Guo *et al. Mini-invasive Surg* 2023;7:19
DOI: 10.20517/2574-1225.2023.45

Mini-invasive Surgery

Review

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Pylorus-preserving gastrectomy for early middle gastric cancer (T1a-bN0M0) is safer and more effective than distal gastrectomy: a narrative review

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How to cite this article: Guo W, He Z, Su S, Mei X, Fedor CN, Fukunaga T, Wang Y, Zhang K, Guan X, Brock MV, Orita H. Pylorus-preserving gastrectomy for early middle gastric cancer (T1a-bN0M0) is safer and more effective than distal gastrectomy: a narrative review. *Mini-invasive Surg* 2023;7:19. https://dx.doi.org/10.20517/2574-1225.2023.45

Received: 19 Apr 2023 **First Decision:** 11 May 2023 **Revised:** 18 May 2023 **Accepted:** 23 May 2023 **Published:** 30 May 2023

Academic Editors: Fernando A. M. Herbella **Copy Editor:** Yanbing Bai **Production Editor:** Yanbing Bai

Abstract

As a treatment option for early middle gastric cancer, pylorus-preserving gastrectomy (PPG) has been shown to exhibit good clinical efficacy in Japan and Korea and has attracted widespread attention in China. PPG has a similar surgical safety to conventional distal gastrectomy (DG). The incidence of postoperative complications (such as dumping syndrome, bile reflux gastritis, gallstones, weight loss, and malnutrition) has been shown to be lower, while that of delayed gastric emptying (DGE) was higher after PPG than after DG. However, preserving the vagus nerve, blood supply to the pylorus, and adequate antral cuff length can effectively reduce DGE after PPG. Whether or not incomplete lymphadenectomy affects tumor safety is a primary focus for concern. According to the analysis of lymph node metastasis rates in early middle gastric cancer, the metastasis rates of lymph nodes No. 5 and No. 6 were low, providing a theoretical basis for performing limited lymph node dissection.

Keywords: Pylorus-preserving gastrectomy, lymph node metastasis rate, lymph node dissection, delayed gastric emptying

INTRODUCTION

Considering the increased importance of a complete physical examination as well as improved clinical diagnosis methods, the detection rate of early gastric cancer (EGC) has been increasing in Asian countries, with the rate in both Japan and Korea at > 60% and that in China at 20%; recently, the detection rate in China has been increasing[1]. EGC often has good prognosis after treatment, with a survival rate of > 90% over a 5-year period[2]. In previous years, EGC was treated with radical surgery [total gastrectomy or distal gastrectomy (DG)], and surgeons tended to neglect the preservation of the normal digestive and secretory functions of the residual stomach. With technological advancements, function-preserving gastrectomy (FPG), which preserves the function of the residual stomach and improves the quality of life (QOL) of the patient, has become a major option of treatment. It is generally accepted that endoscopic therapy does not belong to FPG. But Nomura E[3] believes that with the development of endoscopic resection techniques and the expansion of indications for endoscopic resection, the boundary between routine surgery and endoscopic resection has become unclear. Therefore, endoscopic resection can be regarded as an FPG and mainly refers to endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD). Initially, the accepted indications for EMR and ESD were limited to differentiated intramucosal carcinoma ≤ 2 cm in diameter (cT1a) without ulceration (UL0). Then, based on the results of the JCOG0607 study, the fifth edition of the guidelines included cT1a, UL0, and differentiated cancer with a diameter > 2 cm as accepted indications for ESD. The expanded indications were cT1a, UL0, and undifferentiated carcinoma with a diameter ≤ 2 cm[4]. Additionally, for tumors with a risk of lymph node metastasis > 1% or submucosal invasion (T1b), surgical treatment is often preferred. Furthermore, endoscopic resection has the possibility of incomplete resection and metachronous gastric neoplasms[5], which would require additional surgery. Therefore, the role of surgical treatment in EGC remains crucial. Pylorus-preserving gastrectomy (PPG), a type of FPG, has become popular.

PPG was first proposed by Maki for treating peptic ulcers[6] and was subsequently used for treating early middle gastric cancer[7]. According to the Japanese gastric cancer treatment guidelines[4], the main indication for PPG is T1a-bN0M0 gastric cancer in the middle of the stomach that is at least 4 cm away from the pylorus and unsuitable for endoscopic treatment. At present, PPG is primarily performed laparoscopically. Laparoscopic approaches preserve the right gastric and infrapyloric vessels, the hepatic and pyloric branches, and the abdominal branch selectively. Lymph node Nos. 1, 3, 4sb, 4d, 6a, 6v, 7, 8a, and 9 are cleared, and reconstruction is performed via hand-sewn or linear stapler gastro-gastrostomy via extracorporeal or intracorporeal approaches.

