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Impact of distal or pylorus preserving gastrectomy on postoperative quality of life in T1 stage middle third gastric cancer patients

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Pylorus-preserving gastrectomy (PPG) and distal gastrectomy (DG) are widely utilized surgical approaches for the treatment of gastric cancer. In this study, we employed questionnaire surveys and follow-up assessments to examine the effects of these surgical procedures on postoperative quality of life and pancreatic exocrine function in patients with stage T1 middle-third gastric cancer. A retrospective cohort study was conducted to analyze clinical and follow-up data from 63 gastric cancer patients who underwent distal gastrectomy and 21 who underwent pylorus-preserving gastrectomy at Nanjing University Drum Tower Hospital between January 2019 and January 2023. Patients were categorized into two groups: distal gastrectomy ($n = 63$) and pylorus-preserving gastrectomy ($n = 21$). The primary outcome measure was postoperative quality of life assessed at 1 year using the Gastric Resection Syndrome Assessment Scale, Gastroparesis Cardinal Symptom Index (GSCI), and Pancreatic Exocrine Insufficiency Questionnaire (PEI-Q). Secondary outcomes included intraoperative and postoperative conditions, incidence of complications, and changes in nutritional status at 6 and 12 months post-surgery. Compared to the DG group, the PPG group exhibited fewer lymph node dissections [20 (17, 26) vs. 25 (19.5, 32), Z = 2.013, $P = 0.052$], shorter distances from the upper resection margin [2.0 (1.3, 3.0) vs. 3.5 (2.5, 4.75), Z = 4.664, $P = 0.0002$], and shorter distances from the lower resection margin [2.0 (1.4, 3.0) vs. 4.5 (4.0, 5.5), Z = 6.691, $P < 0.001$]. However, they experienced longer operative times [270 (240, 300) vs. 220 (187.5, 257.5), Z = 4.133, $P = 0.0002$], postoperative gas discharge times [4 (4, 5) vs. 4 (3, 4), Z = 5.96, $P < 0.0001$], and postoperative hospital stays [12 (10, 14) vs. 10 (9, 12), Z = 1.493, $P = 0.0098$]. One year postoperatively, patients in the PPG group demonstrated superior quality of life scores compared to the DG group in terms of the dumping symptom scale [1.0 (1.0, 1.33) vs. 2.5 (1.75, 2.5), Z = 7.192, $P < 0.001$], amount of food intake per meal [6 (6, 7) vs. 6 (4, 6), Z = 4.724, $P = 0.0008$], and meal quality scale [4.0 (3.67, 4.0) vs. 2.33 (1.67, 2.67), Z = 11.554, $P < 0.0001$]. Additionally, preoperative serum albumin levels were higher in the PPG group compared to the DG group [41.7 (40.3, 43) vs. 40.2 (39.15, 41.3), Z = 2.916, $P = 0.006$], and the PPG group had a lower rate of postoperative chemotherapy requirement ($P = 0.024$). Compared to distal gastrectomy (DG), pylorus-preserving gastrectomy (PPG) results in fewer dumping symptoms and an improved quality of life for patients following surgery. This makes PPG a highly favorable surgical option for treating stage T1 middle-third gastric cancer.

Keywords Pylorus-preserving gastrectomy, Distal gastrectomy, Gastric cancer, Stomach neoplasms, Surgery, Quality of life

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Gastric cancer ranks as the fifth most common malignancy globally and the fourth leading cause of cancer-related deaths[1]. Despite a general decline in incidence and mortality rates over the past decade in various countries, gastric cancer continues to pose a significant global health challenge[2]. Recent advancements in diagnostic technology have substantially increased the detection rates of gastric cancer, thereby improving overall survival rates for patients post-surgery[3], with standardized surgical interventions now achieving a 5-year survival rate exceeding 90%[4]. Consequently, the treatment approach for gastric cancer has increasingly focused on minimizing invasiveness and preserving gastric function, aiming to enhance patients' postoperative quality of life[5,6].

