Nutritional risk index predicts the prognosis of gastric cancer patients with pyloric stenosis who received preoperative parenteral nutrition

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Abstract. Patients with gastric cancer with pyloric stenosis frequently have poor nutritional status and preoperative parenteral nutrition has been a common treatment strategy. The present study aimed to explore the predictive ability of the nutritional risk index (NRI) regarding the prognosis of patients with gastric cancer and pyloric stenosis who received preoperative parenteral nutrition. A total of 194 patients with gastric cancer with pyloric stenosis who received preoperative parenteral nutrition at Tthe Second People's Hospital of Neijiang (Neijiang, China) between January 2016 and December 2021 were included. At the same time, 221 patients with gastric cancer without pyloric stenosis who received surgery during the same period were also collected and the clinicopathological characteristics of the patients were compared. The optimal cut-off value of the NRI was determined from the receiver operating characteristic curve and prognostic factors were identified by survival analysis. Finally, a nomogram was constructed to predict the survival probability of patients with gastric cancer. The results indicated that patients with pyloric stenosis exhibited a wide range of unfavorable pathological characteristics and blood parameters. In addition, their overall survival (OS) was significantly worse (P<0.001). Among the patients with pyloric stenosis, there were 120 patients (61.9%) with an NRI <93.42 and 74 patients (38.1%) with NRI ≥93.42. Furthermore, patients with an NRI <93.42 had poorer OS (34.37 months vs. not reached, P=0.004). Of note, age, tumor size, radical resection, NRI and TNM stage were determined to be independent prognostic factors for OS. The C-index of the nomogram was 0.760 (95%CI: 0.688-0.832). In conclusion, the NRI was indicated to be an accurate score reflecting the nutritional status of patients, which was able to predict the clinical outcomes of patients with gastric cancer with pyloric stricture who received preoperative parenteral nutrition. Patients with a low NRI had shorter survival times.

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Key words: gastric cancer, pyloric stenosis, preoperative parenteral nutrition, nutritional risk index, prognosis

Introduction

As the fifth most common cancer type and the third leading cause of cancer-related death worldwide, gastric cancer remains a serious health challenge (1). Cancer patients with poor nutritional status are not only limited in their choice of treatment strategies but also often have worse clinical outcomes (2,3). The nutritional status of cancer patients deserves attention, particularly that of patients with digestive tract cancers (4,5).

Pyloric stenosis is a common complication in patients with gastric cancer, particularly in antral tumors (6). Mechanical obstruction of the pyloric duct due to tumor progression causes patients to suffer from digestive system symptoms such as abdominal pain, bloating and loss of appetite, which severely affects energy intake. The increase in energy consumption caused by cancer makes the nutritional status of patients with pyloric stenosis deteriorate rapidly, even leading to cachexia (7-9). Numerous studies have explored that poor nutritional status was an important negative influence on the development of postoperative complications and on prognosis (10-12). Parenteral nutrition is an important treatment strategy for malnourished cancer patients. Preoperative parenteral nutrition may not only improve the treatment tolerance of cancer patients but also reduce the occurrence of postoperative complications and perioperative mortality (13).

The nutritional risk index (NRI) incorporates changes in patient weight and serum albumin levels, making it an accurate scoring system for evaluating the nutritional status of cancer patients (14). Numerous studies have revealed a significant association between NRI and clinical outcomes in a variety of cancer types, including gastric cancer (15-17). Patients with gastric cancer with pyloric stricture who received preoperative parenteral nutrition have a unique nutritional status and

the predictive ability of the NRI for them has remained to be clarified. The present study analyzed the pathological characteristics and clinical outcomes of patients with gastric cancer with pyloric stricture in detail and explored the predictive ability of NRI for the prognosis of patients with gastric cancer with pyloric stricture who received preoperative parenteral nutrition. These results provided a reference for evaluating the severity of the disease and the risk of postoperative recurrence.

Materials and methods

Patients. The present study included 415 patients with gastric cancer treated at The Second People's Hospital of Neijiang (Neijiang, China) between January 2016 and December 2021, including 194 cases with pyloric stenosis who received preoperative parenteral nutrition and 221 cases without pyloric stenosis. The inclusion criteria were as follows: i) All subjects were confirmed by pathological diagnosis; ii) all subjects received surgical treatment; iii) pyloric stenosis was confirmed by electric gastroscope or imaging examination; iv) all subjects with pyloric stenosis received parenteral nutrition for 3-14 days before the surgery; and v) all subjects had complete clinical information. Patients with pyloric stenosis received a peripherally inserted central catheter or central venous catheter within 24 h after admission. Parenteral nutrient solutions were Kabiven Peripheral (1,920 ml) or Kabiven Peripheral (1,440 ml) (Fresenius Kabi AG). This study was based on the Helsinki Declaration as well as its amendments and the protocol was approved by the Ethics Committee of the Second People's Hospital of Neijiang (Neijiang, China). This study was retrospective and did not require informed consent.

Data collection. The observation outcome of the present study was overall survival (OS), which was defined as the period from the first day of treatment to death or the last follow-up and was obtained by telephone follow-up. The NRI was calculated as follows: NRI=1.519 x albumin (g/l) + 41.7 x personal weight (kg)/ideal weight (kg) (14). The ideal weight was calculated by the Lorentz equations, which were as follows: Male ideal weight (kg)=height (m)-100-[(height (m)-150)/4]; female ideal weight (kg)=height (m)-100-[(height (m)-150)/2.5]. The cut-off point for the NRI in patients with pyloric stenosis was obtained from the receiver operating characteristic (ROC) curve. The area under curve of the ROC curve at the maximum Youden index of 0.239 was 0.633, with sensitivity and specificity values of 0.771 and 0.468, respectively (Fig. 1). All patients were divided into the low-value group (NRI<93.42) and the high-value group (NRI ≥93.42).

