$/L (score 1), 0.80–1.19 $\times 10^9$/L (score 2), and <0.80 $\times 10^9$/L (score 3); total cholesterol ≥180 mg/dL (score 0), 140–179 mg/dL (score 1), 100–139 mg/dL (score 2), and <100 mg/dL (score 3). The individual scores were summed to generate the total CONUT score, ranging from 0 to 12, with higher scores reflecting poorer nutritional status. The CALLY index was calculated as (serum albumin × total lymphocyte count) / (serum CRP × 10), with albumin in g/dL, lymphocyte count in $\times 10^9$/L, and CRP in mg/dL, serves as a composite biomarker that comprehensively reflects both inflammatory activation and immunonutritional status.

Imaging and Pathological Evaluation

Imaging Assessment

All patients underwent preoperative contrast-enhanced abdominal CT within 2 weeks before surgery. Lymph nodes were considered positive if they met at least one of the following criteria: short-axis diameter ≥10 mm, marked or heterogeneous enhancement, round shape (long-to-short axis ratio <2), or presence of necrosis or fusion. Otherwise, lymph nodes were classified as negative. All CT images were independently reviewed by two senior radiologists (with >10 years of experience), and discrepancies were resolved by consensus.

Pathological Assessment

All patients underwent curative gastrectomy (total or subtotal) with standard D2 lymphadenectomy according to the Japanese Gastric Cancer Treatment Guidelines. Retrieved lymph nodes were numbered according to the Japanese classification of gastric carcinoma. All retrieved

nodes were fixed in 10% formalin, embedded in paraffin, sectioned at 4-μm thickness, and stained with hematoxylin and eosin (H&E) for histopathological examination. Each lymph node was examined microscopically by an experienced pathologist. LNM was defined as the presence of cancer cells in perigastric lymph nodes on H&E-stained sections. Micrometastases and isolated tumor cells were not included in the definition of LNM. Based on pathological findings, patients were categorized into LNM-positive and LNM-negative groups.

Statistical Methods

Statistical analyses were performed using SPSS 26.0 (IBM Corp, Armonk, NY, USA) and R 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were first tested for normality using the Shapiro-Wilk test. Normally distributed continuous variables were presented as mean ± standard deviation (SD) and compared using the independent samples *t*-test; non-normally distributed continuous variables were presented as median (Q_1, Q_3) and compared using the Mann-Whitney U test. Categorical variables were presented as frequencies and percentages (n, %) and compared using the χ^2 test or Fisher's exact test, as appropriate. For all categorical variables, the following coding scheme was used: male = 1, female = 0; yes = 1, no = 0; positive = 1, negative = 0; upper = 1, middle/lower = 0; depressed = 1, protruded/superficial = 0. LNM-positive = 1 and LNM-negative = 0. Continuous variables (age, tumor size, CEA, CONUT score, and CALLY index) were included as continuous values. Candidate variables for univariate analysis were selected based on established clinical relevance and biological plausibility for LNM in early gastric cancer, as reported in previous studies. Variables with $p < 0.05$ in univariate analysis were entered into multivariate logistic regression with backward stepwise selection to identify independent factors and calculate odds ratios (OR) with 95% confidence intervals (CIs). A prediction model was constructed from the independent predictors and evaluated by ROC curve (area under the curve (AUC), optimal cutoff, sensitivity, specificity). The optimal cut-off value of the predicted probability was determined by the Youden index (sensitivity + specificity – 1). Internal validation of the final model's calibration was performed using 1000 bootstrap resampling iterations, and calibration was further evaluated by a calibration plot. DCA was performed to evaluate the clinical net benefit of the model. A two-sided α of 0.05 was considered significant.

Results

Patient Demographics and Clinical Features by LNM Status

Of the 255 enrolled early gastric cancer patients, 61 (23.9%) were pathologically confirmed to have LNM and 194 (76.1%) were not. There were no significant differences in gender, age, hypertension, diabetes, family history, tumor location, gross type, Hp infection, anemia, melena, hematemesis, dyspepsia, abdominal distension, tumor size or CEA level between the two groups (all $p > 0.05$). However, the LNM group exhibited significantly higher proportions of radiologically suspicious lymph nodes (19.67% vs. 3.09%) compared with the non-LNM group (all $p < 0.05$). Moreover, patients with nodal metastasis had a significantly higher median CONUT score (3.00 vs. 1.00) and a lower median CALLY index (2.22 vs. 3.01) than those without metastasis (both $p < 0.01$) (Table 1).

