SPANDIDOS PUBLICATIONS
ONCOLOGY LETTERS 27: 214, 2024

Effect of different preoperative nutritional treatments on postoperative recovery and clinical outcomes in patients with gastric cancer and early gastric outlet obstruction

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Received October 15, 2023; Accepted February 20, 2024

DOI: 10.3892/ol.2024.14348

Abstract. Patients with gastric cancer and early gastric outlet obstruction often experience malnutrition and require various nutritional support strategies. This study aimed to evaluate the impact of different preoperative nutritional treatments on their postoperative recovery and prognosis. The present retrospective study collected data from 467 patients with gastric cancer and early gastric outlet obstruction who underwent surgery at Harbin Medical University Cancer Hospital (Harbin, China) between January 2016 and December 2018. All patients received preoperative nutritional treatment, with a mean treatment duration of 8.23±2.33 days. The present study analyzed associations and survival in different groups using χ^2, independent-samples t-test, ANOVA and log-rank tests. Furthermore, single- and multi-factor survival analyses were conducted and nomograms and calibration curves constructed to investigate factors influencing patient survival. In this study, 230 patients (49.3%) received only parenteral nutrition (PN; Group 1), 162 patients (34.7%) received PN combined with enteral nutrition (EN; Group 2) and 75 patients (16.0%) received PN combined with a full- or semi-liquid diet (Group 3). No significant differences in clinical and pathological parameters were observed among the groups. However, Group 2 showed significant advantages in postoperative recovery, including faster time to first postoperative bowel sounds, flatus and bowel movement. Survival analysis indicated that Group 3 had shorter progression-free survival (χ^2=30.485) and overall survival (χ^2=31.249). Preoperative nutritional treatment was identified as an independent prognostic factor. Preoperative PN combined with EN proved advantageous for postoperative recovery of patients with gastric cancer and early gastric outlet obstruction. Furthermore, PN combined with full- or semi-liquid diets may not have fully met the nutritional needs of these patients, resulting in less favorable clinical outcomes.

Introduction

As the fifth most common type of cancer and the third highest cause of cancer-related mortality worldwide as of 2020, gastric cancer remains a global health threat due to its high malignancy (1). Gastric outlet obstruction refers to a condition where food and gastric juices cannot smoothly pass through the exit of the stomach into the duodenum or small intestine (2). This is a common complication of gastric cancer and can occur at any stage of the treatment process (3). Certain patients may experience symptoms of gastric outlet obstruction at an early stage due to the unfavorable location of the tumor or high malignancy (4). These patients often suffer from abdominal distention and eating difficulties, resulting in severe malnutrition and decrease in immune function (5).

In recent years, the treatment paradigm for gastric cancer has evolved to incorporate comprehensive strategies such as surgical treatment, adjuvant and targeted therapy and immunotherapy (6). However, surgery remains the primary treatment choice for gastric cancer (7). Patients with early gastric outlet obstruction often have poor nutritional status and treatment tolerance and are often unable to receive surgery immediately (8). Therefore, nutritional support therapy serves a key role in their treatment regimen. Commonly used clinical nutritional support strategies include enteral nutrition (EN), parenteral nutrition (PN) and the addition of full- or semi-liquid diets (9-11). While there are clear indications and methods for nutritional support in gastric cancer treatment recommendations, numerous factors such as disease state of the patient, economic situation and personal preferences have led to the clinical use of multiple nutritional treatment methods (12). Further research is needed to explore the differences in the effectiveness of these treatment methods.

The present study aimed to assess the impact of different preoperative nutritional treatments on postoperative recovery and prognosis in patients with gastric cancer and early gastric outlet obstruction by retrospectively collecting nutritional approaches and clinical information.

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Key words: gastric cancer, gastric outlet obstruction, nutritional treatment, postoperative recovery, clinical outcome

Materials and methods

Patients. The present study was a retrospective study that included 467 patients with gastric cancer and early gastric outlet obstruction who underwent surgery at Harbin Medical University Cancer Hospital (Harbin, China) from January 2016 to December 2018. The inclusion criteria were as follows: i) Patients were diagnosed with gastric cancer through pathological examination; ii) patients underwent surgical treatment; iii) patients were confirmed to have gastric outlet obstruction through gastroscopy, enhanced computed tomography and patient assessment; iv) no occurrence of distant metastasis and v) all patients received preoperative nutritional therapy. Preoperative nutritional therapy was administered for 7-20 days, with a mean treatment duration of 8.23±2.33 days. The inability to restore nutritional status through nutritional therapy and lack of follow-up data were exclusion criteria. The present study obtained approval from the Ethics Committee of Harbin Medical University Cancer Hospital (approval no. 2019-57-IIT). Due to the retrospective nature of this study, the Ethics Committee of Harbin Medical University Cancer Hospital waived the requirement for informed consent.

Data collection and follow-up. The present study screened and collected the medical history data of all enrolled patients through the medical record system and obtained progression-free survival (PFS), defined as the period during which there is no tumor growth, spread or metastasis following treatment, and overall survival (OS) defined as the period from the initiation of treatment to the patient death or the last follow-up. Patients received regular telephone follow-ups every three months, with the longest follow-up duration being 80 months.