The primary surgical options for gastric cancer located in the middle third of the stomach are distal gastrectomy (DG) and pylorus-preserving gastrectomy (PPG)[7]. PPG is a function-preserving gastrectomy for early gastric cancer in the middle third of the stomach. It removes part of the stomach while preserving the pyloric valve, thus maintaining the normal physiological function of the stomach[8]. According to the Japanese Gastric Cancer Treatment Guidelines revised in 2010[9], PPG is recommended for cT1cN0 gastric cancer in the middle third of the stomach, provided that the distal tumor margin is at least 4 cm from the pylorus. Research from both domestic and international studies has shown that, compared to traditional DG, PPG is associated with a lower incidence of postoperative dumping syndrome, bile reflux, and gallstone formation, and it generally leads to improved postoperative quality of life[8,10]. These findings suggest that PPG is a promising alternative to DG. However, PPG also presents certain disadvantages: the surgical indications are more restrictive, the procedure is more complex, and there is a higher likelihood of complications such as gastric retention and gastroparesis, as well as potential tumor safety risks[11]. Despite some studies highlighting the nutritional and quality-of-life benefits of PPG[12,13], many of these studies utilized a single type of assessment scale and lacked clarity regarding tumor site selection.

This study aimed to investigate the effects of distal gastrectomy (DG) and pylorus-preserving gastrectomy (PPG) on the postoperative quality of life in patients with gastric cancer through a retrospective analysis employing three assessment scales: PGSAS-45, GSCI, and PEI-Q. The PGSAS-45 is a scale for assessing the quality of life of patients after gastrectomy, the GSCI is a tool for evaluating digestive function in patients undergoing gastrointestinal surgery, and the PEI-Q may be used to assess the nutritional status of postoperative patients. By analyzing these scales comprehensively, the study seeks to provide a deeper understanding of the long-term impacts of these two surgical approaches on patient outcomes, thereby offering valuable insights for clinicians and patients in selecting the most appropriate surgical method.

Materials and methods

Patients

This study adopts a retrospective cohort study design.

Inclusion Criteria:

(1) Patients with primary gastric adenocarcinoma confirmed by endoscopic biopsy before surgery and stage I (T1) according to the 8th edition of the American Joint Committee on Cancer (AJCC) clinical staging system for gastric cancer; (2) Preoperative CT and other imaging examinations confirmed that the tumor was located in the middle 1/3 of the stomach; (3) The tumor is located at least 4 cm away from the pyloric canal; (4) Patients undergo either distal gastrectomy or pylorus-preserving gastrectomy; (5) Pathological reports confirm negative surgical margins; (6) Availability of comprehensive clinical pathology and follow-up data, with patients having undergone at least one postoperative follow-up examination.

Exclusion Criteria:

(1) Age ≥ 80 years; (2) Receipt of neoadjuvant therapy prior to surgery; (3) Presence of preoperative pancreatic exocrine insufficiency; (4) Concurrent malignancies at other sites; (5) Severe cardiopulmonary dysfunction with NYHA classification of III and above or MRC classification of II and above that affects the tolerability of surgical or endoscopic treatment.

According to the specified criteria, clinical and pathological data were retrospectively collected from 84 patients with gastric adenocarcinoma located in the middle third of the stomach. These patients were admitted to the General Surgery Center at Drum Tower Hospital, affiliated with Nanjing University Medical School, between January 2019 and January 2023. Based on the surgical methods employed, the patients were categorized into two groups: the distal gastrectomy group ($n = 63$) and the pylorus-preserving gastrectomy group ($n = 21$). Statistical analysis revealed no significant differences in baseline characteristics between the two groups, as detailed in Table 1. Informed consent was obtained from both patients and their families prior to surgery. This study was approved by the Ethics Committee of Drum Tower Hospital, Nanjing University. We confirm that all research was performed in accordance with relevant guidelines/regulations.

Surgical procedure

1. Distal gastrectomy group: Distal gastrectomy Stomach resection including the pylorus. The cardia is preserved. In the standard gastrectomy, two-third of the stomach is resected and the GI tract is reconstructed using Roux-en-Y reconstruction, which is used to ensure the patient's nutrient absorption and postoperative recovery[14].
2. Preservation of pylorus gastrectomy group: Pylorus-preserving gastrectomy (PPG) Stomach resection preserving the upper third of the stomach and the pylorus along with a portion of the antrum[14]. Lymph node clearance is performed along the proximal splenic artery and hepatic artery, followed by interruption of the left gastric vein and clearance of lymph nodes along the left artery's adventitia. The pyloric branch, vagus nerve hepatic branch, and abdominal branch are kept intact, and side-to-side anastomosis of the posterior