Logistic Regression Analyses of LNM-Associated Factors

Univariate Logistic regression analysis showed (Table 2) that imaging lymph node status ($p < 0.01$), CONUT score ($p < 0.01$) and CALLY index ($p < 0.01$) were significantly associated with LNM of early gastric cancer. With LNM as the dependent variable, variables with $p < 0.05$ in univariate analysis (imaging lymph node status, CONUT score, and CALLY index) were included in multivariate logistic regression analysis. Collinearity diagnosis showed that the variance inflation factor (VIF) of each variable was: The degree of imaging lymph node status (VIF = 1.024), CONUT score (VIF = 1.142), and CALLY index (VIF = 1.151) were far less than 10. It is suggested that there is no obvious multicollinearity among the variables included in the model. Multivariate logistic regression analysis further showed (Table 3) that imaging lymph node status ($p < 0.01$), CONUT score ($p < 0.01$) and CALLY index ($p < 0.01$) were independent factors for LNM of early gastric cancer. The prediction formula for the combined model was as follows: Logit(P) = –0.34 + 1.93 × (imaging lymph node status) + 0.44 × (CONUT score) –0.72 × (CALLY index).

ROC Curve Analysis of the Prediction Model

A combined prediction model was developed incorporating the three independent determinants identified by multivariate analysis: imaging-detected nodal status, CONUT score, and CALLY index. ROC analysis (Fig. 1) yielded an AUC of 0.77 (0.70–0.84) for predicting LNM, with an optimal cutoff of 0.35. At this threshold, the model achieved a sensitivity of 0.61 (0.48–0.73) and a specificity of 0.90 (0.85–0.94), indicating satisfactory predictive performance. After 1000 bootstrap resampling iterations of the final model, the bootstrap-corrected AUC was 0.77 (0.74–0.79). The bootstrap-corrected sensitivity and specificity were 0.64 (0.51–0.87) and 0.84 (0.59–0.95), respectively.

Calibration and Clinical Applicability Evaluation of the Model

Calibration analysis (Fig. 2) demonstrated close agreement between model-predicted and actual LNM risk. The bootstrap-corrected calibration slope was 0.844 (95%

Table 1. Patient demographics and clinical features by LNM status.

Variables	Total (n = 255)	LNM_negative (n = 194)	LNM_positive (n = 61)	Statistic	*p*
Age, Mean ± SD	60.72 ± 5.57	60.95 ± 5.46	60.00 ± 5.91	$t = 1.16$	0.25
Tumor size mm, Mean ± SD	20.83 ± 7.90	20.49 ± 7.64	21.90 ± 8.66	$t = –1.22$	0.22
CEA (ng/mL), Mean ± SD	4.29 ± 0.67	4.26 ± 0.66	4.41 ± 0.67	$t = –1.56$	0.12
CONUT score, M (Q_1, Q_3)	1.00 (1.00, 3.00)	1.00 (1.00, 2.00)	3.00 (1.00, 4.00)	Z = –4.91	<0.01
CALLY, M (Q_1, Q_3)	3.01 (2.28, 3.05)	3.01 (2.88, 3.05)	2.22 (1.22, 2.78)	Z = –6.84	<0.01
Sex, n (%)				$\chi^2 = 1.29$	0.26
Female	82 (32.16)	66 (34.02)	16 (26.23)		
Male	173 (67.84)	128 (65.98)	45 (73.77)		
Hypertension, n (%)				$\chi^2 = 0.26$	0.61
No	173 (67.84)	130 (67.01)	43 (70.49)		
Yes	82 (32.16)	64 (32.99)	18 (29.51)		
Diabetes, n (%)				$\chi^2 = 0.37$	0.54
No	227 (89.02)	174 (89.69)	53 (86.89)		
Yes	28 (10.98)	20 (10.31)	8 (13.11)		
Family history, n (%)				-	1.00
No	251 (98.43)	191 (98.45)	60 (98.36)		
Yes	4 (1.57)	3 (1.55)	1 (1.64)		
Tumor site, n (%)				$\chi^2 = 0.38$	0.54
Middle/Lower	125 (49.02)	93 (47.94)	32 (52.46)		
Upper	130 (50.98)	101 (52.06)	29 (47.54)		
Macroscopic type, n (%)				$\chi^2 = 0.78$	0.68
Depressed	74 (29.02)	59 (30.41)	15 (24.59)		
Protruded	92 (36.08)	69 (35.57)	23 (37.70)		
Superficial	89 (34.90)	66 (34.02)	23 (37.70)		
Lymphadenopathy, n (%)				$\chi^2 = 17.00$	<0.01
No	237 (92.94)	188 (96.91)	49 (80.33)		
Yes	18 (7.06)	6 (3.09)	12 (19.67)		
H pylori, n (%)				$\chi^2 = 1.39$	0.24
Negative	87 (34.12)	70 (36.08)	17 (27.87)		
Positive	168 (65.88)	124 (63.92)	44 (72.13)		
Anemia, n (%)				$\chi^2 = 1.06$	0.30
No	249 (97.65)	191 (98.45)	58 (95.08)		
Yes	6 (2.35)	3 (1.55)	3 (4.92)		
Melena, n (%)				$\chi^2 = 0.00$	1.00
No	250 (98.04)	190 (97.94)	60 (98.36)		
Yes	5 (1.96)	4 (2.06)	1 (1.64)		
Hematemesis, n (%)				-	0.42
No	253 (99.22)	193 (99.48)	60 (98.36)		
Yes	2 (0.78)	1 (0.52)	1 (1.64)		
Dyspepsia, n (%)				$\chi^2 = 2.01$	0.16
No	226 (88.63)	175 (90.21)	51 (83.61)		
Yes	29 (11.37)	19 (9.79)	10 (16.39)		
Fullness, n (%)				$\chi^2 = 1.64$	0.20
No	232 (90.98)	174 (89.69)	58 (95.08)		
Yes	23 (9.02)	20 (10.31)	3 (4.92)		