Preoperative nutritional treatment. All patients received central venous catheter placement on the day of admission or the following day; those receiving EN also underwent nasoenteric nutrition tube placement. PN solution used was Kabiven Peripheral (1,440 ml; Fresenius Kabi AB), providing energy at a rate of 30-35 kcal/kg body weight per day. The EN solution used was Enteral Nutritional Emulsion (TPF-T; Fresenius Kabi AB), which was combined with PN to provide the required energy to the patients. The full- or semi-liquid diet primarily consisted of cereal-based foods providing carbohydrates and Intact Protein Enteral Nutrition Powder (Milupa GmbH & Co., KG), with the quantity controlled based on patient tolerance. Patients were grouped according to preoperative nutritional treatment as follows: Group 1, 230 patients (49.3%) who received PN only; Group 2, 162 patients (34.7%) who received PN combined with EN and Group 3, 75 patients (16.0%) who received PN combined with a full or semi-liquid diet. The criteria for discontinuation of nutritional therapy included the restoration of normal peripheral blood levels of albumin and prealbumin, resolution of fatigue symptoms, weight gain or maintenance and meeting the standards of the 6-min walk test (13).

Statistical analysis. Continuous and categorical variables are presented as the mean ± standard deviation and n (%), respectively; differences between groups were compared using an independent sample t, χ^2 or one-way ANOVA followed by Sheffe's post-hoc test. Furthermore, when the count of cells in the contingency table for categorical variables was ≤5 in <0% of the cells, Fisher's exact test was used to assess the association. A two-tailed P<0.05 was considered to indicate a statistically significant difference.

Differences in PFS and OS between groups were compared using Kaplan-Meier survival analysis and log-rank test. Single- and multi-factor survival analyses were conducted to identify independent prognostic factors. Finally, the impact of independent prognostic factors on patient survival was validated through nomograms and their C-indexes.

Results

Patient characteristics. There were a total of 346 (74.1%) males and 121 (25.9%) females, with a mean age of 63.95±9.66 years. Furthermore, 141 patients (30.2%) were TNM stage II, while 326 patients (69.8%) were TNM stage III. The χ^2 or Fisher's exact test indicated that there were no statistically significant differences in age, sex, nutritional status and pathological information between the three groups (all P>0.05). This suggested that the three groups of patients had good comparability (Table I).

Postoperative recovery status. ANOVA demonstrated statistically significant differences in all postoperative recovery indicators between the three groups of patients in this study (all P<0.05, Table II). Post-hoc test results demonstrated significant differences in nutritional treatment time and length of hospital stay among all groups (Table III). Patients in Group 3 had a significantly longer preoperative nutritional treatment time compared with the other groups [Group 1 (5.75 days) vs. Group 2 (6.84 days) vs. Group 3 (12.16 days), P<0.001]. This extended treatment time also resulted in a longer length of hospital stay for these patients [Group 1 (18.77 days) vs. Group 2 (16.52 days) vs. Group 3 (23.52 days), P<0.001]. Furthermore, the time to first postoperative bowel sounds for patients in Groups 1, 2 and 3 was 2.47, 1.72 and 2.36 days, respectively (Table II). Patients in Group 2 had a shorter time to first postoperative bowel sounds compared with the other groups (P<0.001). However, time to first postoperative flatus and bowel movement in Group 1 was significantly longer compared with those in Group 2, while there was no significant difference between Groups 2 and 3 (P=0.882 and P=0.416, respectively; Table III). Furthermore, there were no significant differences in removal time of abdominal drainage tube between any groups of patients. Patients who received preoperative PN combined with EN demonstrated advantages in several aspects of postoperative recovery, with the exception of no significant improvement in the removal time of the abdominal drainage tube.

Survival analysis

Uni- and multivariate survival analysis. Uni- and multivariate analyses were performed to assess the factors associated with survival. Age, PALB, radical resection, Borrmann type, TNM stage and nutritional treatment were associated with PFS and OS of patients. Among these factors, age [PFS: Hazard ratio (HR)=1.024, P=0.022; OS: HR=1.027, P=0.010], radical resection (PFS: HR=1.635, P=0.012; OS: HR=1.674, P=0.011), TNM stage (PFS: HR=4.046, P<0.001; OS: HR=4.198, P<0.001) and

Table I. Patient characteristics.

Parameter	Group 1	Group 2	Group 3	P-value
Age, years	63.79±9.18	63.58±10.36	65.24±9.58	0.442
BMI, kg/m^2	20.72±3.46	20.29±3.00	20.27±3.53	0.564
TP, g/l	61.36±7.53	61.70±6.70	60.50±7.25	0.324
ALB, g/l	35.75±4.56	35.96±4.09	35.38±4.44	0.797
GLOB, g/l	26.57±5.73	26.26±4.83	25.40±4.48	0.242
PALB, g/l	175.12±54.79	171.46±48.95	171.12±43.97	0.644
Sex				
Male	174 (75.7)	118 (72.8)	54 (72.0)	0.743
Female	56 (24.3)	44 (27.2)	21 (28.0)	
Radical resection				
Yes	208 (90.4)	149 (92.0)	68 (90.7)	0.428
No	22 (9.6)	13 (8.0)	7 (9.3)	
Primary tumor site				
Upper 1/3 of the stomach	16 (7.0)	6 (3.7)	5 (6.7)	0.064
Middle 1/3 of the stomach	30 (13.0)	14 (8.6)	16 (21.3)	
Lower 1/3 of the stomach	180 (78.3)	136 (84.0)	54 (72.0)	
Whole stomach	4 (1.7)	6 (3.7)	0 (0.0)	
Borrmann type				
I	28 (12.2)	36 (22.2)	13 (17.3)	0.467
II	174 (75.7)	94 (58.0)	47 (62.7)	
III	22 (9.6)	26 (16.0)	12 (16.0)	
IV	6 (2.6)	6 (3.7)	3 (4.0)	
Tumor size, mm				
<50	106 (46.1)	56 (34.6)	31 (41.3)	0.053
≥50	124 (53.9)	106 (65.4)	44 (56.7)	
Differentiation				
Poor	18 (7.8)	10 (6.2)	5 (6.6)	0.518
Moderately	86 (37.4)	70 (43.2)	28 (37.3)	
Well	126 (54.8)	82 (50.6)	42 (56.1)	
TNM stage				
II	78 (33.9)	48 (29.6)	15 (20.0)	0.073
III	152 (66.1)	114 (70.4)	60 (80.0)	