Statistical analysis. All analyses were completed by R 4.2.2 and continuous variables were expressed as the mean ± standard deviation and compared by Student's t-test and Pearson's correlation analysis, while categorical variables were reported as the number of patients and percentage and compared by the Chi-square test or Fisher's exact test. Kaplan-Meier survival curves and the log-rank test were used to compare differences in survival time. Univariate and multivariate Cox's analyses were conducted to identify significant prognostic markers and the predictive ability of NRI for OS was further explored through stratified analyses. Nomograms were also constructed

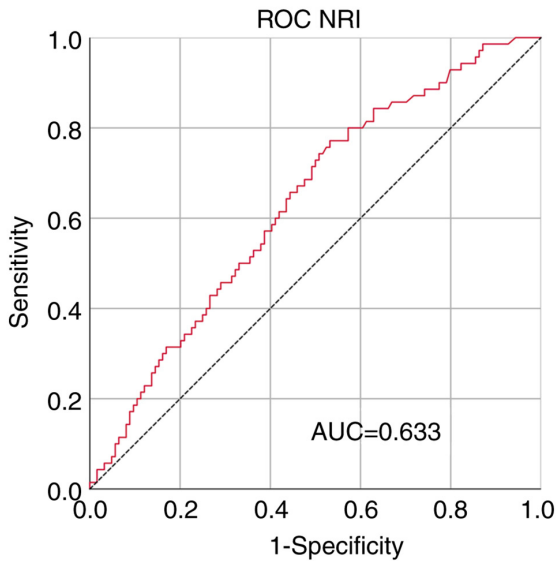

Figure 1. ROC curve of the NRI. ROC, receiver operating characteristic; NRI, nutritional risk index.

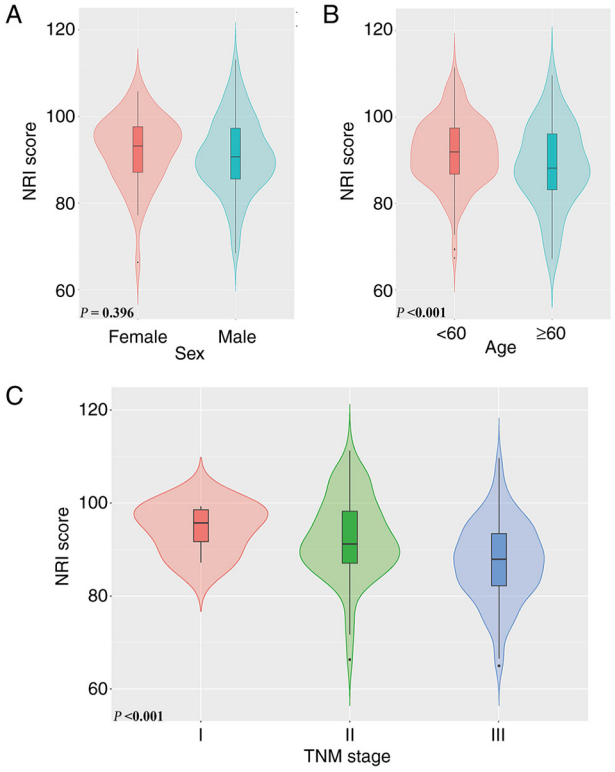

Figure 2. Distribution of the NRI in different groups. Distribution of the NRI in patient groups according to (A) Sex; (B) age; and (C) TNM stage. NRI, nutritional risk index.

the calibration curves were drawn to analyze the predictive effectiveness of the nomograms. A two-sided P<0.05 was considered to indicate a statistically significant difference.

Results

Patient characteristics. Of the 415 subjects included, 295 (71.1%) were males and 120 (28.9%) were females, with a

Table I. Patient characteristics grouped by pyloric stenosis.

Item	Total (n=415)	Pyloric stenosis		P-value
		Yes (n=194)	No (n=221)	
Age, years	60.83±10.42	63.85±9.55	58.18±10.46	<0.001
Sex				0.048
Male	295 (71.1)	147 (75.8)	148 (67.0)	
Female	120 (28.9)	47 (24.2)	73 (33.0)	
BMI, kg/m^2	21.97±3.51	20.83±3.34	22.97±3.34	<0.001
Length of stay, days	18.44±5.67	19.06±5.25	17.90±5.98	0.036
Stomachache				<0.001
Yes	254 (61.2)	98 (50.5)	156 (70.6)	
No	161 (38.8)	96 (49.5)	65 (29.4)	
Abdominal distension				<0.001
Yes	177 (42.7)	113 (58.2)	64 (29.0)	
No	238 (57.3)	81 (41.8)	157 (71.0)	
Black stool				0.814
Yes	92 (22.2)	44 (22.7)	48 (21.7)	
No	323 (77.8)	150 (77.3)	173 (78.3)	
Weight loss				<0.001
Yes	271 (65.3)	167 (86.1)	104 (47.1)	
No	144 (34.7)	27 (13.9)	117 (52.9)	
Fatigue				0.578
Yes	134 (32.3)	60 (30.9)	74 (33.5)	
No	281 (67.7)	134 (69.1)	147 (66.5)	
Sour regurgitation				0.001
Yes	138 (33.3)	80 (41.2)	58 (26.2)	
No	277 (66.7)	114 (58.8)	163 (73.8)	
Radical resection				<0.001
Yes	346 (83.4)	130 (67.0)	216 (97.7)	
No	69 (16.6)	64 (33.0)	5 (2.3)	
Primary tumor site				0.025
Upper 1/3	20 (4.8)	13 (6.7)	7 (3.2)	
Middle 1/3	56 (13.5)	22 (11.3)	34 (15.4)	
Lower 1/3	320 (77.1)	155 (79.9)	165 (74.7)	
Whole	19 (4.6)	4 (2.1)	15 (6.8)	
Borrmann type				<0.001
I	34 (8.2)	1 (0.5)	33 (14.9)	
II	106 (25.5)	30 (15.5)	76 (34.4)	
III	250 (60.2)	141 (72.7)	109 (49.3)	
IV	25 (6.0)	22 (11.3)	3 (1.4)	
LNP				<0.001
Yes	205 (49.4)	151 (77.8)	54 (24.4)	
No	210 (50.6)	43 (22.2)	167 (75.6)	
Tumor size, mm				<0.001
<50	229 (55.2)	85 (43.8)	144 (65.2)	
≥50	186 (44.8)	109 (56.2)	77 (34.8)	
Differentiation				<0.001
Poor	223 (53.7)	79 (40.7)	144 (65.2)	
Moderate	189 (45.5)	112 (57.7)	77 (34.8)	
Well	3 (0.7)	3 (1.5)	0 (0.0)	
TNM stage				<0.001
I	21 (5.1)	4 (2.1)	17 (7.7)	
II	181 (43.6)	62 (32.0)	119 (53.8)	
III	213 (51.3)	128 (66.0)	85 (38.5)	

Table I. Continued.