LNM, lymph node metastasis; SD, standard deviation; CONUT, Controlling Nutritional Status; CALLY, C-reactive protein–albumin–lymphocyte.

CI: 0.607–1.164), and the corrected calibration intercept was –0.146 (95% CI: –0.500–0.283). Although the slope was slightly below 1 and the intercept slightly below 0, both 95% confidence intervals included the ideal values (1 and 0, respectively), indicating acceptable calibration. The mean absolute error of the calibration curve was 0.043, further supporting satisfactory calibration. Decision curve analysis (Fig. 3) further revealed that the model provided superior net benefit over the "treat all" or "treat none" strategies across threshold probabilities of 0.1 to 0.7, confirming

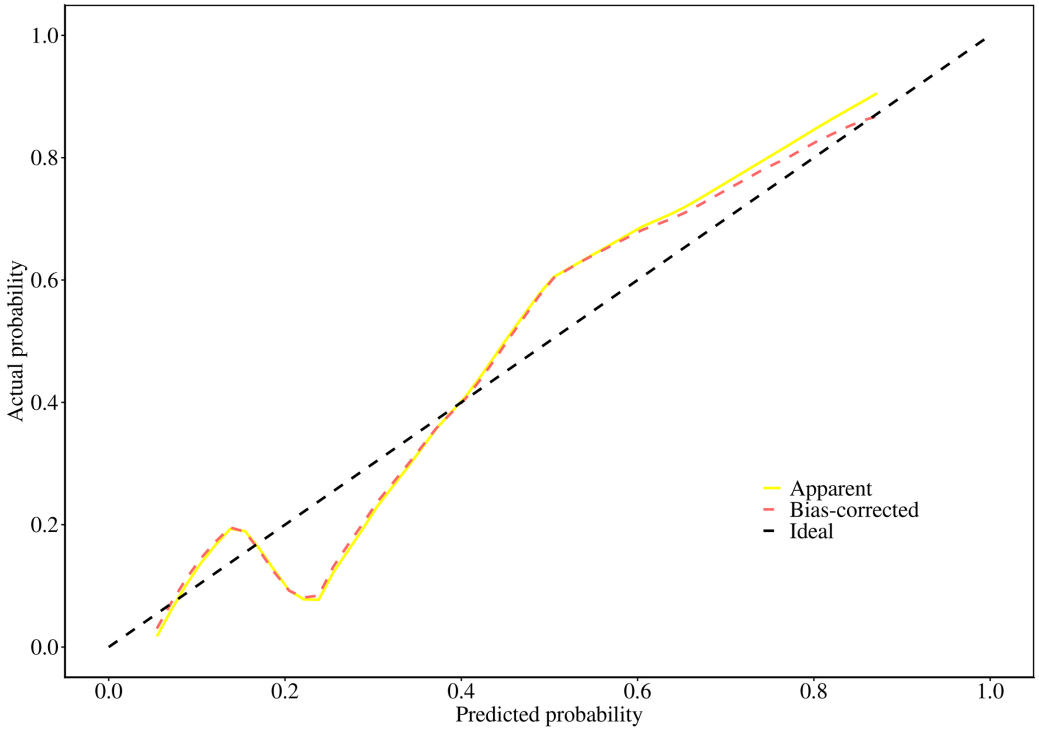


Fig. 2. Calibration curve of the joint prediction model.