Compared with traditional DG, PPG has several advantages, including reduction in the incidence of reflux, dumping syndrome, and gallstones by preserving the pylorus, thereby ensuring good QOL after surgery[8-10]. However, the high incidence of delayed gastric emptying (DGE) remains challenging. This may be avoided by preserving the vagus nerve, pyloric blood supply, and adequate antral cuff length and by manually dilating the pylorus[10,11]. With increases in the incidence of EGC, PPG gradually received more attention. However, lymph node dissection and the complexity of protecting the associated blood vessels and nerves limit the wide application of PPG. In this review, the clinical efficacy and safety of PPG have been discussed by comparing the advantages and disadvantages of PPG with DG and analyzing the rates of lymph node metastasis in EGC in the middle stomach and the scope of lymph node dissection.

SURGICAL SAFETY ANALYSIS OF PPG

Table 1[9,12-17] summarizes the safety of different surgical approaches, including the operation time, intraoperative blood loss, and postoperative hospital stay. Although the procedures of PPG were more complicated owing to the need to preserve nerves and blood vessels, with improved surgical methods and

Table 1. Comparison of the surgical safety between DG and PPG

Reference	Approach	Age	BMI	Operation time (min)	Blood loss (mL)	Postoperative hospital stay (day)
Xia *et al.*[9]	LADG	57.5 ± 12.1	22.7 ± 4.8	223.8 ± 28.1	48.5 ± 51.1	
	LAPPG	56.8 ± 10.9	22.3 ± 2.3	220.5 ± 17.2	46.9 ± 49.6	
	P-value	0.667	0.495	0.216	0.830	
Ikeguchi *et al.*[12]	Open DG			258	219	21
	Open PPG			204	99	20.8
	P-value			**0.004**	0.079	0.917
	LADG			330	155	31.1
	LAPPG			348	105	12.7
	P-value			0.603	0.443	**0.003**
Suh *et al.*[13]	LADG	59.1 ± 12.0	24.0 ± 3.1	216.57 ± 67.4	-	8.7 ± 3.2
	LAPPG	54.1 ± 12.3	23.3 ± 3.0	193.8 ± 32.4	-	8.8 ± 4.9
	P-value	**0.001**	0.052	< **0.001**	-	0.809
Aizawa *et al.*[14]	DG	61.7 ± 11.4	22.69 ± 3.08	198 (84-462)	45 (0-1750)	10 (7-41)
	PPG	60.7 ± 9.6	22.71 ± 3.14	206 (80-497)	37 (0-830)	11 (7-78)
	P-value	-	-	0.051	**0.03**	< **0.001**
Eom *et al.*[15]	LADG	56.5 ± 11.8	24.0 ± 3.1	150.0 (130.0, 185.0)	100.0 (12.5, 200.0)	7.0 (6.0, 7.0)
	LAPPG	58.3 ± 12.0	24.1 ± 3.1	210.0 (185.0, 235.0)	100.0 (50.0, 200.0)	7.0 (5.5, 7.0)
	P-value	0.218	0.617	**< 0.001**	0.253	0.940
Han *et al.*[16]	TLPPG	58.6 ± 10.7	23.7 ± 2.9	216.7 ± 4 1.1	25 (20-50)	7.7 ± 2.3
	LAPPG	56.8 ± 10.7	23.6 ± 2.8	197.8 ± 43.3	22.5 (20-70)	7.7 ± 2.3
	P-value	0.71	0.81	0.40	0.43	0.79
Akiyama *et al.*[17]	TLPPG	57.8 ± 10.5	21.3 ± 1.8	264.3 ± 37.3	18.5 ± 13.7	10 (8-40)
	LAPPG	60.4 ± 12.7	22.4 ± 3.2	246.7 ± 49.1	30.7 ± 22.2	10 (7-18)
	P-value	0.409	0.064	0.145	**0.008**	0.2412