Item	Total (n=415)	Pyloric stenosis		P-value
		Yes (n=194)	No (n=221)	
ALT, U/l	18.37±12.92	14.29±10.42	21.94±13.83	<0.001
AST, U/l	20.33±8.24	18.35±7.79	22.07±8.24	<0.001
ALP, U/l	76.05±45.07	72.39±24.12	76.43±21.27	0.070
γ-GGT, U/l	21.23±17.70	17.64±11.86	24.37±21.09	<0.001
LDH, U/l	163.43±52.66	162.91±68.65	163.90±32.92	0.855
TBIL, μmol/l	12.30±9.19	10.82±9.23	13.59±8.97	0.002
DBIL, μmol/l	3.62±9.19	2.67±1.88	4.46±1.90	<0.001
IDBIL, μmol/l	8.13±4.58	7.73±5.02	8.47±4.15	0.100
TP, g/l	64.86±7.42	61.21±7.20	68.06±6.00	<0.001
ALB, g/l	38.37±5.05	35.52±4.40	40.86±4.21	<0.001
GLOB, g/l	26.77±4.55	26.34±5.37	27.14±3.65	0.079
PALB, mg/l	229.50±83.86	171.94±52.37	280.02±73.10	<0.001
Urea, mmol/l	6.34±5.95	6.56±7.18	6.14±4.62	0.474
CREA, μmol/l	79.78±31.41	74.67±14.09	84.27±40.48	0.002
UA, μmol/l	281.37±88.86	258.54±91.78	301.42±81.28	<0.001
Glu, mmol/l	5.45±1.51	5.71±1.80	5.22±1.16	0.001
Hb, g/l	129.19±27.25	119.66±27.12	137.56±24.53	<0.001
Hct, l/l	39.47±8.39	37.23±9.50	41.44±6.71	<0.001
W, 10^9/l	6.49±2.09	6.14±1.79	6.80±2.28	0.001
N, 10^9/l	4.06±1.87	4.04±1.57	4.07±2.10	0.841
L, 10^9/l	1.75±0.70	1.45±0.55	2.02±0.71	<0.001
P, 10^9/l	256.09±79.89	258.37±82.60	254.09±77.57	0.587
NRI	97.00±9.67	91.46±8.61	101.87±7.74	<0.001

Values are expressed as n (%) or the mean ± standard deviation. BMI, body mass index; LNP, lymph node-positive; ALT, alanine transaminase; AST, aspartate aminotransferase; APL, alkaline phosphatase; γ-GGT, γ-glutamyl transferase; LDH, lactate dehydrogenase; TBIL, total bilirubin; DBIL, direct bilirubin; IDBIL, indirect bilirubin; TP, total protein; ALB, albumin; GLOB, globulin; PALB, prealbumin; Urea, urea nitrogen; CREA, creatinine; UA, uric acid; Glu, glucose; Hb, hemoglobin; Hct, hematocrit; W, white blood cell; N, neutrophils; L, lymphocyte; P, platelet; NRI, Nutritional Risk Index.

mean (± SD) age of 60.83±10.42 years. There were 194 patients (46.7%) with pyloric stenosis, and it was observed that subjects with pyloric stenosis had a higher age, larger proportion of males, lower body mass index (BMI), longer length of stay, lower occurrence of stomachache, a higher occurrence of abdominal distension, weight loss and sour regurgitation, a larger proportion of cases with lymph node-positive status, TNM stage III and lower NRI, as well as larger tumor size and poorer blood parameters (all P<0.05). In addition, Fisher's exact test indicated that tumors in patients with pyloric stenosis tended to be less frequently subjected to radical resection (P<0.001), and more frequently located in the lower 1/3 (P=0.025), moderately differentiated (P=0.004) and of the Borrmann type III (P<0.001) (Table I).

NRI. Comparisons of different groups of patients with pyloric stenosis revealed that there was no significant difference in the NRI score among patients with different sex (P=0.396). However, patients with higher age had a lower NRI score (P<0.001). Furthermore, a decrease in the NRI score was observed to be associated with an increase in TNM stage (P<0.001) (Fig. 2A-C). After conducting a Gaussian distribution test on the data, Pearson correlation analysis was performed on all parameters that satisfied the criteria for a Gaussian distribution. The NRI was found to be significantly correlated with higher total protein, albumin (ALB), pre-ALB, hemoglobin and hematocrit (all R>0.3, P<0.05) (Fig. 3).

All cases were stratified into two groups based on the cut-off point of the NRI. There were 120 patients (61.9%) with NRI <93.42 and 74 patients (38.1%) with NRI ≥93.42. The NRI was related to age, BMI, TNM stage and extensive blood parameters (all P<0.05) (Table II).

Survival analysis for NRI. The cohort of the present study included 194 cases (46.7%) with pyloric stenosis and 221 cases (53.3%) with non-pyloric stenosis. The 1-year survival rate of patients with pyloric stenosis and non-pyloric stenosis was 85.7 and 98.2%, while the 3-year survival rate was 54.5 vs. 90.0% and the 5-year survival rate was 44.6 and 71.9%, respectively. Patients with pyloric stenosis had a shorter OS [median survival time (MST): 42.71 vs. 69.92 months, P<0.001] (Fig. 4A).