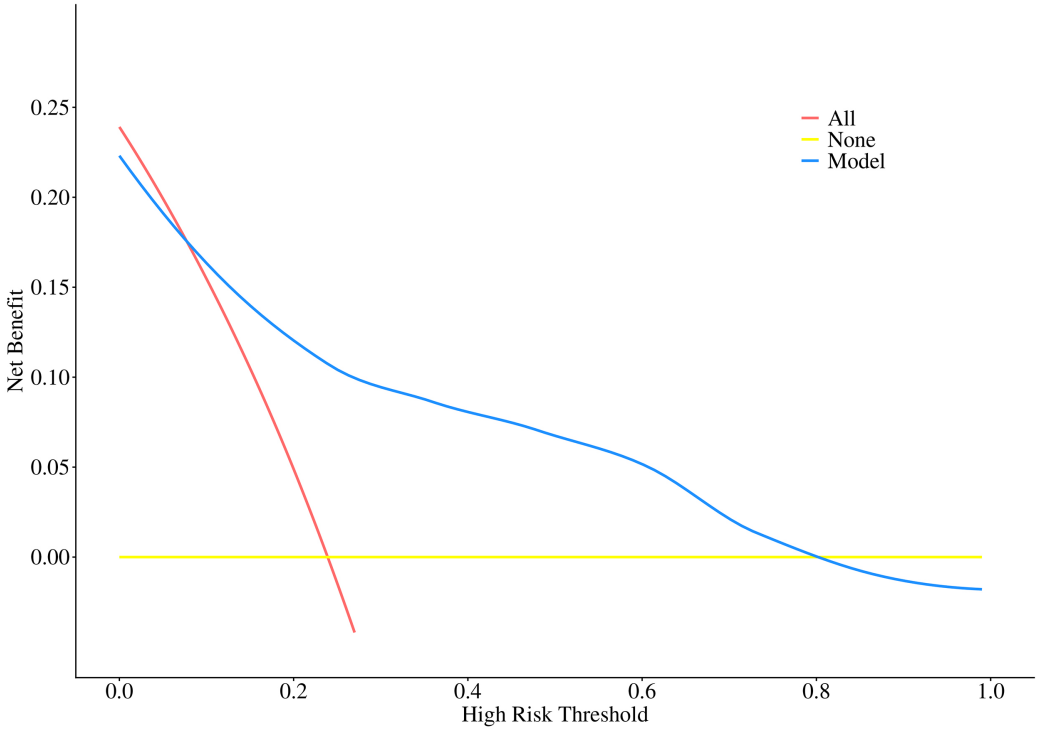


Fig. 3. DCA of the joint prediction model. DCA, decision curve analysis.

its clinical utility. After bootstrap correction of the final model, the corrected DCA curve showed that the model still provided a higher net benefit than the "treat all" or "treat none" strategies across a threshold probability range of 0.1 to 0.7 (Fig. 4).

Discussion

Lymph node metastasis critically influences both recurrence and long-term survival in early gastric cancer. Its precise evaluation is essential for tailoring individualized

Table 2. Univariate logistic regression analyses of LNM-associated factors.