medical equipment, the operation time of PPG was not significantly different and was even lower than that of DG in some centers. Intraoperative blood loss and hospital stay were also lower in PPG than in DG. In particular, the wide application of laparoscopy makes the anatomy more precise, reducing intraoperative blood loss. In addition, the minimally invasive incision greatly shortens the hospital stay of the patient. Thus, PPG has a similar surgical safety to DG. Furthermore, the laparoscopic technique combined with the ERAS (Enhanced Recovery After Surgery) protocol enables a shorter hospital stay and a lower complication rate. Although it has been widely used in many patients undergoing elective abdominal surgery, especially in patients with colorectal cancer, it is rarely used in gastric cancer surgery at present. It is believed that with the development of technology and equipment, ERAS can further shorten the length of hospital stay. In addition, totally laparoscopic pylorus-preserving gastrectomy (TLPPG) has attracted significant attention in recent years, and compared with laparoscopic-assisted pylorus-preserving gastrectomy (LAPPG), TLPPG also has a similar safety profile with its own advantages.

SHORT-TERM POSTOPERATIVE EFFICACY ANALYSIS OF PPG

By summarizing and comparing the perioperative complications of PPG [Table 2][9,13-15,18-21] and analyzing the short-term postoperative efficacy, we found that the incidence of DGE was significantly higher after PPG than after DG and that the incidence of other complications, such as anastomotic leakage, anastomotic stenosis, pancreatic leakage, infection, and in-hospital mortality, were not significantly different between the

Table 2. Comparison of the short-term postoperative efficacy between DG and PPG

Reference	Approach	Anastomotic leakage	Anastomotic stenosis	Pancreatic leak	DGE	Infection	In-hospital mortality
Xia *et al.*[9]	LADG	3 (3.1%)			2 (2.1%)		
	LAPPG	1 (1.4%)			4 (5.7%)		
	P-value	0.824			0.824		
Suh *et al.*[13]	LADG	2 (1.2%)			3/176 (1.7%)		
	LAPPG	0 (0%)			9/116 (7.8%)		
	P-value	-			**0.015**		
Aizawa *et al.*[14]	DG	3 (0.6%)	1 (0.2%)	4 (0.8%)	1 (0.2%)	2 (0.4%)	0 (0%)
	PPG	3 (0.6%)	3 (0.6%)	5 (1.0%)	0 (0%)	2 (0.4%)	0 (0%)
	P-value	-	-	-	-	-	-
Eom *et al.*[15]	LADG	1 (0.5%)			2 (1.0%)		
	LAPPG	1 (1.0%)			9 (8.9%)		
	P-value	0.282			**0.001**		
Hiki *et al.*[18]	CPPG*	1 (3%)	4 (11%)		4 (11%)		
	LAPPG	0 (0%)	5 (7%)		11 (15%)		
	P-value	0.73	0.73		0.77		
Lee *et al.*[19]	LDG	9/305	3/305	16/305	8/305	13/305	1/305
	LPPG	2/148	2/148	4/148	10/148	4/148	0/148
	P-value	-	-	-	**< 0.05**	-	-
Tsujiura *et al.*[20]	LDG	1 (1.0%)		1 (1.0%)	1 (1.0%)	5 (5.0%)	0 (0%)
	LPPG	1 (1.0%)		1 (1.0%)	3 (3.0%)	9 (8.9%)	0 (0%)
	P-value	1.000		1.000	0.313	0.268	-
Park *et al.*[21]	LDG	2 (1.6%)	2 (1.6%)		1 (0.8%)	3 (2.4%)	0 (0%)
	LPPG	2 (1.6%)	1 (0.8%)		7 (5.4%)	6 (4.7%)	0 (0%)
	P-value	1.000	> 0.999		**0.014**	0.500	-

*CPPG: conventional PPG

two surgical methods.

DGE is the most common complication after PPG. Several studies have analyzed the causes of DGE and evaluated different methods to prevent it. Pylorus function insufficiency and old age are risk factors for DGE. During surgery, the preservation of blood supply to the gastric antrum, vagus nerve, and length of the antral cuff are the primary factors that affect the occurrence of DGE.

Nunobe *et al.* suggested that preserving the infrapyloric vessel and the first branch of the right gastric vessel to ensure blood supply to the pylorus can significantly reduce the occurrence of DGE[22]. Nishizawa *et al.* reported that the retention of the infrapyloric vein might not be helpful in reducing DGE[23]. Kaji S *et al.* also revealed that preserving the IPV did not help prevent DGE, and there is no significant difference in the outcomes between IPV-preserved and IPV-non-preserved[24]. Recent studies by Takahashi R *et al.* have shown that DGE occurs in 7.6% of patients after laparoscopic pylorus-preserving gastrectomy (LPPG). Age, diabetes, and intraperitoneal infection were significantly correlated with DGE[25]. The preservation of the infrapyloric vein and celiac branch is not significantly related to the occurrence of DGE.