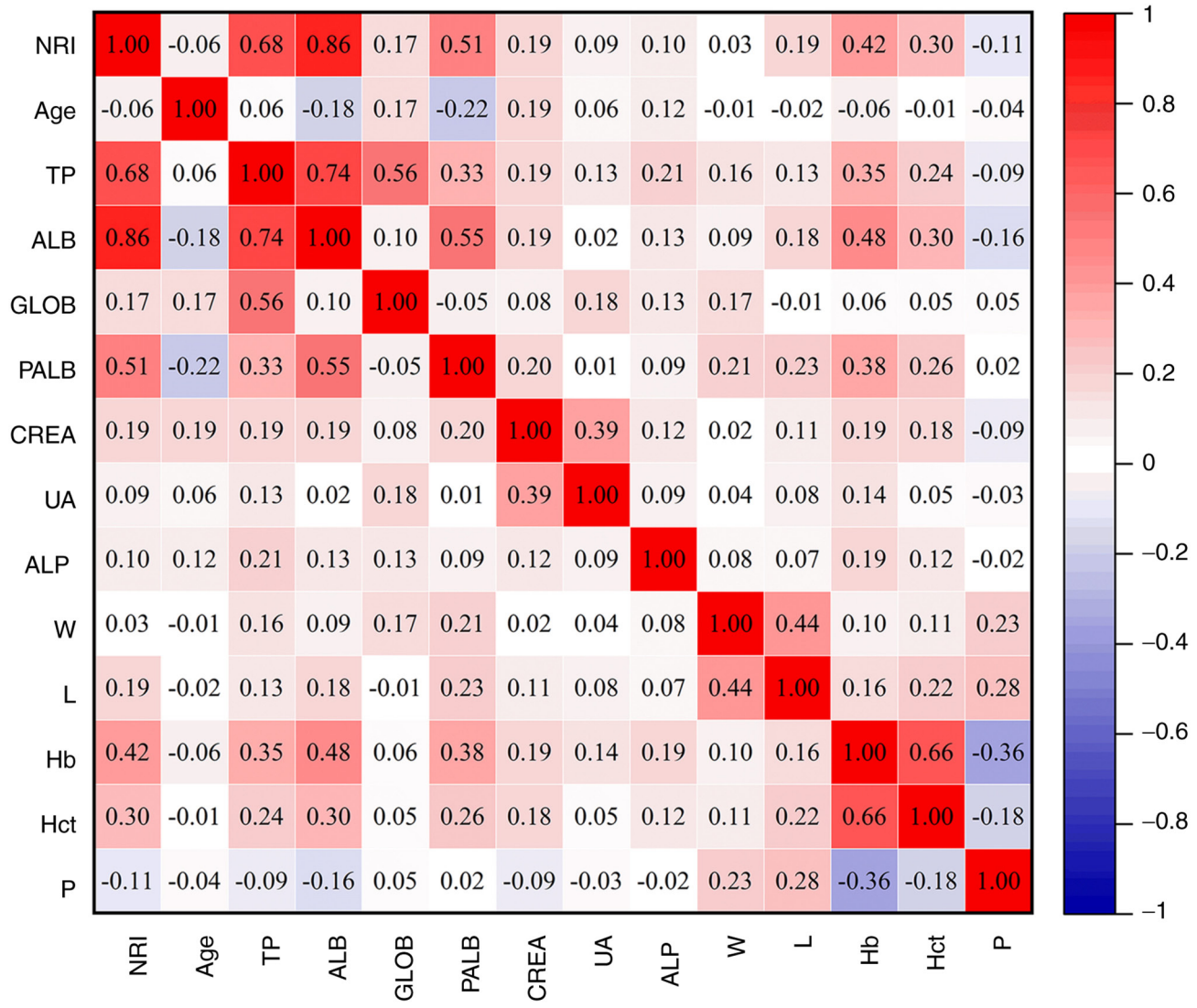

Figure 3. Person analysis of the correlation of the NRI with various factors. NRI, nutritional risk index; TP, total protein; ALB, albumin; GLOB, globulin; PALB, prealbumin; CREA, creatinine; UA, uric acid; Hb, hemoglobin; W, white blood cell; L, lymphocyte; Hb, hemoglobin; Hct, hematocrit; P, platelet.

Among the patients with pyloric stenosis, there were 120 cases (61.9%) with NRI <93.42 and 74 cases (38.1%) with NRI ≥93.42. The 1- and 3-year survival rates of patients with NRI <93.42 and NRI ≥93.42 were 82.2 and 48.7 vs. 91.2 and 66.0%, respectively. Patients with NRI <93.42 had shorter OS (MST: 34.37 months vs. not reached, P=0.004) (Fig. 4B).

Univariate and multivariate survival analysis. In the present study, OS was related to age, ALB, NRI, radical resection, tumor size and TNM stage (all P<0.05). The independent prognostic factors for OS were age, NRI, radical resection, tumor size and TNM stage (all P<0.05) (Table III). In addition, a stratified analysis was performed according to the multivariate analysis. It was found that a low NRI was associated with a shorter survival time in patients who were males and those who had a stomachache, tumor size ≥50 mm, radical resection, TNM stage II and TNM stage III (all P<0.05) (Fig. 5).

Nomogram for OS. Finally, a nomogram was established to predict the survival probability of patients with pyloric stenosis based on independent prognostic factors obtained from the multivariate analysis (Fig. 6). To verify the predictive ability of the nomogram, a bootstrap calibration was conducted and the calibration curves were plotted (Fig. 7A-C). The C-index of the nomogram was 0.760 (95%CI: 0.688-0.832) and the calibration curves also showed good predictive ability.

Discussion

Pyloric stenosis is a common complication in patients with gastric cancer, which is related to the site of tumor growth and disease progression. However, detailed and comprehensive studies on the clinical and pathological characteristics and prognosis of patients with gastric cancer with pyloric stenosis are still lacking. In addition, patients with pyloric stenosis may present with malnutrition early. Therefore, preoperative parenteral nutrition is essential to restore patients' surgical tolerance. The predictive ability of the NRI regarding the prognosis of such patients had so far remained elusive.