Variables	β	S.E	Z	*p*	OR (95% CI)
Sex					
Female					1.00 (Reference)
Male	0.37	0.33	1.13	0.26	1.45 (0.76–2.76)
Hypertension					
No					1.00 (Reference)
Yes	–0.16	0.32	–0.51	0.61	0.85 (0.45–1.59)
Diabetes					
No					1.00 (Reference)
Yes	0.27	0.45	0.61	0.54	1.31 (0.55–3.15)
Family history					
No					1.00 (Reference)
Yes	0.06	1.16	0.05	0.96	1.06 (0.11–10.39)
Tumor site					
Middle/Lower					1.00 (Reference)
Upper	–0.18	0.29	–0.62	0.54	0.83 (0.47–1.48)
Macroscopic type					
Depressed					1.00 (Reference)
Protruded	0.27	0.38	0.72	0.47	1.31 (0.63–2.74)
Superficial	0.32	0.38	0.84	0.40	1.37 (0.65–2.87)
Lymphadenopathy					
No					1.00 (Reference)
Yes	2.04	0.53	3.88	<0.01	7.67 (2.74–21.48)
H pylori					
Negative					1.00 (Reference)
Positive	0.38	0.32	1.18	0.24	1.46 (0.78–2.75)
Anemia					
No					1.00 (Reference)
Yes	1.19	0.83	1.44	0.15	3.29 (0.65–16.76)
Melena					
No					1.00 (Reference)
Yes	–0.23	1.13	–0.21	0.84	0.79 (0.09–7.22)
Hematemesis					
No					1.00 (Reference)
Yes	1.17	1.42	0.82	0.41	3.22 (0.20–52.21)
Dyspepsia					
No					1.00 (Reference)
Yes	0.59	0.42	1.40	0.16	1.81 (0.79–4.13)
Fullness					
No					1.00 (Reference)
Yes	–0.80	0.64	–1.25	0.21	0.45 (0.13–1.57)
Age	–0.01	0.03	–0.29	0.77	0.99 (0.94–1.04)
Tumor size mm	0.02	0.02	1.22	0.22	1.02 (0.99–1.06)
CEA (ng/mL)	0.34	0.22	1.55	0.12	1.41 (0.91–2.17)
CONUT score	0.61	0.12	4.93	<0.01	1.84 (1.44–2.34)
CALLY	–0.98	0.19	–5.08	<0.01	0.38 (0.26–0.55)

S.E, standard error; OR, odds ratios; CI, confidence interval; CEA, carcinoembryonic antigen.

treatment and adjuvant therapy strategies. However, current imaging examinations have some limitations in the evaluation of LNM. Identifying biomarkers for predicting LNM is of significant clinical importance. This retrospective study analyzed 255 patients with early gastric cancer to investigate factors associated with LNM, evaluate the predictive performance of the CONUT score and CALLY index, and construct a combined prediction model. Multivariate logistic regression identified imaging-detected nodal status, CONUT score, and a lower CALLY index as inde-

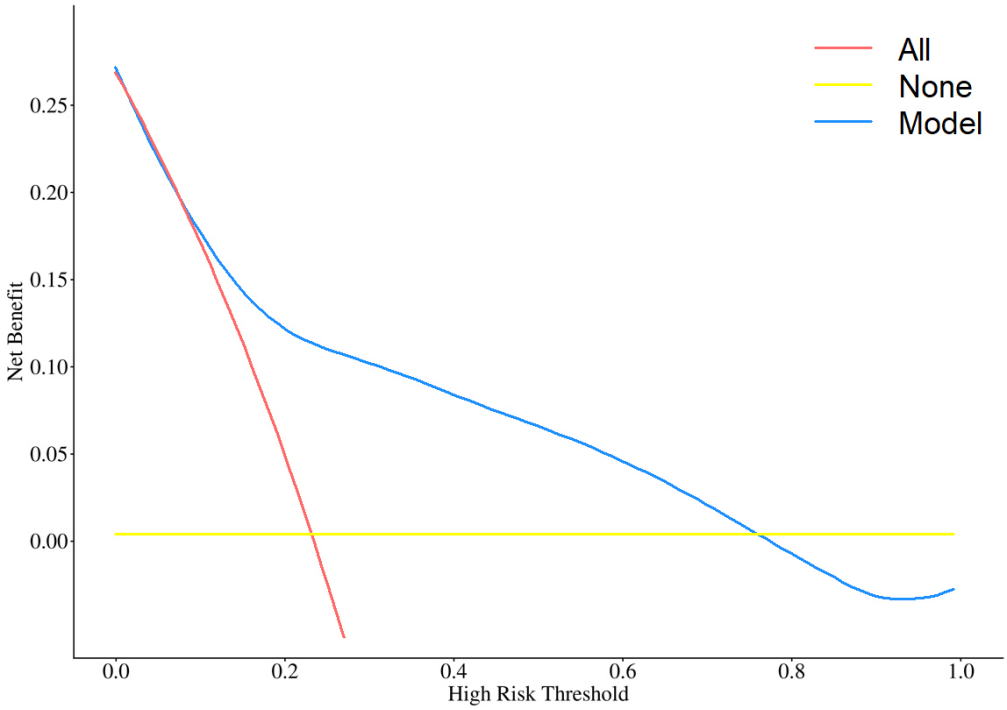


Fig. 4. Bootstrap-corrected DCA of the prediction model.

Table 3. Multivariate logistic regression analyses of LNM-associated factors.