At present, it is believed that the preservation of the hepatic branch and pyloric branch is critical for maintaining the normal physiological function of the pylorus[22]; however, the significance of the abdominal branch is still debated. In a comparative study, Furukawa *et al.* revealed no clinical benefit of retaining the abdominal branches during PPG[26]. Additionally, Kinami S *et al.* reported that celiac branch preservation can improve postgastrectomy syndromes in patients undergoing DG and PPG[27]. Therefore, we recommend retaining the celiac branch as much as possible.

In another comparative analysis, Nakane *et al.* found that preserving the short antral cuff during PPG was one of the risk factors of postoperative DGE and that the short antral cuff was likely to lead to insufficient food intake and poor body weight recovery[28]. During PPG operation, the length of the antral cuff was usually kept at 1.5 cm, and the incidence of DGE ranged from 23% to 40%[22,28,29]. Other studies have shown that to preserve the functions of the antrum and pylorus and reduce the occurrence of DGE, the preserved length of the antral cuff should be at least 2.5 cm-3.0 cm[30], with one center recommending > 4.0 cm[31]. Namikawa T *et al.* found that the size of the proximal gastric (less than a quarter, about one-third, or more than a half of the original size) significantly affects the changes in weight, the scores of meal dissatisfaction, and subscales of daily life dissatisfaction (P = 0.030, P = 0.005, and P = 0.034, respectively) by the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45)[32]. Some physicians[33] have proposed that simple manual pyloric dilatation during surgery can prevent pyloric stenosis. Others, such as Xia *et al.*, have suggested that DGE after PPG could be relieved by certain conservative treatments, such as fasting, gastrointestinal decompression, and nutritional support[9]. Yet, for anastomotic stenosis after PPG, Suh *et al.* indicated that most patients only require a simple balloon dilatation under intervention to relieve the stenosis[13]. Despite the numerous treatment options, additional prospective studies are still needed to verify the method that yields ideal results.

LONG-TERM POSTOPERATIVE EFFICACY OF PPG

The long-term postoperative complications after gastrectomy include dumping syndrome, gallstones, bile reflux gastritis, weight loss, and nutritional status. After summarizing and analyzing the results regarding long-term complications [Table 3][9-11,13,34,35], we found that PPG is superior to DG in reducing dumping syndrome, maintaining postoperative weight, reducing bile reflux, and maintaining gallbladder function.

Gallstones

Gallstones are one of the most common complications after gastrectomy. PPG can reduce the risk of gallstone development by protecting the hepatic and pyloric branches of the vagus nerve, maintaining the continuity of the pyloric and duodenal muscles, and preserving the contraction of the sphincter of Oddi and the normal emptying function of the gallbladder[36]. Fukagawa *et al.* followed up with 672 patients after gastrectomy for > 5 years and observed that 173 patients (25.7%) had gallstones after the procedure and that none of the 11 patients of the 672 patients who underwent PPG developed gallstones[37].

Bile reflux gastritis

Bile reflux gastritis is a common complication of DG[38] as the pyloric sphincter of the patient is removed, which can lead to the release of duodenal contents into the residual stomach. In contrast to DG, PPG can completely preserve the normal anatomical structure and physiological function of the pylorus, thereby avoiding the occurrence of reflux gastritis[33]. Hotta T *et al.* compared the endoscopic results of PPG and distal gastrectomy with Billroth-I (DG-BI) at six months after surgery[39]. They found that the incidence of bile reflux was 15.8% with PPG and 53.3% with DG-BI. It was also reported to be 15% after PPG and 68% after conventional DG (CDG) by Imada *et al.*[31]. Kodama *et al.* reported that the incidence of bile reflux was 11% and 62% after one year of PPG and DG[30]. In a retrospective study by Tomita R et al., with follow-up