Certain clinical studies have reported on patients with gastric cancer with early pyloric stenosis. In 1998, Watanabe *et al* (6) analyzed 122 gastric cancer patients with pyloric stenosis and

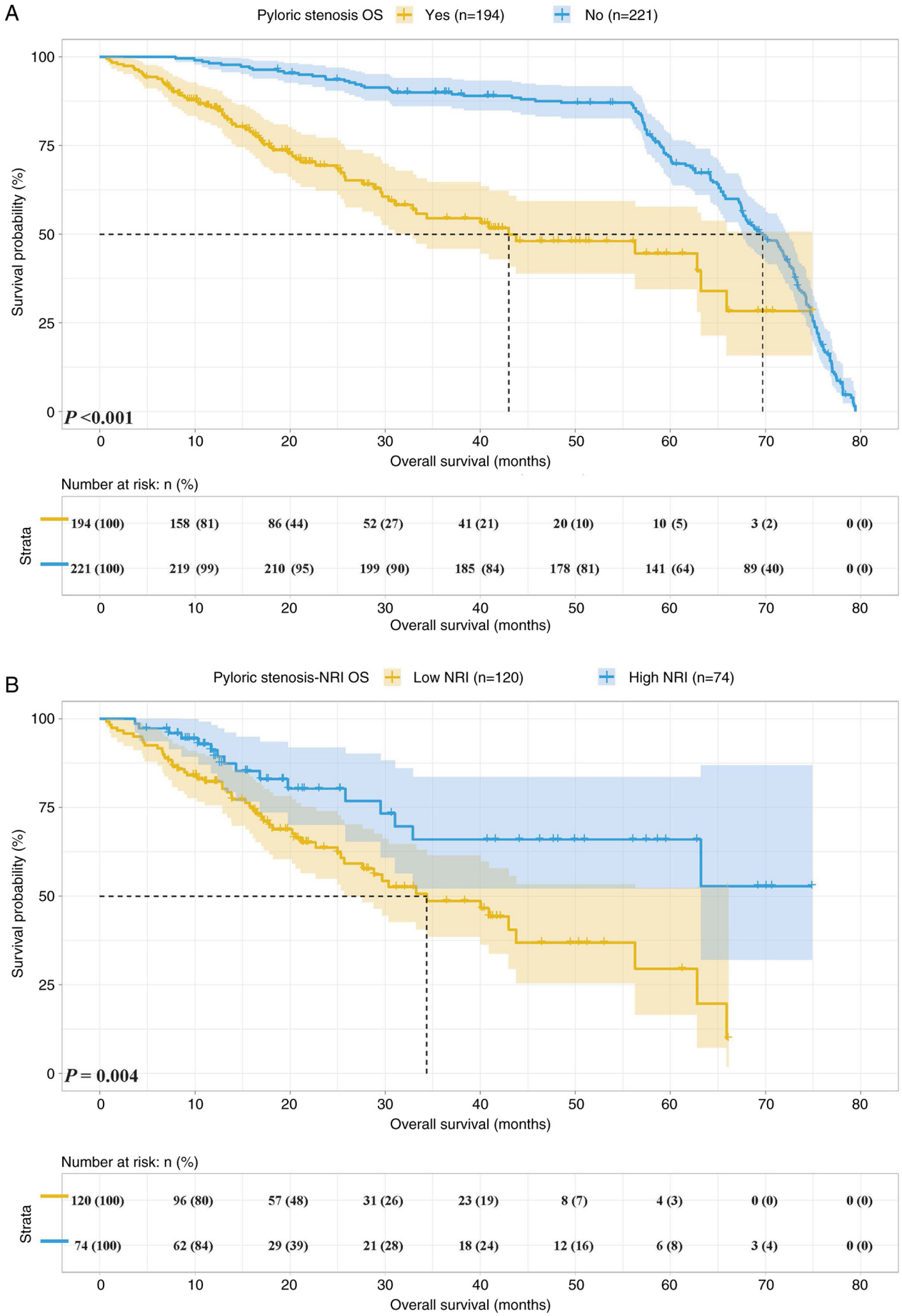

Figure 4. NRI-related survival curve. (A) Survival curve of NRI for OS in all patients; (B) Survival curve of NRI for OS in pyloric stenosis patients. OS, overall survival; NRI, nutritional risk index.

Table II. Patient characteristics grouped by NRI.

Item	Total (n=194)	NRI		P-value
		<93.42 (n=120)	≥93.42 (n=74)	
Age, years	63.85±9.55	65.54±8.77	60.25±9.31	<0.001
Sex				0.160
Male	147 (75.8)	95 (79.2)	52 (70.3)	
Female	47 (24.2)	25 (20.8)	22 (29.7)	
BMI, kg/m^2	20.83±3.34	19.70±3.28	22.66±2.55	<0.001
Length of stay, days	19.06±5.25	19.30±5.21	18.68±5.32	0.422
Stomachache				0.855
Yes	98 (50.5)	60 (50.0)	38 (51.4)	
No	96 (49.5)	60 (50.0)	36 (48.6)	
Abdominal distension				0.385
Yes	113 (58.2)	67 (55.8)	46 (62.2)	
No	81 (41.8)	53 (44.2)	28 (37.8)	
Black stool				0.529
Yes	44 (22.7)	29 (24.2)	15 (20.3)	
No	150 (77.3)	91 (75.8)	59 (79.7)	
Weight loss				0.765
Yes	167 (86.1)	104 (86.7)	63 (85.1)	
No	27 (13.9)	16 (13.3)	11 (14.9)	
Fatigue				0.777
Yes	60 (30.9)	38 (31.7)	22 (29.7)	
No	134 (69.1)	82 (68.3)	52 (70.3)	
Sour regurgitation				0.175
Yes	80 (41.2)	54 (45.0)	26 (35.1)	
No	114 (58.8)	66 (55.0)	48 (64.9)	
Radical resection				0.283
Yes	130 (67.0)	77 (64.2)	53 (71.6)	
No	64 (33.0)	43 (35.8)	21 (28.4)	
Primary tumor site				0.106
Upper 1/3	13 (6.7)	12 (10.0)	1 (1.4)	
Middle 1/3	22 (11.3)	12 (10.0)	10 (13.5)	
Lower 1/3	155 (79.9)	93 (77.5)	62 (83.8)	
Whole	4 (2.1)	3 (2.5)	1 (1.4)	
Borrmann type				0.554
I	1 (0.5)	0 (0.0)	1 (1.4)	
II	30 (15.5)	17 (14.2)	13 (17.6)	
III	141 (72.7)	89 (74.2)	52 (70.3)	
IV	22 (11.3)	14 (11.7)	8 (10.8)	
LNP				0.200
Yes	151 (77.8)	97 (80.8)	54 (73.0)	
No	43 (22.2)	23 (19.2)	20 (27.0)	
Tumor size, mm				0.863
<50	85 (43.8)	52 (43.3)	33 (44.6)	
≥50	109 (56.2)	68 (56.7)	41 (55.4)	
Differentiation				0.552
Poor	79 (40.7)	48 (40.0)	31 (41.9)	
Moderate	112 (57.7)	71 (59.2)	41 (55.4)	
Well	3 (1.5)	1 (0.8)	2 (2.7)	
TNM stage				<0.001
I	4 (2.1)	1 (0.1)	3 (4.1)	
II	62 (32.0)	25 (20.8)	37 (50.0)	
III	128 (66.0)	94 (79.1)	34 (45.9)	

Table II. Continued.