Variables	β	S.E	Z	*p*	OR (95% CI)
Lymphadenopathy					
No					1.00 (Reference)
Yes	1.93	0.59	3.29	<0.01	6.92 (2.18–21.92)
CONUT score	0.44	0.13	3.31	<0.01	1.56 (1.20–2.03)
CALLY	–0.72	0.21	–3.35	<0.01	0.49 (0.32–0.74)

pendent predictors of LNM. The model incorporating these three variables demonstrated favorable discrimination, calibration, and clinical net benefit, indicating its potential utility for preoperative risk stratification in early gastric cancer.

Imaging lymph node status is an important influencing factor. Lymph node abnormalities, such as enlargement, enhancement, and fusion, detected by CT or MRI provide an important basis for the clinical diagnosis of LNM. However, normal-sized micrometastatic lymph nodes are often difficult to identify on imaging, resulting in limited sensitivity and specificity. In this study, some patients with positive imaging lymph nodes were pathologically confirmed negative, while some patients with negative imaging lymph nodes were pathologically positive. One study found that the sensitivity of CT scanning in the diagnosis of LNM was only 25%, and the specificity was 83%. Even when a short-axis lymph node diameter of 6.5 mm was used as the threshold, the sensitivity increased to only 47%, and the study further reported that, in patients with diffuse or mixed-type tumors, the AUC of CT for diagnosis was only 0.51 [21]. Therefore, the results of imaging examination should be combined with other clinical and laboratory indicators to improve the accuracy of prediction.

The core finding of this study is that the CONUT score and CALLY index were independent factors for LNM. The CONUT score comprehensively reflects the nutritional status of patients. Malnutrition can lead to impaired immune function and weakened anti-tumor immune surveillance, thus creating conditions for the proliferation, invasion, and metastasis of tumor cells. Studies have confirmed that an elevated CONUT score is associated with poor prognosis across a variety of malignant tumors [22,23], but the relationship between the CONUT score and LNM has not been systematically investigated. This study systematically evaluated the relationship between the CONUT score and LNM in early gastric cancer and provided a reference for the clinical development of individualized treatment strategies.

CALLY index, as a novel inflammation-nutrition composite index, combines CRP, which reflects the degree of inflammation, with albumin and lymphocyte count, which reflect the nutritional immune status, and theoretically enables a more comprehensive assessment of patients' systemic status. Compared with a single index, the CALLY index can partially offset the impact of individual differences and basal level fluctuations. In this study, a decreased CALLY index was significantly associated with increased risk of LNM. The decrease in the CALLY index indicates that patients have different degrees of inflammatory activation (increased CRP) and/or deterioration of nutritional immune status (decreased albumin and lymphopenia), both of

which can promote tumor progression and metastasis. Previous studies have confirmed that the CALLY index has a good predictive value for the prognosis of gastrointestinal tumors such as liver cancer and colorectal cancer [24,25].

This study has the following limitations. First, this study is a single-center retrospective study with a limited sample size, which may cause selection bias. The conclusions need to be further validated in multi-center, large-sample prospective studies. Second, the calculation of the CONUT score and CALLY index depends on laboratory tests, and the testing methods and reference ranges may vary across different hospitals. The generalization ability of the model needs to be further verified. Third, although the joint model in this study was internally validated using 1000 bootstrap resampling iterations, this procedure was applied to the final selected model to assess its calibration stability, rather than encompassing the entire variable selection process (i.e., univariate screening and backward stepwise regression). Consequently, the reported model performance may be somewhat optimistic due to the inherent instability of stepwise selection and *p*-driven screening. Additionally, its generalization needs to be further evaluated due to the lack of external validation. Fourth, the relationship between LNM and long-term prognosis was not evaluated in this study. Further studies are warranted to validate this model's predictive utility for survival outcomes and treatment response. Another limitation is that micrometastases and isolated tumor cells were not included in the definition of LNM in this study, because routine HE staining was used for pathological examination. As a result, the model's performance in predicting micrometastatic disease remains unknown. Future studies incorporating serial sectioning and immunohistochemical staining (e.g., anti-cytokeratin) are warranted to evaluate whether the CONUT score and CALLY index can also predict micrometastatic LNM.