	DG Group ($n=63$)	PPG Group ($n=21$)	Statistical Value	*P*-value
Age			$\chi2=3.208$	0.073
≤ 65years	41 (65.1)	18 (85.7)		
>65years	22 (34.9)	3 (14.3)		
Gender			$\chi2=0.066$	0.797
male	38(60.3)	12(57.1)		
female	25(39.7)	9(42.9)		
BMI			$\chi2=0.702$	0.704
≤ 18	2 (3.2)	0(0)		
18 ~ 25	53 (84.1)	18 (85.7)		
≥ 25	8 (12.7)	3 (14.3)		
NRS2002			$\chi2=0.064$	0.801
< 3, no nutritional risk	32 (50.8)	10 (47.6)		
≥ 3, with nutritional risk	31 (49.2)	11 (52.4)		
Tumor T stage			$\chi2=0.782$	0.377
T1a	31 (49.2)	8 (38.1)		
T1b	32 (50.8)	13 (61.9)		
Tumor N stage			$\chi2=1.496$	0.473
N0	54 (85.7)	20 (95.2)		
N1	7 (11.1)	1 (4.8)		
N2	2 (3.2)	0 (0)		
Tumor longest diameter[[cm, M(QR)]	2(1.5, 2.5)	1.7(1.2, 2.5)	Z = 0.677	0.502
Pathological type			$\chi2=2.964$	0.227
Tubular adenocarcinoma	34 (54.0)	10 (47.6)		
Low-adhesive adenocarcinoma	21 (33.3)	5 (23.8)		
Mixed adenocarcinoma	8 (12.7)	6 (28.6)		
Differentiation			$\chi2=1.718$	0.633
High differentiation	7 (11.1)	4 (19.0)		
Medium differentiation	11 (17.5)	4 (19.0)		
Low differentiation	27 (42.9)	6 (28.6)		
Mixed	18 (28.6)	7 (33.3)		

Table 1. Clinicopathologic features in DG and PPG.

wall of the stomach is performed. We used hand sutures to avoid disruption of the pylorus and to maintain normal gastric emptying function.

QOL assessment

The PGSAS-45 is a comprehensive questionnaire designed to assess the living status and quality of life of patients after gastrectomy. It comprises eight items sourced from the Short-Form Health Survey (SF-8), 15 items from the Gastrointestinal Symptom Rating Scale (GSRS), and 22 items initially proposed by members of the JPGSWP[15]. The items within the PGSAS-45 are categorized into three domains: symptomatology, living conditions, and quality of life. The quality of life domain encompasses the SF-8 and three items related to dissatisfaction, while the living conditions domain includes items concerning meal-related issues and workability. The symptomatology domain is further delineated into 23 symptom-related items grouped into seven subscales: esophageal reflux, abdominal pain, meal-related distress, indigestion, diarrhea, constipation, and dumping. Higher scores on items 1–8, 34, 35, and 38–40 indicate more favorable outcomes, whereas higher scores on items 9–28, 30, 31, 33, and 41–45 indicate poorer outcomes[16].

The Gastroparesis Cardinal Symptom Index (GCSI)[17]encompasses three subscales drawn from the PAGI-SYM, specifically tailored to assess critical symptoms associated with gastroparesis: nausea/vomiting, post-prandial fullness/early satiety, and bloating.The nausea/vomiting subscale comprises three pivotal items: nausea, retching, and vomiting. Meanwhile, the post-prandial fullness/early satiety subscale encompasses four essential indicators: stomach fullness, inability to complete a normal-sized meal, feeling excessively full after meals, and loss of appetite. Lastly, the bloating subscale comprises two distinct elements: bloating and visible enlargement of the stomach or belly.The GCSI total score is calculated as the mean of the scores from the three symptom subscales. Ranging from 0 to 5, higher scores denote heightened symptom severity. If any of the subscale scores is missing, the total score is marked as missing as well[18].

The Pancreatic Exocrine Insufficiency Questionnaire (PEI-Q) is designed to assess symptoms associated with pancreatic exocrine insufficiency. It consists of 13 questions, which are divided into two domains: 1.Abdominal Symptoms (Domain A): This domain includes 7 questions. 2.Bowel Movement Symptoms (Domain B): This domain comprises 6 questions. Responses to each question were graded on a scale of 0–4, with a higher score

indicating more severe complaints.In order to calculate the total PEI-Q score, it was necessary for a minimum of 50% of the questions within each domain to be answered. A total PEI-Q score of ≥ 0.6 was regarded as indicative of a patient exhibiting symptoms of PEI, distinguishing them from healthy control participants[19].