Values are expressed as the mean ± standard deviation or n (%). Group 1 received PN only. Group 2 received PN combined with enteral nutrition. Group 3 received PN combined with a full or semi-liquid diet. BMI, body mass index; TP, total protein; ALB, albumin; GLOB, globulin; PALB, prealbumin; PN, parenteral nutrition.

nutritional treatment according to Group 3 (PFS: HR=2.110, P=0.001; OS: HR=2.112, P=0.001) were independent prognostic factors in the present study (Tables IV and V).

Survival analysis of nutritional treatments. Kaplan-Meier survival curves demonstrated that patients in Group 3 receiving PN combined with a full- or semi-liquid diet had significantly shorter PFS (χ^2=30.485) and OS (χ^2=31.249) compared with the Group 1 receiving PN only and Group 2 receiving PN combined with EN (Fig. 1).

Moreover, as independent prognostic factors, the relationship between preoperative nutritional treatment and prognosis in patients of different ages, TNM stages and those who underwent radical resection was analyzed. There was a total of 141 patients in TNM stage II, with 78 in Group 1, 48 in Group 2 and 15 in Group 3. Survival curves did not show significant differences in PFS (χ^2=1.789) and OS (χ^2=1.658; Fig. 2). There was a total of 326 patients in TNM stage III, with 152 in Group 1, 114 in Group 2 and 60 in Group 3. Kaplan-Meier analysis demonstrated a significantly shorter PFS (χ^2=25.350) and OS (χ^2=26.535) for patients in Group 3 compared to those in Groups 1 and 2 (Fig. 3).

As the age of 60 years is widely recognized as a threshold in gastric cancer and considering that the median age in the present study was close to 60 years (63.59 years), a cutoff value of 60 years was chosen for age analysis (14,15). There were a total of 229 patients aged <60 years, including 116 in Group 1, 80 in Group 2 and 33 in Group 3. Patients in Group 3 had a significantly shorter PFS (χ^2=9.485) and OS (χ^2=9.603)

Table II. Postoperative recovery status.

Item	Group 1	Group 2	Group 3	F-value	P-value
Mean nutritional treatment time, days	5.75±2.05	6.84±1.73	12.16±2.97	260.486	<0.001
Mean length of hospital stay, days	18.77±5.51	16.52±4.48	23.52±4.52	28.635	<0.001
Mean time to first postoperative bowel sounds, days	2.47±0.23	1.72±0.18	2.36±0.33	17.464	0.021
Mean time to first postoperative flatus, days	5.88±1.10	5.17±0.82	5.24±0.77	29.781	<0.001
Mean time to first postoperative bowel movement, days	5.97±1.08	5.19±0.81	5.36±0.75	35.279	<0.001
Mean removal time of abdominal drainage tube, days	8.69±3.18	7.23±2.29	8.80±2.30	15.640	0.034

Values are expressed as the mean ± standard deviation. Group 1 received PN only. Group 2 received PN combined with enteral nutrition. Group 3 received PN combined with a full or semi-liquid diet. PN, parenteral nutrition.

Table III. Analysis by Sheffe's post-hoc multiple-comparisons test.

Item	Mean difference	P-value
Mean nutritional treatment time, days		
Group 1 vs. 2	-1.092	<0.001
Group 1 vs. 3	-6.412	<0.001
Group 2 vs. 3	-5.320	<0.001
Mean length of hospital stay, days		
Group 1 vs. 2	2.251	<0.001
Group 1 vs. 3	-4.754	<0.001
Group 2 vs. 3	-7.000	<0.001
Mean time to first postoperative bowel sounds, days		
Group 1 vs. 2	0.750	<0.001
Group 1 vs. 3	-0.113	0.446
Group 2 vs. 3	-0.640	<0.001
Mean time to first postoperative flatus, days		
Group 1 vs. 2	0.705	<0.001
Group 1 vs. 3	0.638	<0.001
Group 2 vs. 3	-0.067	0.882
Mean time to first postoperative bowel movement, days		
Group 1 vs. 2	0.780	<0.001
Group 1 vs. 3	0.605	<0.001
Group 2 vs. 3	-0.175	0.416
Mean removal time of abdominal drainage tube, days		
Group 1 vs. 2	0.452	0.282
Group 1 vs. 3	-0.113	0.954
Group 2 vs. 3	-0.565	0.344

Group 1 received parenteral nutrition (PN) only. Group 2 received PN combined with enteral nutrition (EN). Group 3 received PN combined with a full or semi-liquid diet.

compared to Groups 1 and 2 (Fig. 4A and B). Furthermore, there were 238 patients aged ≥60 years; 114 were in Group 1, 82 were in Group 2 and 42 were in Group 3. Survival curves demonstrated a significantly shorter PFS (χ^2=22.949) and OS (χ^2=23.472) in Group 3 compared to Groups 1 and 2 (Fig. 5A and B).

A total of 425 patients underwent R0 resection, accounting for 91% of the total cohort. Therefore, the present study only analyzed patients who underwent R0 resection. Among these patients, there were 208 individuals in Group 1 (48.9%), 149 in Group 2 (35.1%) and 68 in Group 3 (16.0%). Group 3 demonstrated a significantly shorter PFS (χ^2=25.350) and OS (χ^2=26.535) compared to Groups 1 and 2 (Fig. 6).