Item	Total (n=194)	NRI		P-value
		<93.42 (n=120)	≥93.42 (n=74)	
ALT, U/l	14.29±10.41	12.41±7.67	17.34±13.27	0.004
AST, U/l	18.35±7.79	17.27±5.77	20.11±10.05	0.029
ALP, U/l	72.39±24.12	70.33±23.17	75.73±25.39	0.130
γ-GGT, U/l	17.64±11.86	16.17±9.04	20.04±15.14	0.049
LDH, U/l	162.91±68.65	157.90±43.05	171.03±96.60	0.197
TBIL, μmol/l	10.82±9.23	9.79±5.42	12.49±13.14	0.096
DBIL, μmol/l	2.67±1.88	2.56±1.67	2.84±2.17	0.319
IDBIL, μmol/l	7.73±5.02	7.26±4.46	8.48±5.75	0.100
TP, g/l	61.21±7.20	58.15±6.00	66.18±6.15	<0.001
ALB, g/l	35.52±4.40	33.14±3.19	39.39±3.17	<0.001
GLOB, g/l	26.34±5.37	26.10±5.91	26.73±4.36	0.422
PALB, mg/l	171.94±52.37	155.83±45.50	198.08±52.50	<0.001
Urea, mmol/l	6.56±7.18	6.03±2.10	7.43±11.31	0.188
CREA, μmol/l	74.67±14.09	72.39±12.70	78.36±15.49	0.004
UA, μmol/l	258.54±91.78	252.38±90.36	168.51±93.80	0.235
Glu, mmol/l	5.71±1.80	5.73±1.84	5.69±1.74	0.886
Hb, g/l	119.66±27.12	113.33±25.55	129.92±16.61	<0.001
Hct, l/l	37.23±9.50	35.67±9.26	39.75±9.40	<0.001
W, 10^9/l	6.14±1.79	6.13±1.93	6.16±1.55	0.913
N, 10^9/l	4.04±1.57	4.03±1.67	4.06±1.40	0.900
L, 10^9/l	1.45±0.55	1.40±0.54	1.53±0.57	0.101
P, 10^9/l	258.37±82.60	263.68±85.54	249.74±77.40	0.255

Values are expressed as n (%) or the mean ± standard deviation. NRI, nutritional risk index; BMI, body mass index; LNP, lymph node-positive; ALT, alanine transaminase; AST, aspartate aminotransferase; APL, alkaline phosphatase; γ-GGT, γ-glutamyl transferase; LDH, lactate dehydrogenase; TBIL, total bilirubin; DBIL, direct bilirubin; IDBIL, indirect bilirubin; TP, total protein; ALB, albumin; GLOB, globulin; PALB, prealbumin; Urea, urea nitrogen; CREA, creatinine; UA, uric acid; Glu, glucose; Hb, hemoglobin; Hct, hematocrit; W, white blood cell; N, neutrophils; L, lymphocyte; P, platelet.

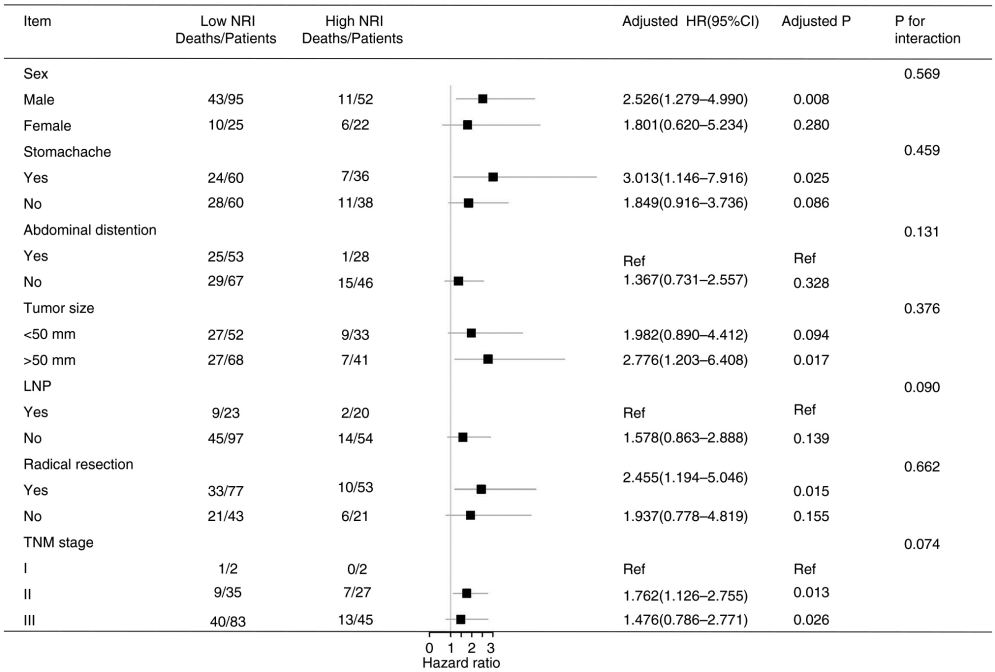

Figure 5. Stratified analysis for OS. OS, overall survival; NRI, nutritional risk index; LNP, lymph node-positive; HR, hazard ratio.

Table III. Univariate and multivariate analysis of factors influencing overall survival.