Table 3. Comparison of the long-term postoperative efficacy between DG and PPG

Reference	Approach	Decrease in body weight (kg)	Dumping syndrome	Gallstones	Bile reflux gastritis	Hemoglobin (g/dL)	Albumin (g/dL)
Xia *et al.*[9]	LADG			8 (8.2%)	25.7%	-2.73 ± 3.8	10.06 ± 15.4
	LAPPG			5 (7.1%)	5.7%	-1.09 ± 4.0	17.20 ± 25.6
	P-value			1.000	0.024	0.014	**0.048**
Park *et al.*[10]	DG			11.8%	(3/12)25%		4.1 ± 0.2
	PPG			0	(0/12)0%		4.1 ± 0.2
	P-value			0.05	0.05		--
Zhu *et al.*[11]	PPG	-4.3 ± 4.1				-0.5 ± 1.2	-0.0 ± 0.4
	DG	-6.4 ± 4.5				-1.1 ± 1.0	-0.2 ± 0.3
	P-value	**0.007**				**0.002**	**0.001**
Suh *et al.*[13]	LADG			8/165 (6.5%)			-0.6 ± 8.3
	LAPPG			0/109 (0%)			4.0 ± 11.9
	P-value			**0.038**			**0.003**
Tomita *et al.*[34]	PPG		0% (0/10)	0% (0/10)	10.0%(1/10)		
	CDG		22.7% (5/22)	18.1% (5/22)	63.6%(14/22)		
	P-value		0.1007	0.1494	**0.0048**		
Shibata *et al.*[35]	PPG	-6.7 ± 1.7	2/24 (8.3%)			13.6 ± 0.3	
	CDG	-6.9 ± 1.2	7/21 (33.3%)			13.3 ± 0.3	
	P-value	> 0.05	**0.0365**			> 0.05	

*CDG: conventional DG.

over five years, the frequency of gastritis was significantly lower in the PPG group than in the DG group (10.0% *vs.* 63.6%)[34].

Dumping syndrome

PPG preserves the anatomy and function of the pylorus and prevents food from entering the small intestine too quickly, reducing the incidence of postoperative dumping syndrome. Tanizawa et al. surveyed 2,368 patients after six types of gastrectomy approaches using the PGSAS-45 and found that the incidence of dumping syndrome was the highest in patients who underwent total gastrectomy with Roux-en-Y (TGRY) (33.0%), followed by proximal gastrectomy (PG) (27.0%), DG-BI (25.8%), distal gastrectomy with Roux-en-Y (DGRY) (24.3%), PPG (18.6%), and local resection (LR) (10.1%)[40]. In addition, Fujita *et al.* revealed that age and the preservation of the celiac branch of the vagus nerve were independent factors predicting diarrhea and dumping[41].

Weight loss

PPG can preserve more of the residual stomach, which helps to maintain the digestive and storage functions. Because of this, the postoperative patient weight loss is usually lower after PPG than after DG. Suh *et al.* speculated that because PPG preserved the pyloric sphincter, food could be retained in the stomach for a long time, indicating that it would have a larger "functional gastric reservoir[13]". This would enable a patient to obtain optimal nutrition and recover body weight faster after PPG than after DG. In addition, a low body mass index (BMI) may be associated with poor prognosis[42]. Migita *et al.* revealed that the postoperative survival time of underweight patients was significantly lower than that of normal weight or overweight patients[43]. In their study, 73 patients (11.4 %) were underweighted, 431 patients (67.6 %)

were of normal weight, and 134 patients (21 %) were overweight. The 5-year overall survival (OS) rate was 66.6 % in the underweight patients, 81.3 % in the normal weight patients, and 79.9 % in the overweight patients ($P = 0.001$).

Reflux esophagitis

Reflux esophagitis has recently attracted attention as a disadvantage of PPG. Otake R *et al.* revealed that the factors correlated with postoperative reflux esophagitis were male sex, preoperative grade A reflux esophagitis, postoperative BMI of ≥ 23 kg/m^2, hiatal hernia, and long-term gastric stasis[44]. Therefore, for cancer patients with these risk factors, sufficient attention should be paid to LPPG and postoperative management after LPPG.

Postoperative nutritional status

The comparison of hemoglobin and albumin levels of postoperative patients suggested that the nutritional status is significantly better after PPG than after DG. Anemia due to decreased hemoglobin is a common clinical complication after gastrectomy. Kim *et al.* conducted a follow-up study on 566 nonanemic patients with gastric cancer before surgery and found that 240 cases (42.4%) developed anemia at least once in 5 years after gastrectomy[45]. The possible causes of anemia after gastric cancer surgery include iron absorption disorder, insufficient oral intake, and occult blood loss[46]. Because PPG retains the original lumen and absorption function via gastro-gastrostomy anastomosis, it can effectively prevent anemia compared with DG.