Nomograms. Finally, to assess the impact of different preoperative nutritional treatments on prognosis of patients with

Table IV. Uni- and multivariate analysis of progression-free survival.

	Univariate analysis		Multivariate analysis	
Parameter	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value
Age	1.023 (1.004-1.042)	0.016	1.024 (1.003-1.044)	0.022
TP	0.993 (0.971-1.017)	0.584		
ALB	0.990 (0.951-1.031)	0.633		
PALB	0.994 (0.991-0.998)	0.004	0.996 (0.992-1.000)	0.084
Sex (female vs. male)	1.032 (0.695-1.532)	0.876		
Radical resection (no vs. yes)	2.238 (1.572-3.187)	<0.001	1.635 (1.112-2.405)	0.012
Borrmann type				
II vs. I	0.819 (0.470-1.429)	0.482	0.804 (0.456-1.418)	0.451
III vs. I	1.172 (0.584-2.351)	0.655	0.867 (0.430-1.748)	0.689
IV vs. I	2.584 (1.331-5.014)	0.005	1.308 (0.630-2.718)	0.471
Tumor size (≥50 vs. <50 mm)	1.210 (0.853-1.717)	0.286		
TNM stage (III vs. II)	2.952 (1.918-3.503)	<0.001	4.046 (2.346-6.976)	<0.001
Nutritional treatment group				
2 vs. 1	1.126 (0.735-1.723)	0.586	1.157 (0.747-1.792)	0.512
3 vs. 1	2.818 (1.876-4.233)	<0.001	2.110 (1.343-3.314)	0.001

Group 1 received PN only. Group 2 received PN combined with enteral nutrition. Group 3 received PN combined with a full or semi-liquid diet. TP, total protein; ALB, albumin; PALB, prealbumin; CI, confidence interval; PN, parenteral nutrition.

Table V. Uni- and multivariate analysis of overall survival.

	Univariate analysis		Multivariate analysis	
Parameter	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value
Age	1.024 (1.005-1.043)	0.012	1.027 (1.006-1.047)	0.010
TP	0.994 (0.971-1.018)	0.618		
ALB	0.992 (0.953-1.033)	0.689		
PALB	0.995 (0.991-0.998)	0.006	0.997 (0.993-1.001)	0.110
Sex (female vs. male)	1.026 (0.691-1.524)	0.897		
Radical resection (no vs. yes)	2.261 (1.588-3.220)	<0.001	1.674 (1.120-2.423)	0.011
Borrmann type				
II vs. I	0.799 (0.458-1.393)	0.428	0.801 (0.453-1.415)	0.444
III vs. I	1.176 (0.586-2.358)	0.648	0.894 (0.443-1.806)	0.755
IV vs. I	2.689 (1.386-5.219)	0.003	1.457 (0.700-3.030)	0.314
Tumor size (≥50 vs. <50 mm)	1.167 (0.822-1.656)	0.387		
TNM stage (III vs. II)	2.580 (1.915-3.475)	<0.001	4.198 (2.434-7.242)	<0.001
Nutritional treatment group				
2 vs. 1	1.121 (0.733-1.717)	0.598	1.150 (0.742-1.718)	0.532
3 vs. 1	2.847 (1.895-4.276)	<0.001	2.112 (1.344-3.312)	0.001

Group 1 received PN only. Group 2 received PN combined with enteral nutrition. Group 3 received PN combined with a full or semi-liquid diet. TP, total protein; ALB, albumin; PALB, prealbumin; CI, confidence interval; PN, parenteral nutrition.

early gastric outlet obstruction, nomograms were created to predict the 1- and 3-year survival probabilities based on the results of the multivariate analysis. The figure shows nomograms constructed based on independent prognostic factors for PFS and OS, respectively (Fig. 7A and B). C-index for the nomograms of PFS and OS was 0.819 and 0.822, indicating the good predictive performance of nomograms that included preoperative nutritional treatment.

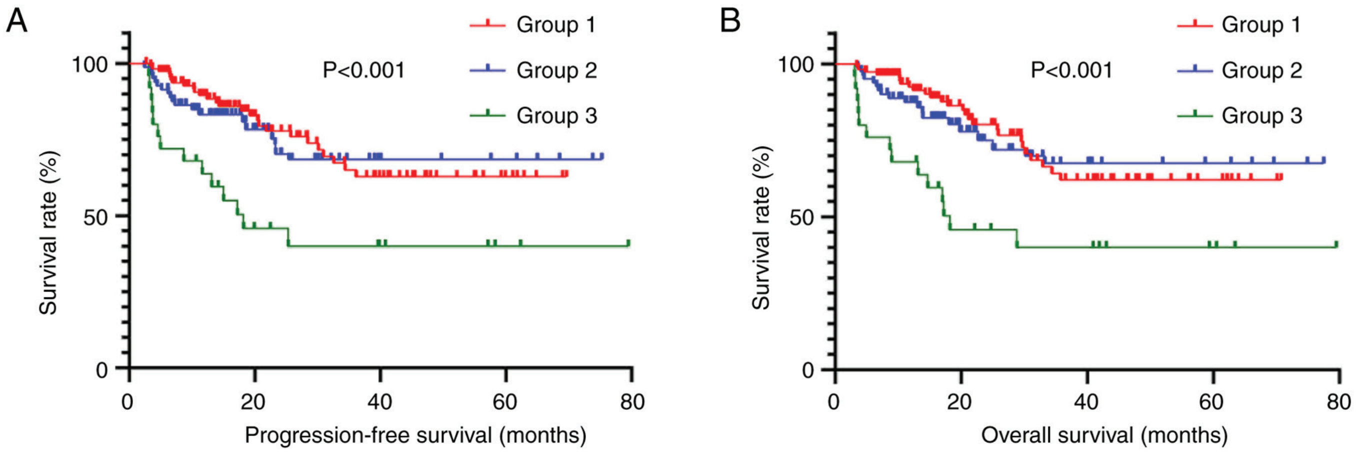

Figure 1. Survival curves for nutritional treatment. Nutritional treatment-associated survival curve for (A) progression-free survival and (B) overall survival.