Observation indicators and evaluation criteria

1. Observation Indicators:

(1) Primary observation indicator: Quality of life of patients one year after surgery.

(2) Secondary observation indicators: Intraoperative and postoperative conditions, the incidence of postoperative complications, and changes in nutritional status at 6 and 12 months postoperatively.

2. Evaluation Criteria:

(1) Quality of life: The evaluation criteria refer to the three scales of PGSAS-45, GSCI and PEI-Q. These scales measure various symptoms following gastrectomy and assess their impact on the patient's quality of life.

(2) Nutritional status: Nutritional status was evaluated based on hemoglobin and serum albumin levels. Anemia was defined as hemoglobin levels below 120 g/L for males and below 110 g/L for females. Hypoalbuminemia was indicated by serum albumin levels below 25 g/L[20].

(3) Postoperative complications: Postoperative complications, including gastric retention, pancreatic exocrine insufficiency, and gastric emptying disorders, were monitored at 6 months and 1 year post-surgery. Gastric retention and gastric emptying disorders were assessed using upper gastrointestinal tract radiography and gastroscopy.

Follow-up method

The patients were followed up for 1 year after surgery, and the patients were reviewed after surgery at 1, 3, 6, and 12 months. These assessments comprised physical examinations, laboratory tests (including routine blood tests, biochemical complete set, etc.), and endoscopic evaluations. At 12 months after surgery, the patients were followed up by telephone or questionnaire to collect information on physical symptoms, living conditions, and quality of life. The follow-up deadline was February 2024.

Statistical methods

Data analysis was conducted using SPSS version 26.0. Quantitative data that were normally distributed were presented as mean ± standard deviation ($\bar{x} \pm s$), with inter-group comparisons performed using independent two-sample t-tests. For non-normally distributed quantitative data, values were expressed as median (Q1, Q3), and inter-group comparisons were made using the Mann-Whitney U test. Categorical data were presented as frequency (percentage), with comparisons between groups for non-ranked categorical data conducted using the chi-squared (χ^2) test, and comparisons for ranked categorical data performed using the Mann-Whitney U test. A p-value of less than 0.05 was considered statistically significant.

Results

Comparison of intraoperative and postoperative conditions between two groups of patients

Both patient groups successfully completed the surgery with R0 resection. There were no significant differences between the groups concerning intraoperative blood loss, postoperative defecation time, presence of gastric retention on follow-up gastroscopy, presence of gastric emptying disorder on postoperative angiography, incidence of unplanned secondary surgeries, or early postoperative complications (all p-values > 0.05), as detailed in Tables 2 and 3. Notably, two patients (one from each group) who experienced severe intestinal obstruction and anastomotic complications underwent a second operation, while other complications were

	DG Group ($n=63$)	PPG Group ($n=21$)	Statistical Value	*P*-value
Surgical Approach			$\chi2=38.24$	< 0.001
Robot-assisted	0 (0)	10 (47.6)		
Open	21 (33.3)	0 (0)		
Laparoscopic	39 (61.9)	11 (52.4)		
Intraoperative Blood Loss[ml, M(QR)]	100(100,200)	150(100,200)	$Z=1.590$	0.1205
Number of Lymph Nodes Dissected[A, M(QR)]	25(19.5,32)	20(17,26)	$Z=2.013$	0.052
Distance from Upper Resection Margin[cm, M(QR)]	3.5(2.5,4.75)	2.0(1.3,3.0)	$Z=4.664$	0.0002
Distance from Lower Resection Margin[cm, M(QR)]	4.5(4.0,5.5)	2.0(1.4,3.0)	$Z=6.691$	< 0.001
Operative Time[min, M(QR)]	220(187.5,257.5)	270(240,300)	$Z=4.133$	0.0002
Postoperative Gas Discharge Time [d, M(QR)]	4(3,4)	4(4,5)	$Z=5.96$	<0.0001
Postoperative Bowel Movement Time[d, M(QR)]	5(4,5)	5(4,6)	$Z=1.188$	0.379
Postoperative Hospital Stay[d, M(QR)]	10(9,12)	12(10,14)	$Z=1.493$	0.0098

Table 2. Comparison of intraoperative and postoperative conditions between two groups of patients.