Conclusions

In conclusion, radiologically suspicious lymph nodes, an elevated CONUT score, and a decreased CALLY index were identified as independent predictors of LNM in early gastric cancer. The combined model incorporating these three factors demonstrates favorable discrimination, calibration, and clinical utility, enabling preoperative stratification of patients by nodal metastasis risk. As simple and cost-effective nutritional-inflammatory composite indicators, the CONUT score and CALLY index hold promise for clinical application in preoperative risk assessment. However, multicenter prospective studies are warranted to further validate the model's predictive performance.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

XJS and YY designed the research study. YY and YND performed the research. XJS, RGD and YY analyzed the data. XJS drafted the article and all authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study protocol was approved by the Ethics Committee of Shijiazhuang People's Hospital (Approval No.: 2026(147)). Due to the retrospective nature of the study, informed consent was waived by the ethics committee. This study process adhered to the ethical principles of the Declaration of Helsinki.

Acknowledgment

Not applicable.

Funding

This work was supported by Shijiazhuang Science and Technology Research and Development Project (No.211460923).

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Morgan E, Arnold M, Camargo MC, Gini A, Kunzmann AT, Matsuda T, et al. The current and future incidence and mortality of gastric cancer in 185 countries, 2020-40: A population-based modelling study. EClinicalMedicine. 2022; 47: 101404. https://doi.org/10.1016/j.eclinm.2022.101404

[2] Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA: a Cancer Journal for Clinicians. 2021; 71: 209–249. https://doi.org/10.3322/caac.21660

[3] Jung YJ, Kim SJ, Seo HS, Lee HH, Song KY, Kim SG. Low Absolute Lymphocyte Count Correlates with Lymph Node Metastases and Worse Survival of Patients with Gastric Cancer. Annals of Surgical Oncology. 2024; 31: 6951–6958. https://doi.org/10.1245/s10434-024-15874-w

[4] He Y, Xie X, Yang B, Jin X, Feng Z. Combining biomarkers to construct a novel predictive model for predicting preoperative lymph node metastasis in early gastric cancer. Frontiers in Oncology. 2025; 15: 1533889. https://doi.org/10.3389/fonc.2025.1533889

[5] Xu HM, Wang PL, Gong YB. Optimization of TNM staging and control of pathological quality in gastric cancer. Zhonghua Wei Chang Wai Ke Za Zhi = Chinese Journal of Gastrointesti-

nal Surgery. 2020; 23: 87–91. https://doi.org/10.3760/cma.j.issn.1671-0274.2020.01.016 (In Chinese)

[6] Kwee RM, Kwee TC. Imaging in assessing lymph node status in gastric cancer. Gastric Cancer: Official Journal of the International Gastric Cancer Association and the Japanese Gastric Cancer Association. 2009; 12: 6–22. https://doi.org/10.1007/s10120-008-0492-5

[7] Teng F, Fu YF, Wu AL, Xian YT, Lin J, Han R, et al. Computed Tomography-Based Predictive Model for the Probability of Lymph Node Metastasis in Gastric Cancer: A Meta-analysis. Journal of Computer Assisted Tomography. 2024; 48: 19–25. https://doi.org/10.1097/RCT.0000000000001530

[8] Li J, Zhang S, Hu X, Huang T, Chen M. Correlation between the C-reactive protein (CRP)-albumin-lymphocyte (CALLY) index and the prognosis of gastric cancer patients after gastrectomy: a systematic review and meta-analysis. Surgery Today. 2025; 55: 483–491. https://doi.org/10.1007/s00595-024-02921-y

[9] Shen DY, Li ZY, Xia WB, Li D, Zhao S, Yang X, et al. Long-term prognostic value of postoperative C-reactive protein in gastric cancer patients: a systematic review and meta-analysis. BMC Gastroenterology. 2025; 25: 887. https://doi.org/10.1186/s12876-025-04481-y

[10] Matsui R, Ohashi M, Ri M, Makuuchi R, Irino T, Hayami M, et al. Prognostic impact of postoperative fixed-point inflammation in patients with gastric cancer after curative gastrectomy: A validation cohort study. Annals of Gastroenterological Surgery. 2025; 9: 698–710. https://doi.org/10.1002/ags3.70006

[11] Christodoulidis G, Voutyras A, Fotakopoulos G, Koumarelas KE, Georgakopoulou VE, Kouliou MN, et al. CRP to Albumin Ratio as a Prognostic Nutrition-Based Biomarker for Patients With Gastric Cancer: A Narrative Review. Cureus. 2024; 16: e71516. https://doi.org/10.7759/cureus.71516

[12] Bernstein LH, Leukhardt-Fairfield CJ, Pleban W, Rudolph R. Usefulness of data on albumin and prealbumin concentrations in determining effectiveness of nutritional support. Clinical Chemistry. 1989; 35: 271–274.