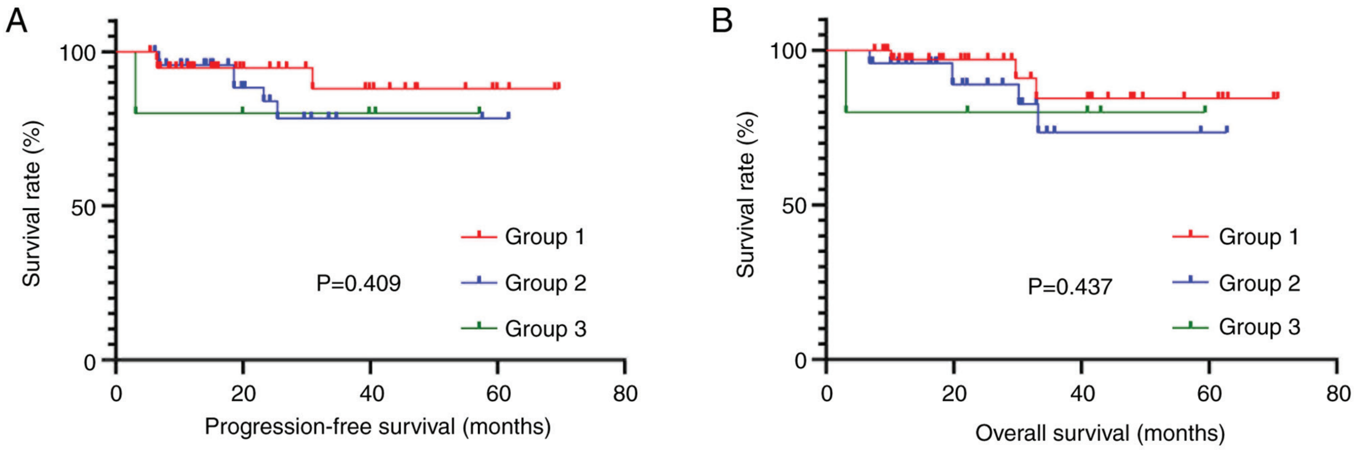

Figure 2. Survival curves for nutritional treatment in TNM stage II. Nutritional treatment-associated survival curve in TNM stage II for (A) progression-free survival and (B) overall survival.

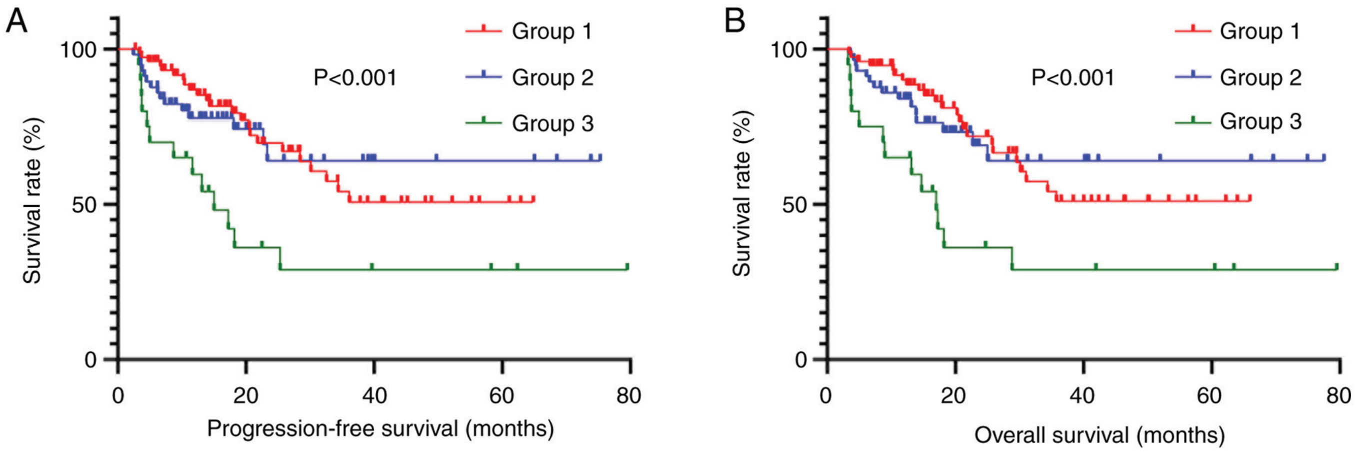

Figure 3. Survival curves for nutritional treatment in TNM stage III. Nutritional treatment-associated survival curve in TNM stage III for (A) progression-free survival and (B) overall survival.

Discussion

Gastric outlet obstruction is a common complication in patients with gastric cancer (16-18). This condition often coincides with varying degrees of malnutrition, potentially accelerating the progression of the tumor (19-21). To restore the nutritional and immune status patient and enhance treatment tolerance, comprehensive preoperative nutritional treatment is required (22,23).