	DG Group ($n=63$)	PPG Group ($n=21$)	Statistical Value	*P*-value
Unplanned Reoperation (%)			$\chi2=0.683$	0.409
Yes	1 (1.6)	1 (4.8)		
No	62 (98.4)	20 (95.2)		
Postoperative Chemotherapy (%)			$\chi2=5.127$	0.024
Yes	13 (20.6)	0 (0)		
No	50 (79.4)	21 (100.0)		
Postoperative Complications			$\chi2=0.800$	0.371
None	35 (55.6)	14 (66.7)		
Present	28 (44.4)	7 (33.3)		
Postoperative Imaging for Gastric Emptying Obstruction (%)			$\chi2=2.857$	0.091
Yes	8 (12.7)	6 (28.6)		
No	55 (87.3)	15 (71.4)		
Follow-up Gastroscopy for Gastric Retention (%)			$\chi2=0.021$	0.884
Yes	16 (25.4)	5 (23.8)		
No	47 (74.6)	16 (76.2)		

Table 3. Comparison of postoperative complications between two groups of patients.

managed conservatively. Compared to the distal gastrectomy group, the pylorus-preserving gastrectomy group had fewer lymph node dissections [20 (17, 26) vs. 25 (19.5, 32), $Z=2.013$, $p=0.052$], a shorter distance to the upper resection margin [2.0 (1.3, 3.0) vs. 3.5 (2.5, 4.75), $Z=4.664$, $p=0.0002$], and a shorter distance to the lower resection margin [2.0 (1.4, 3.0) vs. 4.5 (4.0, 5.5), $Z=6.691$, $p<0.001$]. However, the pylorus-preserving gastrectomy group had longer operation times [270 (240, 300) vs. 250 (230, 290), $Z=1.493$, $p=0.0098$], a longer postoperative flatus time [4 (4, 5) vs. 3 (3, 4) minutes, $Z=5.96$, $p<0.0001$], and a longer postoperative hospital stay [12 (10, 14) vs. 10 (9, 12) days, $Z=1.493$, $p=0.0098$], as shown in Tables 2 and 3.

Evaluation of postoperative quality of life in two groups of patients

One year following surgery, the pylorus-preserving gastrectomy group exhibited superior outcomes in the somatic symptom domain, specifically in terms of dumping symptoms, compared to the distal gastrectomy group. Additionally, the pylorus-preserving group showed improved results in evaluations of living conditions and overall quality of life, including symptoms, meal-related factors, and daily life activities. Conversely, the distal gastrectomy group reported better outcomes regarding esophageal reflux, abdominal pain, and diarrhea within the somatic symptom domain. All differences between the groups were statistically significant ($p<0.05$), as detailed in Table 4.

Comparison of postoperative survival and prognosis between two groups of patients

One year after surgery, the pylorus-preserving gastrectomy group demonstrated a lower requirement for postoperative chemotherapy compared to the distal gastrectomy group, with this difference reaching statistical significance ($p<0.05$). There were no significant differences in the incidence of postoperative complications, including gastric retention, intestinal obstruction, anastomotic bleeding, and gastric emptying disorder, between the two groups (all p-values >0.05), as illustrated in Table 2. Specifically, in the distal gastrectomy group, one patient with anastomotic bleeding required surgical intervention. In contrast, the pylorus-preserving gastrectomy group had one patient with intestinal obstruction who underwent surgery, while the remaining patients were managed with symptomatic conservative treatment. Patients experiencing long-term complications in both groups exhibited favorable prognoses following treatment.

Changes in postoperative nutritional indicators in both groups of patients

No significant differences were observed in hemoglobin and serum albumin levels between the two groups at any postoperative time point (all p-values >0.05). From 1 to 12 months after surgery, hemoglobin levels increased in both patient groups. In contrast, serum albumin levels in the pylorus-preserving gastrectomy group initially increased from 1 to 6 months postoperatively but then exhibited a slight decrease from 6 to 12 months. Detailed data are presented in Table 5.