	Univariate analysis		Multivariate analysis	
Item	Hazard ratio (95%CI)	Crude P-value	Hazard ratio (95%CI)	Adjusted P
Age, years	1.011 (0.985-1.038)	0.018	1.009 (1.000-1.015)	0.049
ALB, g/l	0.925 (0.875-0.979)	0.007		
BMI, kg/m^2	0.963 (0.890-1.041)	0.339		
NRI (<93.42 vs. ≥93.42)	2.305 (1.309-4.058)	0.004	2.048 (1.139-3.811)	0.017
Sex (female vs. male)	1.168 (0.668-2.043)	0.586		
Stomachache	1.151 (0.717-1.848)	0.560		
Abdominal distension	1.187 (0.730-1.930)	0.490		
Black stool	1.288 (0.735-2.255)	0.376		
Weight loss	1.561 (0.713-3.416)	0.265		
Fatigue	1.155 (0.708-1.884)	0.564		
Sour regurgitation	1.164 (0.727-4.864)	0.528		
Radical resection	1.615 (0.989-2.636)	0.035	1.637 (0.969-2.765)	0.046
Primary tumor site				
Middle vs. upper 1/3	0.402 (0.148-1.094)	0.074	0.722 (0.250-2.084)	0.547
Lower vs. upper 1/3	0.431 (0.211-0.879)	0.021	0.607 (0.285-1.291)	0.195
Whole vs. upper 1/3	0.605 (0.131-2.801)	0.520	0.870 (0.151-5.011)	0.876
LNP	2.099 (1.100-4.007)	0.025	1.220 (0.425-3.506)	0.712
Tumor size (≥50 vs. <50 mm)	1.454 (0.905-2.336)	0.022	1.775 (1.064-2.960)	0.028
TNM stage				
II vs. I	2.541 (1.214-4.573)	0.004	2.354 (1.687-3.265)	0.006
III vs. I	3.459 (1.789-5.862)	0.012	2.582 (1.848-3.156)	0.015

ALB, albumin; NRI, nutritional risk index; BMI, body mass index; LNP, lymph node-positive.

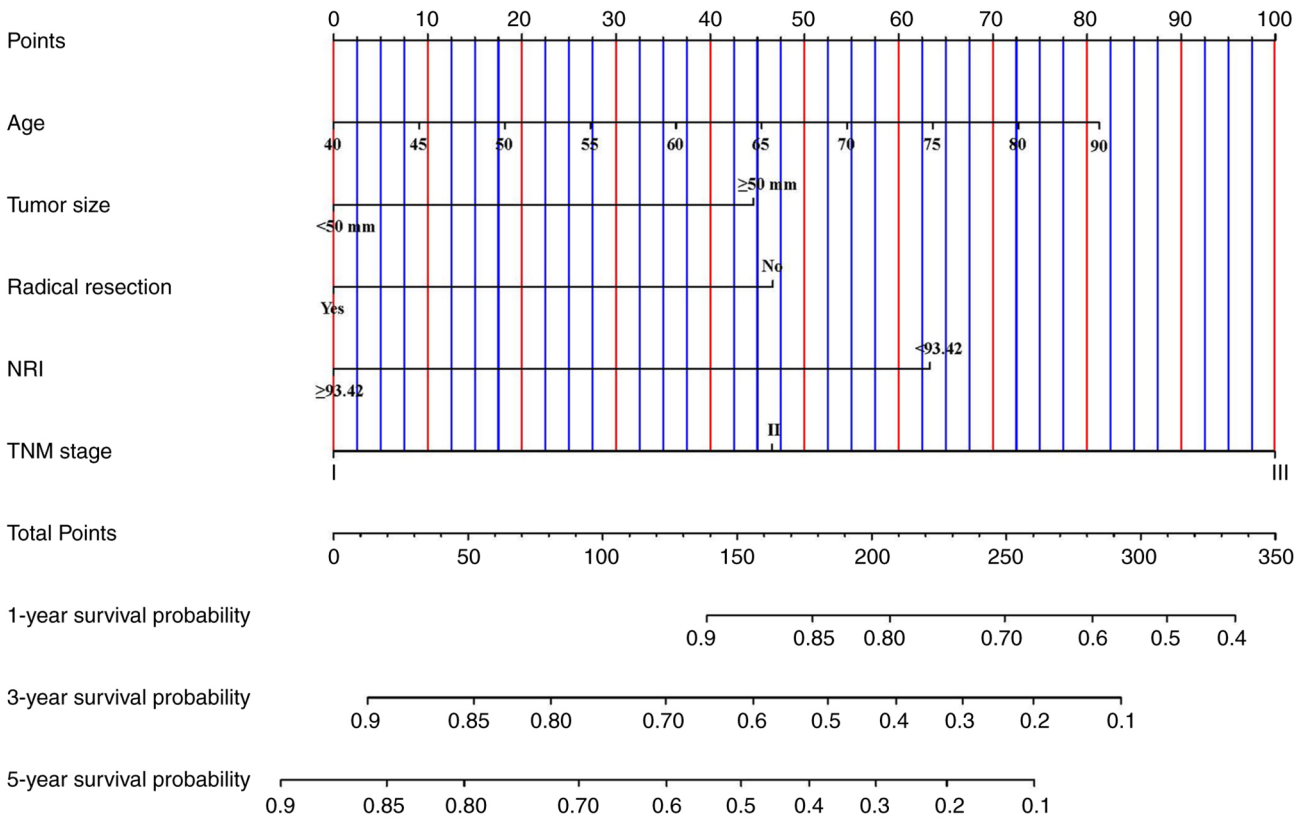

Figure 6. Nomogram for predicting survival probability of overall survival. NRI, nutritional risk index.