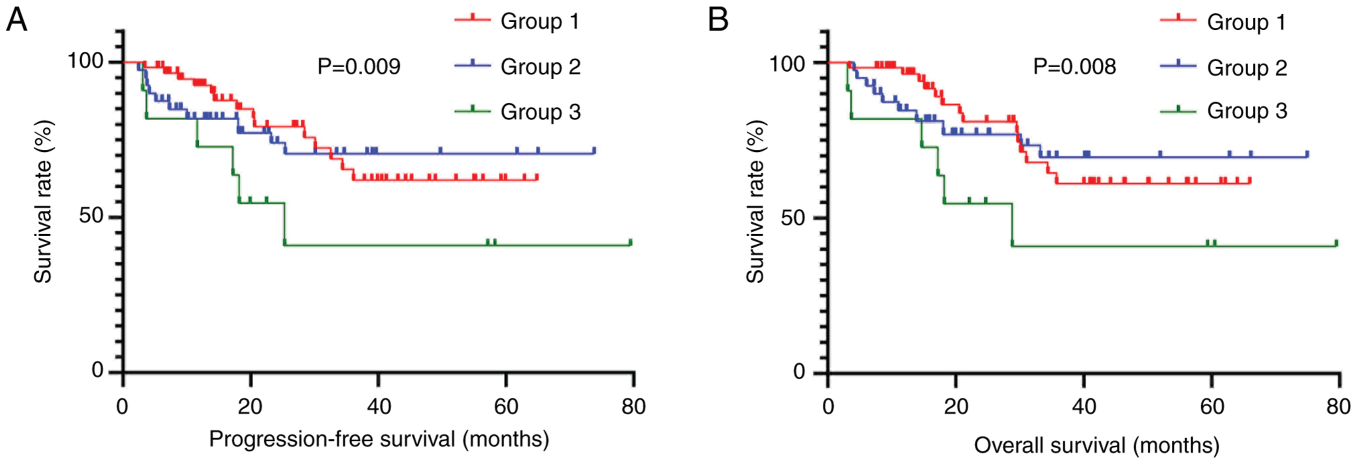

Figure 4. Survival curves for nutritional treatment in patients aged <60 years. Nutritional treatment-associated survival curve in patients aged <60 years for (A) progression-free survival and (B) overall survival.

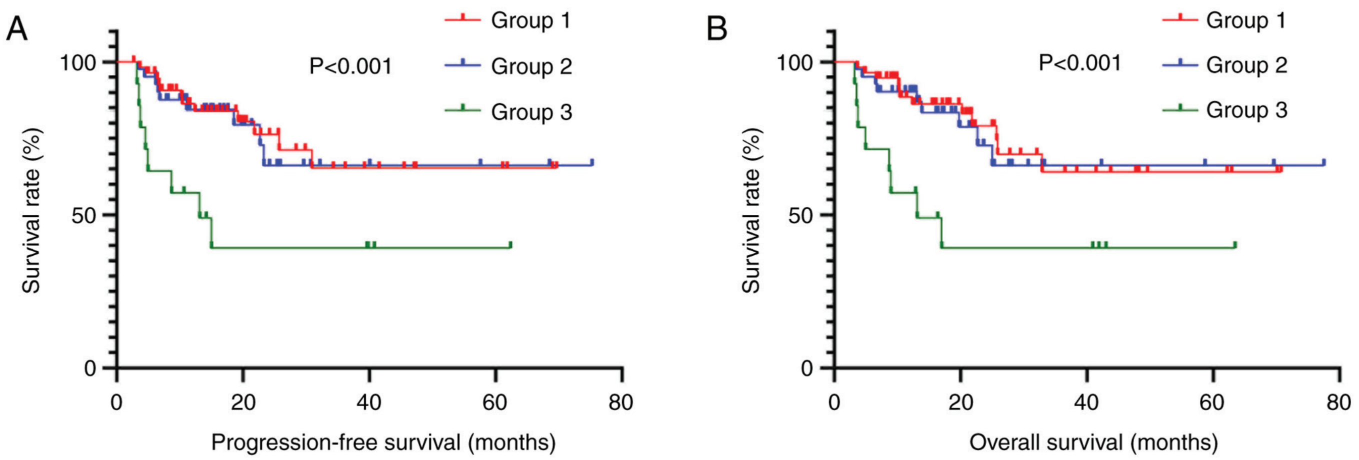

Figure 5. Survival curves for nutritional treatment in patients aged ≥60 years. Nutritional treatment-associated survival curve in patients aged ≥60 years for (A) progression-free survival and (B) overall survival.