[13] Matsui R, Nunobe S, Ri M, Makuuchi R, Irino T, Hayami M, et al. Low preoperative prealbumin increases non-gastric cancer mortality in patients with early or advanced gastric cancer after gastrectomy: a retrospective cohort study. Surgery Today. 2026; 56: 152–164. https://doi.org/10.1007/s00595-025-03112-z

[14] Mülküt F, Ofluoğlu CB, Başdoğan MK, Aydın İC, Akdoğan O, Gündoğdu A, et al. Prognostic value of prognostic nutritional index in patients undergoing surgery for gastric cancer. Frontiers in Surgery. 2025; 12: 1618111. https://doi.org/10.3389/fsurg.2025.1618111

[15] Yang S, Li Z, Wang T, Zou C, Wang S, Deng S, et al. Correlation between neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio with prognosis in gastric cancer patients undergoing neoadjuvant chemotherapy: a meta-analysis. BMC Gastroenterology. 2025; 25: 445. https://doi.org/10.1186/s12876-025-04056-x

[16] Hirahara N, Tajima Y, Fujii Y, Kaji S, Kawabata Y, Hyakudomi R, et al. Controlling Nutritional Status (CONUT) as a prognostic immunonutritional biomarker for gastric cancer after curative gastrectomy: a propensity score-matched analysis. Surgical Endoscopy. 2019; 33: 4143–4152. https://doi.org/10.1007/s00464-019-06723-z

[17] Jia P, Wu X, Shen F, Sun K, Wang X, Xu G, et al. The combination of handgrip strength and CONUT predicts overall survival in patients with gastrointestinal cancer: A multicenter cohort study. Clinical Nutrition (Edinburgh, Scotland). 2024; 43: 2057–2068. https://doi.org/10.1016/j.clnu.2024.07.026

[18] Liu X, Zhang D, Lin E, Chen Y, Li W, Chen Y, et al. Preoperative controlling nutritional status (CONUT) score as a predictor of long-term outcome after curative resection followed by adjuvant chemotherapy in stage II-III gastric Cancer. BMC Cancer. 2018; 18: 699. https://doi.org/10.1186/s12885-018-4616-y

[19] Okugawa Y, Ohi M, Kitajima T, Higashi K, Sato Y, Yamashita S, et al. Clinical feasibility of the preoperative C-reactive protein-albumin-lymphocyte index to predict short- and long-term outcomes of patients with gastric cancer. Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract. 2024; 28: 1045–1050. https://doi.org/10.1016/j.gassur.2024.04.016

[20] Chen D, Ma Y, Li J, Wen L, Liu L, Su J, et al. Prognostic and clinicopathological significance of C-reactive protein-albumin-lymphocyte(CALLY) in patients with digestive system neoplasms: a systematic review and meta-analysis. World Journal of Surgical Oncology. 2025; 23: 114. https://doi.org/10.1186/s12957-025-03779-1

[21] Pettigrew MF, Kumar P, Nahi SL, Reznik SI, Hammer STG, Porembka MR, et al. CT Scans Understage Lymph Nodes in Gastric and Gastroesophageal Adenocarcinoma. Journal of Surgical Oncology. 2025; 131: 1571–1579. https://doi.org/10.1002/jso.28112

[22] Chen J, Song P, Peng Z, Liu Z, Yang L, Wang L, et al. The Controlling Nutritional Status (CONUT) Score and Prognosis in Malignant Tumors: A Systematic Review and Meta-Analysis. Nutrition and Cancer. 2022; 74: 3146–3163. https://doi.org/10.1080/01635581.2022.2059091

[23] Zeng T, Ling X, Chen S, Yang J, Chen Y, Zhang C, et al. Prognostic value of nutritional risk assessment indices in patients with digestive system tumors. BMC Cancer. 2025; 25: 1385. https://doi.org/10.1186/s12885-025-14823-4

[24] Zhao H, Yin B, Li XR, Liu XY, Bu ZT, Shi HP. The CRP-albumin-lymphocyte index provides enhanced prognostic value in liver cancer compared to the TNM staging system. Scientific Reports. 2025; 15: 20090. https://doi.org/10.1038/s41598-025-03985-7

[25] Bahardoust M, Shamohammadi M, Danesh N, Garavand AA, Rezaei MK, Alipour H, et al. Prognostic Value of CRP-Albumin-Lymphocyte (CALLY) Index in Colorectal Cancer Survival: A Multicenter Retrospective Cohort Study. Journal of Gastrointestinal Cancer. 2025; 56: 183. https://doi.org/10.1007/s12029-025-01307-8