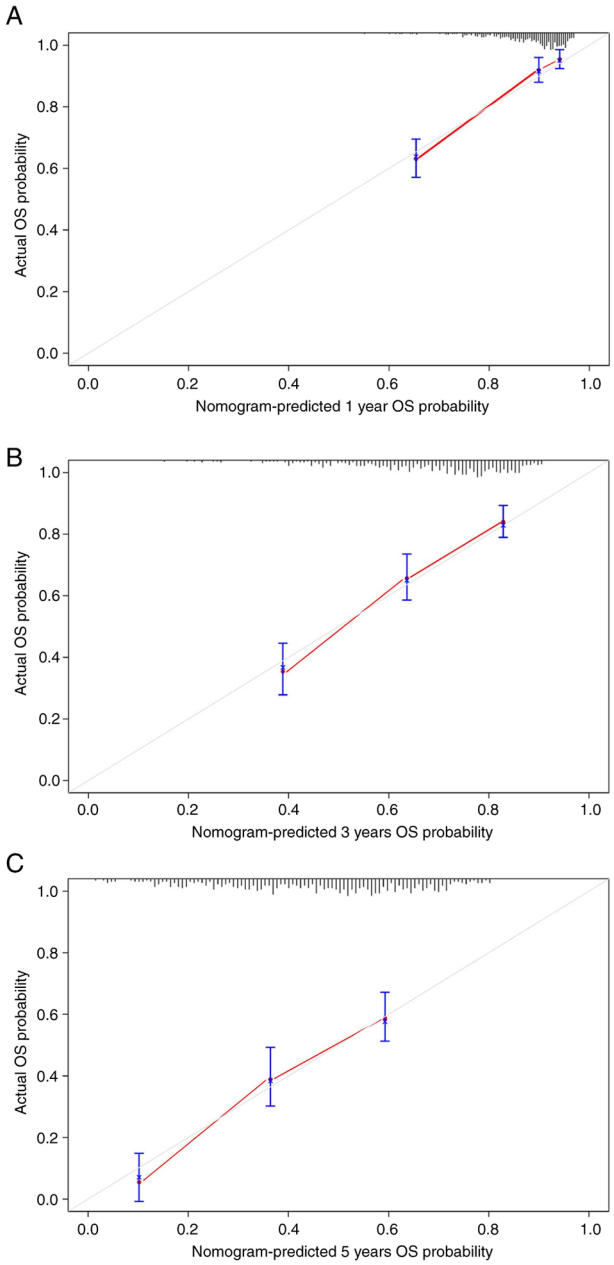

Figure 7. Calibration curves of the nomogram. (A) The 1-year calibration curves of the nomogram for OS; (B) 3-year calibration curves of the nomogram for OS; (C) 5-year calibration curves of the nomogram for OS. OS, overall survival.

found that those cases had faster disease progression and a higher probability of distant metastasis. In addition, they also found that operation was a significant prognostic factor for patients with pyloric stenosis, even if the tumor had distant metastasis. Another study by Mizutani *et al* (18) also found that patients with pyloric stenosis were more inclined to be stage IV and surgery was able to improve their prognosis. Of note, the NRI has been widely used in cancer for numerous years. Xie *et al* (16) combined the NRI and handgrip strength to predict the survival rate of patients with cancer cachexia and they found that NRI was an independent prognostic factor for cancer cachexia. Oh *et al* (19) analyzed the application of NRI in patients with head and neck cancer who received concurrent chemo-radiotherapy. They collected 110 patients and found that the NRI was able to predict OS and complications of their subjects. The close relationship between gastric cancer and nutritional status made the NRI equally widely used in gastric cancer. Song *et al* (20) specifically studied the predictive ability of the NRI regarding the prognosis of patients with stage III gastric cancer. Their results indicated that the NRI was related to a shorter survival time. Other studies on gastric cancer had also reached similar conclusions (21-25).

The present study mainly reported on the clinical and pathological characteristics of patients with gastric cancer with pyloric stricture and analyzed the application of the NRI in patients with gastric cancer with pyloric stricture who received preoperative parenteral nutrition. Correlation analysis indicated that pyloric stenosis was significantly associated with faster disease progression and poorer blood parameters. The NRI also had a strong predictive ability for OS in patients with pyloric stricture. In addition, further multivariate analysis of all patients with gastric cancer found that the NRI was an independent prognostic marker of OS. Finally, the bootstrap correction for the nomogram also showed good consistency between the predicted probability and the actual probability.

The causes of malnutrition in patients with gastric cancer with pyloric stenosis were multiple, mainly related to feeding difficulties and disease progression (26-30). The present study indicated that patients with pyloric stenosis were more prone to abdominal distension and higher TNM stage, which were the main reasons for malnutrition and shorter survival (31-34). The NRI contains ALB levels and body weight, which are closely related to the prognosis of patients with gastric cancer (35-37). ALB not only reflects the nutritional status of patients but also correlates with the systemic inflammatory status (38). Inflammatory factors may act on the liver and inhibit the synthesis of ALB by the liver (39,40). Low serum levels of ALB reflect poor hepatic functional reserve of patients to a certain extent, leading to worse treatment tolerance and shorter survival time (41). The body weight also reflects the nutritional status and it is associated with surgery or chemotherapy tolerance in cancer patients (42). Several studies have indicated that body weight was a strong independent prognostic factor for patients with gastric cancer and the predictive ability of the BMI regarding the clinical outcomes of patients with gastric cancer who received immune checkpoint inhibitors has also been confirmed (43,44).

Due to the retrospective nature of the present study, a certain degree of information bias was inevitable. In addition, the parenteral nutrition for certain patients with mild malnutrition was affected by the operation schedule and did not reach the optimal nutritional status. The present study was only for patients with pyloric stenosis and did not consider gastric emptying disorders due to other causes, such as Borrmann IV gastric cancer. Finally, although the NRI could accurately reflect the nutritional status of patients, it may be more effective when combined with other factors that reflect the inflammatory status or tumor progression. The conclusions of the present study still require to be further verified by numerous prospective studies.

In conclusion, the NRI was an accurate score reflecting the nutritional status of patients, which could predict the clinical outcomes for patients with gastric cancer with pyloric stricture

who received preoperative parenteral nutrition. Patients with a low NRI had shorter survival times.

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Data availability statement

All data generated or analyzed during this study are included in this published article.

Authors' contributions

GL designed and conducted the study, and drafted the manuscript. HS and LH were responsible for data collection, analysis and interpretation. GL and HS confirm the authenticity of all the raw data. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

This study was approved by the ethics committee of the Second People's Hospital of Neijiang (Neijiang, China) (approval no. LSY2022015). All patients provided written informed consent before the study.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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