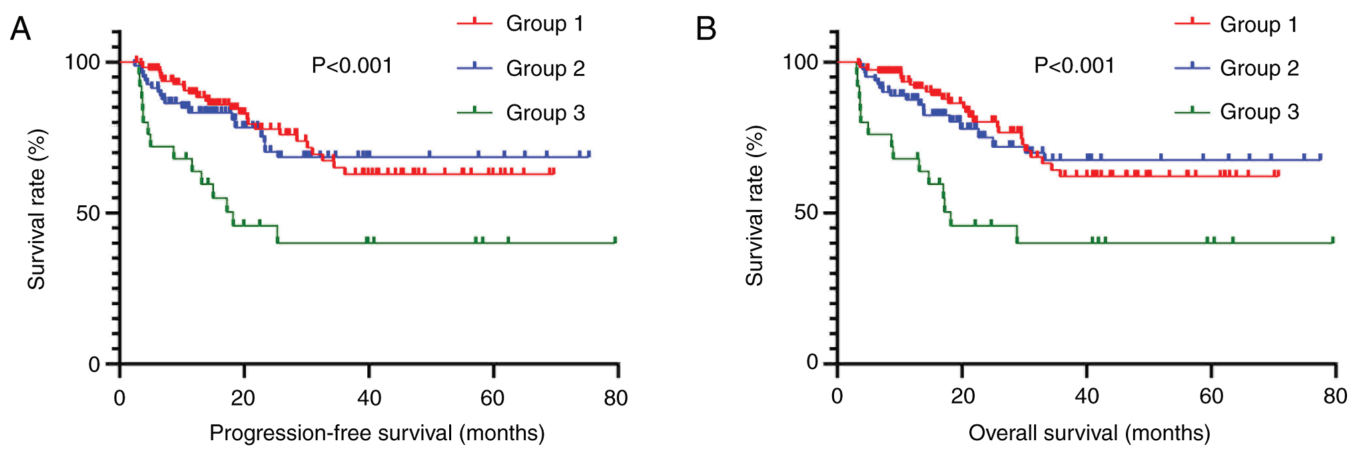

Figure 6. Survival curves for nutritional treatment in R0 resection. Nutritional treatment-associated survival curve in R0 resection for (A) progression-free survival and (B) overall survival.

However, diverse nutritional treatment approaches exhibit differences in energy provision, side effects and patient tolerance (24-26). The present study assessed the effects of nutritional treatments on patients with early gastric cancer complicated by gastric outlet obstruction, offering insights into the development of preoperative nutritional treatment strategies.

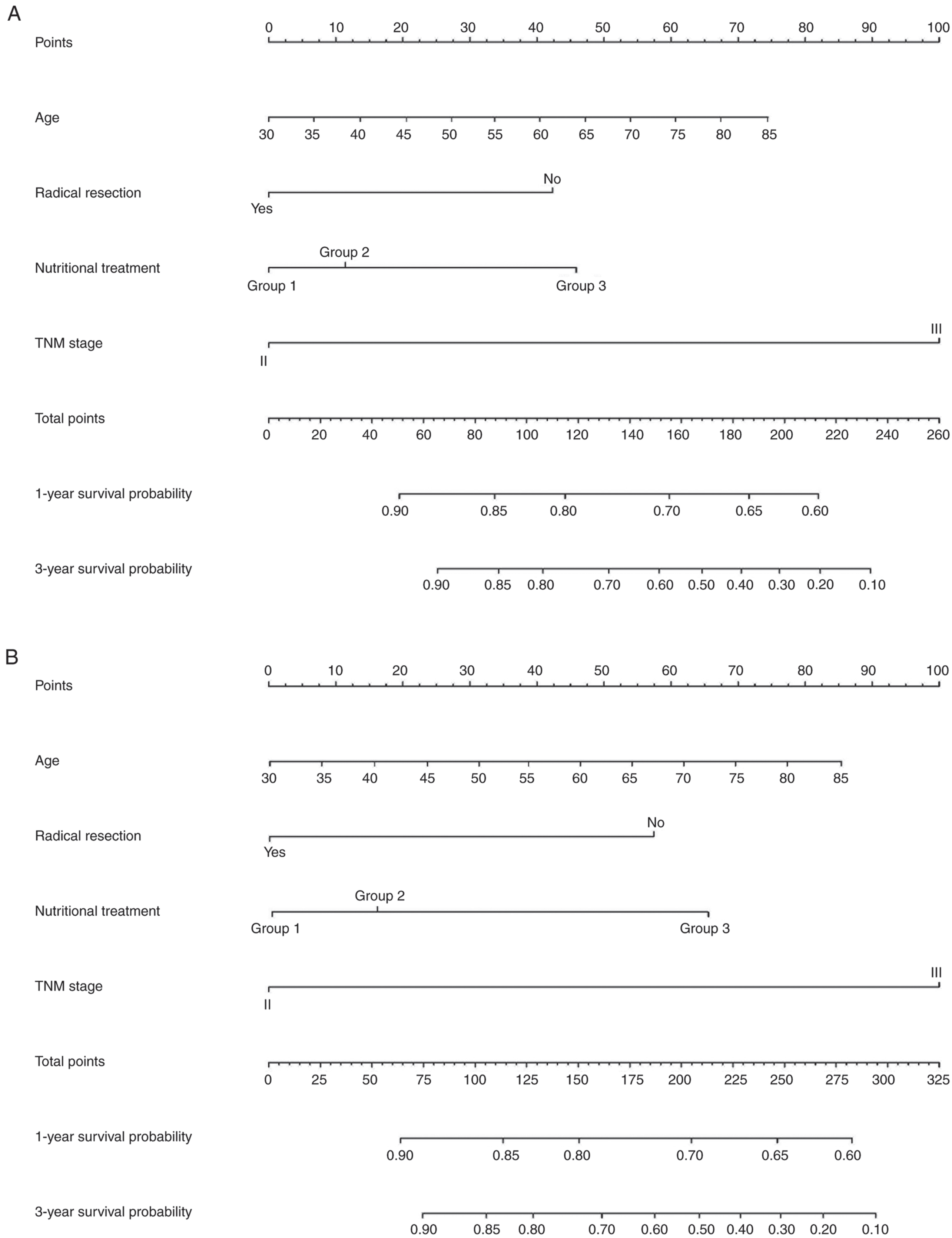

Figure 7. Nomograms for patients with gastric cancer and early partial gastric outlet obstruction. Nomograms for (A) progression-free survival and (B) overall survival.