Discussion

Traditionally, gastric cancer in the middle and lower regions was predominantly managed through distal gastrectomy. This approach, involving pylorus resection and vagus nerve severance, was associated with a high incidence of postoperative complications, including bile reflux and dumping syndrome[21]. Research indicates that rapid gastric emptying and subsequent dumping symptoms represent some of the most distressing sequelae following gastrectomy, significantly impacting patients' satisfaction and postoperative quality of life[22].

In 1967, Maki et al.[23] first introduced pylorus-preserving gastrectomy for the treatment of peptic ulcer and subsequently extended its application to early gastric cancer. According to the Japanese Gastric Cancer Treatment Guidelines (2010 revision)[9]and the Chinese Consensus of Surgical Experts on Function-Preserving Surgery for

	DG Group ($n=63$)	PPG Group ($n=21$)	Statistical Value	*P*-value
Primary Outcome Measures				
Physical Symptoms (Score, M(QR))				
Esophageal Reflux Symptom Score	1.0(1.0,1.25)	1.5(1.0,1.75)	Z = 2.337	0.0011
Abdominal Pain Score	1.0(1.0,1.0)	1.33(1.0,1.33)	Z = 3.110	<0.0001
Dietary Related Distress Score	1.0(1.0,1.33)	1.33(1.0,1.33)	Z = 0.454	0.367
Indigestion Score	1.5(1.0,1.75)	1.5(1.25,2.5)	Z = 1.785	0.127
Diarrhea Score	1.0(1.0,1.33)	1.67(1.0,2.0)	Z = 2.121	0.009
Constipation Score	1.0(1.0,1.0)	1.67(1.0,2.0)	Z = 4.353	<0.0001
Dumping Syndrome Score	2.5(1.75,2.5)	1.0(1.0,1.33)	Z = 7.192	<0.0001
Total Symptom Score	1.32(1.21,1.43)	1.40(1.24,1.52)	Z = 1.725	0.255
Life Status (Score, M(QR))				
Food Intake per Meal*	6(4,6)	6(6,7)	Z = 4.724	0.0008
Need for Additional Meals	4(3,4)	6(6,6)	Z = 14.384	<0.0001
Meal Quality Score*	2.33(1.67,2.67)	4.0(3.67,4.0)	Z = 11.554	<0.0001
Work Ability Score	4(3,5)	4(3,5)	Z = 0.139	0.874
Postoperative Quality of Life (Score, M(QR))				
Dissatisfaction with Symptoms	2(1,2.5)	2(1,2.0)	Z = 1.282	0.512
Dissatisfaction with Meals	1(1,1)	1(1,1)	Z = 1.213	0.067
Dissatisfaction with Work	1(1,1)	1(1,2)	Z = 1.060	0.065
Dissatisfaction with Daily Life	1.33(1.0,1.67)	1.33(1.0,1.67)	Z = 0.187	0.678
Physical Health Total Score*	85(66.25,95)	88.75(73.75,95)	Z = 0.666	0.66
Mental Health Total Score*	93.75(87.5,100)	87.5(75,100)	Z = 1.176	0.163
Postoperative Pancreatic Function (Score, M(QR))				
Abdominal Symptoms Score	0.43(0.29,0.71)	0.43(0.29,0.71)	Z = 0.351	0.468
Bowel Symptoms Score	0.17(0,0.5)	0.17(0,0.33)	Z = 0.871	0.519
Pancreatic Exocrine Insufficiency (PEI) Score	0.3(0.14,0.64)	0.37(0.14,0.46)	Z = 0.43	0.967
Gastroparesis Symptoms (Score, M(QR))				
Nausea/Vomiting Score	0(0,0)	0(0,0)	Z = 1.146	0.497
Postprandial Fullness/Early Fullness Score	0(0,0.5)	0.25(0,0.25)	Z = 0.753	0.991
Bloating Score	0(0,0)	0(0,0)	Z = 0.302	0.748
Gastroparesis Cardinal Symptom Index (GCSI) Score	0.08(0,0.17)	0.08(0,0.08)	Z = 0.931	0.567

Table 4. Analysis of main outcome measures following distal gastrectomy (DG) and pylorus-preserving gastrecrtomy (PPG) procedures.