Gastric cancer complicated by gastric outlet obstruction has long been a focus of researchers. In 2023, Li *et al* (27) conducted comparative analysis to investigate the unique clinical and pathological characteristics of patients with gastric outlet obstruction. Data were collected from 194 patients with gastric cancer accompanied by gastric outlet obstruction and

221 patients without gastric outlet obstruction. Patients with gastric outlet obstruction exhibited poorer clinical features, pathological conditions and blood parameters, which resulted in shorter survival. Another study reported similar results: In 2021, Jiao *et al* (28) collected data from 343 patients with gastric cancer who underwent radical resection. Propensity-matched analyses were conducted to investigate clinical characteristics and survival outcomes of patients with gastric outlet obstruction; although gastric outlet obstruction was unrelated to postoperative complications and mortality, it significantly decreased the OS time of patients.

Preoperative nutritional therapy is key for the treatment of patients with cancer and malnutrition. In 2015, Fukuda *et al* (29) conducted a large retrospective analysis to investigate the optimal preoperative nutritional support for malnourished patients with gastric cancer. Data from 800 patients with gastric cancer undergoing gastrectomy were analyzed; adequate preoperative energy support decreased postoperative surgical site infections in malnourished patients. The impact of different nutritional treatments on patients with cancer has also received attention. Shen *et al* conducted a study on patients with esophageal cancer in 2021, analyzing differences in the effectiveness of preoperative PN and EN. Through a comparative analysis of 29 patients who received preoperative PN and 27 who received preoperative EN, it was reported that preoperative EN had certain advantages in postoperative recovery and occurrence of complications (30). Another study on short-term outcomes of patients with gastric cancer who underwent surgery yielded similar results: In 2021, Li *et al* (31) collected data from 143 patients with gastric outlet obstruction to analyze the impact of preoperative PN and EN on postoperative recovery. Patients who received EN had a shorter time to first postoperative flatus, indicating faster postoperative recovery.

The present study assessed the impact of preoperative nutritional treatment on the short- and long-term clinical outcomes of patients with early gastric outlet obstruction through a large sample cohort. PN combined with EN demonstrated significant advantages in postoperative recovery status, as evidenced by shorter lengths of hospital stay, quicker time to first postoperative bowel sounds, earlier time to first postoperative flatus and faster time to first postoperative bowel movement. While PN combined with full- and semi-liquid diets resulted in shorter times for the first postoperative flatus and bowel movement, it was also associated with longer nutritional treatment time and length of hospital stay. Furthermore, there was no difference between the three groups of patients in the removal time of the abdominal drainage tube. Removal time of the abdominal drainage tube may be associated with surgical methods, extent and time rather than the nutritional status. Combination of PN with full- and semi-liquid diets was associated with poorer survival outcomes. In subgroup analysis, except for TNM stage II patients whose results were less accurate due to uneven distribution in nutritional treatment groups, PN combined with full- and semi-liquid diets also demonstrated worse clinical outcomes in patients with TNM stage III or undergoing radical resection as well as across all age groups. The multivariate survival analysis and nomograms with high C-indices further supported the effect of preoperative nutritional treatment on the clinical outcomes of patients with early gastric outlet obstruction.

The exact mechanisms underlying the advantage of PN combined with EN in postoperative recovery and survival require further research and in-depth analysis. Long-term fasting may lead to varying degrees of damage to intestinal function, including disuse atrophy of the intestine, reduced intestinal motility, disturbances in the intestinal microbiota and metabolic disorder (32,33). Patients with early gastric outlet obstruction often experience varying degrees of intake difficulty before admission, which could result in more severe impairment of intestinal function (34-36). Therefore, while PN could be an effective treatment for patients with early gastric cancer and gastric outlet obstruction to improve nutritional status, enabling patients to undergo surgery, the addition of EN may contribute to faster recovery of intestinal function, thereby expediting postoperative recovery (37-40). This is also a possible reason for the significant advantage of PN combined with EN in postoperative recovery status in the present study compared to PN only and PN combined with a full or semi-liquid diet.

Furthermore, while PN combined with full- or semi-liquid diets improves the recovery of intestinal peristalsis compared with PN only, patients often require extended duration of nutritional treatment due to energy absorption disorder caused by gastric outlet obstruction and decreased tolerance resulting from symptoms such as bloating, leading to an extended hospital stay (41,42). In the present study, PN combined with full- or semi-liquid diet was linked to worse clinical outcomes. As previously discussed, patients with gastric outlet obstruction exhibit decreased capacity to absorb and tolerate full- or semi-liquid diets, resulting in inadequate nutritional recovery. Malnutrition can exert detrimental effects on the immune function and treatment tolerance of patients; these are two well-documented factors associated with tumor progression and recurrence in numerous studies (43-47).

The present study had limitations. First, this was a retrospective study conducted at a single medical center, which may have introduced potential information bias. Second, due to factors such as surgical schedules, certain patients might not have received sufficient preoperative nutritional support. Finally, despite using numerous statistical methods for analysis, further well-designed prospective studies are required to validate these findings and elucidate the underlying mechanisms.

In summary, preoperative PN combined with EN proved advantageous for postoperative recovery of patients with gastric cancer and early gastric outlet obstruction. Furthermore, PN combined with full- or semi-liquid diets may not fully meet the nutritional needs of these patients, resulting in less favorable clinical outcomes.

Acknowledgements

Not applicable.

Funding

No funding was received.

Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

CW made substantial contributions to the conception and design of the work, and wrote and reviewed the manuscript. DY performed experiments. CW and DY confirm the authenticity of all the raw data. Both authors have read and approved the final manuscript.

Ethics approval and consent to participate

This study was approved by the ethics committee of Harbin Medical University Cancer Hospital (Harbin, China; approval no. 2019-57-IIT). Due to the retrospective nature of the study, the Ethics Committee of Harbin Medical University Cancer Hospital waived the requirement for informed consent.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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