	DG Group ($n=63$)	PPG Group ($n=21$)	Statistical Value	*P*-value
Hemoglobin(g/L*M*(*QR*))				
Preoperative	137(126, 148)	141(135, 148)	Z = 0.257	*0.799*
6 Months Post-op	134(125.5, 142.5)	136(129, 142)	Z = 0.029	*0.977*
12 Months Post-op	137(130, 143.5)	137(132, 141)	Z = 0.443	*0.660*
Serum Albumin Level(g/L*M*(*QR*))				
Preoperative	40.2(39.15, 41.3)	41.7(40.3, 43)	Z = 2.916	0.006
6 Months Post-op	42.4(41.15, 43.8)	43.4(41.3, 44.5)	Z = 0.774	0.388
12 Months Post-op	43.3(42.25, 44.2)	42.3(40.2, 44.1)	Z = 1.952	0.063

Table 5. Nutritional Assessment of Hemoglobin and serum albumin.

Gastric Cancer (2021 edition)[6], pylorus-preserving gastrectomy can be used for cT1cN0 gastric cancer in the middle part of the stomach and where the distal border of the tumor is at least 4 cm away from the pylorus. Unlike traditional distal gastrectomy, pylorus-preserving gastrectomy does not remove the patient's No. 5 and No. 12a lymph nodes, but preserves the nerves and blood supply of the human gastric antrum, as well as the normal anatomical structure and physiological function of the pylorus. This approach helps to prevent the rapid emptying of gastric contents postoperatively, thereby significantly reducing the risk of bile and pancreatic juice reflux[24–26], which is crucial for postoperative recovery of gastrointestinal function and enhancing the patient's quality of life.

We found that 13 patients in the DG group required postoperative chemotherapy, which was based on the pathological features of the tumor, including positive lymph nodes, aggressiveness of the tumor, and tumor stage. For these patients, conventional chemotherapy regimens included XELOX, and ECX. may lead to potential bias and affect patients' signs, symptoms, and quality of life. However, studies have shown that postoperative chemotherapy did not affect postoperative quality of life in patients with gastric cancer and has the potential to improve the quality of survival in patients treated palliatively[27]. Secondly, all of our patients were in T1 stages of gastric cancer, and the cycles of the above chemotherapy regimens were not long, six of the patients received the XELOX regimen in cycles of every 21 days for 4 cycles (approximately 3 months), and the other 7 patients received the ECX regimen in cycles of every 21 days for 3–4 weeks (approximately 2–3 months). So this factor was controlled for in the analysis and this potential bias was taken into account in the interpretation of the data.

The study's findings indicated that individuals who underwent pylorus-preserving gastrectomy (PPG) had significantly lower scores on the dumping symptom subscales of the PGSAS-45 questionnaire compared to those who received distal gastrectomy (DG). This questionnaire assesses various aspects of dumping syndrome, including early dumping—general, early dumping—abdominal, and late dumping. Specifically, the early dumping—general subscale measures the overall frequency and severity of symptoms experienced soon after eating, while the early dumping—abdominal subscale focuses on the discomfort and pain in the abdomen during the same period. The late dumping subscale, on the other hand, evaluates symptoms that emerge later, impacting the patient's well-being well after meals. The significantly lower scores observed in the PPG group highlight its effectiveness in reducing both the frequency and severity of dumping symptoms. These results are consistent with previous research[28,29], which has also found that PPG is more effective in managing dumping syndrome compared to DG. Additionally, the PPG group reported superior scores in the food intake per meal and meal quality subscales of the living conditions assessment compared to the DG group. This suggests that preserving pyloric function during surgery better facilitates gastrointestinal recovery, enhances quality of life, and reduces postoperative dietary and daily life dissatisfaction among patients.

In this study, we closely monitored changes in nutritional indicators such as serum albumin and hemoglobin, both before and after surgery. Our analysis demonstrated that patients who underwent pylorus-preserving gastrectomy (PPG) exhibited marginally better nutritional outcomes compared to those who received distal gastrectomy (DG). Despite these observations, the differences in nutritional markers between the two groups were not statistically significant. To thoroughly assess and compare postoperative gastrointestinal symptoms between the two groups, we employed two detailed evaluation scales: the Postoperative Experience Index Questionnaire (PEI-Q) and the Gastrointestinal Symptom Checklist Inventory (GSCI). While GSCI and PEI-Q are not specifically designed for post-gastrectomy patients, they are widely used for assessing other related diseases and symptoms. In this study, we selected these two questionnaires to evaluate the patients' overall health status and quality of life for a more comprehensive assessment. Specifically, GSCI was used to evaluate gastrointestinal function, while PEI-Q was used to assess emotional status and its impact on quality of life. These scales were used to provide a rigorous and scientific analysis of gastrointestinal function and symptoms following surgery. The results showed no significant statistical differences in gastrointestinal symptoms between the PPG and DG groups, indicating that the PPG group performed better during the operation. The recovery of posterior gastrointestinal tract function was no less than that of the DG group.

Despite its advantages, the pylorus-preserving gastrectomy (PPG) group encountered several postoperative challenges. Notably, the duration of the surgery for the PPG group was significantly longer compared to the distal gastrectomy (DG) group ($P<0.05$). This extended operation time is primarily due to the complexities involved in maintaining complete nerve innervation and blood supply to the gastric antrum[7]. Future advancements in surgical techniques may help mitigate these issues. In addition to the increased operation time, the PPG group experienced longer postoperative gas discharge times and extended hospital stays compared to the DG group, with both differences being statistically significant (all $P<0.05$). The PPG group also reported higher scores for abdominal pain and constipation on the PGSAS-45 scale, with statistically significant differences observed (all $P<0.05$). These higher scores are likely related to the postoperative complications commonly associated with gastric emptying disorders observed in the PPG group[11].

The premise of ensuring the quality of life of patients is safe and feasible surgery and radical treatment of tumors. All cases in this study underwent R0 resection, and the postoperative pathological margins were negative. Due to the need to preserve pyloric function, the number of lymph nodes dissected in the PPG group was less than that in the DG group, and the difference was statistically significant ($P=0.052$); however, the study showed that the preservation of these lymph nodes did not increase the potential risk of tumor recurrence and metastasis. The analysis also indicated that the surgical conditions and rates of early postoperative complications were comparable between the two groups. This similarity in outcomes is likely influenced by factors such as the size of the medical institution, the experience level of the surgeon, and the use of laparoscopic techniques. Given the inherent complexities of pylorus-preserving gastrectomy, the author suggests that this procedure be performed at specialized medical centers with extensive experience in such surgeries[29–31].

However, no statistically significant difference was observed between the two groups in the total symptom score of the PGSAS-45. This lack of significant difference may be attributed to the minimal variations observed in the scores for each individual symptom item, which collectively resulted in an overall symptom score that did not show statistical significance. These results are consistent with findings from other studies that have utilized the PGSAS-45 for symptom assessment[32–34].

It is important to note that our study is based on a single-center, retrospective analysis with a limited sample size and a relatively short follow-up period. The small number of patients in each group was an inherent limitation of this study, which can only be dissolved through future prospective studies, but not a propensity-score matching, or multivariate analysis, or weighted regression analysis. We look forward to multicenter, large-scale prospective studies to further confirm these results and establish broader applicability.

Conclusion

In conclusion, our study suggests that pylorus-preserving gastrectomy (PPG) can significantly improve the long-term quality of life for patients with stage T1 middle-third gastric cancer. This surgical approach is associated with enhanced postoperative gastrointestinal function, better nutritional outcomes, and a lower incidence of dumping syndrome, all while meeting patients' dietary needs effectively. Importantly, PPG maintains a level of surgical safety comparable to that of distal gastrectomy (DG). Both surgical methods demonstrate similar short-term and long-term efficacy. Given these findings, PPG is recommended for patients with stage T1 middle-third gastric cancer.

Data availability

We ensure that the study design, data collection, and statistical analyses comply with the STROCSS standards. The datasets generated and analysed during the current study are not publicly available due privacy, but can be obtained by email (wangmeng1980@nju.edu.cn) from the corresponding author on reasonable request.

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Author contributions
M.W and X.C.conceptualized the study. M.W. provided administrative support .H.C.wrote the original draft and the date extraction. S.J.provided the framework.L.C. contributed to modifying and editing the article. Z.K. was involved in the date collection. All authors read and approved the final manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
The entire process of this study followed the ethical standards of Declaration of Helsinki and its later amendments. This study has been approved by the Ethics Committees of Nanjing Drum Tower Hospital and informed consent was obtained from all subjects.

Survey statement
The SF-8 questionnaire from the PGSAS-45 was used in this study and a license to use it has been requested from the original developer, the QualityMetric team.

Additional information
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