LOW METASTATIC RATE OF LYMPH NODES NO. 5 AND NO. 6 IN EGC LOCATED IN THE MIDDLE OF THE STOMACH

Sentinel lymph node dissection and sampling are also important for improved prognosis, as failure to remove certain lymph nodes may increase the chances of metastasis. Table 4 shows the summary of lymph node metastasis in early middle gastric cancer (T1N0M0) from multiple surgical centers across East Asia[11,13,47-50]. Lymph node metastasis was most frequently observed in lymph nodes No. 3 and No. 4, whereas the occurrence was low in No. 5 and No. 6. Shimada *et al.* performed sentinel node navigation surgery (SNNS) and showed that lymph nodes No. 5 and No. 6 were negative for metastasis, but the metastasis rate of lymph node No. 7 was as high as 12%[50]. Lymph node No. 6 is subdivided into No. 6a, 6v, and 6i in the Japanese Classification of Gastric Carcinoma (15th edition)[51]; 6i is the region where the infrapyloric vessels are located, and lymph node metastasis in this region is rare. Mizuno *et al.* reported that the metastasis rate in lymph nodes No. 6a, No. 6v, and No. 6i was 2.6%, 0%, and 0%, respectively, in 117 patients with early middle gastric cancer[52].

Compared with DG, PPG aims to preserve the nerve and blood supply to the antrum, which affects the dissection of lymph nodes No. 5 and No. 6. However, the lymph node metastasis data suggest that the limited lymph node dissection of No. 5 and No. 6 does not affect the oncological outcome of PPG. Table 5 lists details about the scope of lymph node dissection during PPG[11,13,18,47]. It was found that the dissection number of all lymph nodes significantly decreased during PPG compared to DG, especially for lymph node No. 5. There was no significant difference in the number of the dissected lymph nodes, No. 1 and No. 6. The overall number of lymph node dissection in LAPPG was greater than that in conventional PPG (CPPG), but there was no significant difference, indicating that LAPPG did not lead to more difficult lymph node dissection. In addition, some studies have suggested that if lymph node No. 5 is identified as being enlarged during surgery and has a risk of metastasis, it would need to be cleared, or an alternative surgical method would need to be used[53]. The lymph node metastasis rate of No. 11p has been shown to be very low. Therefore, it does not need to be cleared. However, during actual practice, clinicians from Japan, Korea, and

Table 4. Lymph node metastasis in early middle gastric cancer

Reference	Lymph node metastasis (%)									
	No. 1	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 11	No. 12
Zhu *et al.*[11]	2.1	3.5	2.4	**0**	**0.7**	3.8	0.7	2.1	0.4	0
Suh *et al.*[13]	2.3	6.9	7.0	**0**	**1.7**	5.5	1.5	0	0.9	0
Kim *et al.*[47]	1.82	5.45	2.27	**0.45**	**0.45**	0.91	1.36	1.36	0.45	-
Kong *et al.*[48]	-	8.8	11.5	**0.9**	**1.8**	-	-	-	-	-
Khalayleh *et al.*[49]	1.9	5.4	2	**0**	**0.3**	2.1	1.0	0.8	1.7	0
Shimada *et al.*[50]	6	6	17	**0**	**0**	12	0	0	1	0

Table 5. Comparison of lymph node dissection number between PPG and DG

Reference	Surgical method	Lymph node dissection number (mean)				
		Overall	No. 1	No. 5	No. 6	No. 12
Zhu *et al.*[11]	DG	39.8	4.2	0.7	6.3	N/A
	PPG	35.1	4.3	N/A	5.9	N/A
	P-value	0.027	**0.772**	-	0.279	-
Suh *et al.*[13]	LADG	35.2	4.0	0.8	5.3	0.7
	LAPPG	35.9	3.9	N/A	4.8	N/A
	P-value	0.650	0.688	-	0.265	-
Hiki *et al.*[18]	LAPPG	32.3	3.1	0.7	3.4	
	CPPG	28.5	2.6	0.8	3.6	
	P-value	0.16	0.40	0.49	0.67	
Kim *et al.*[47]	CDG	42.53		2.18	5.99	
	PPG	42.29		0.10	5.00	
	P-value	0.942		**< 0.001**	0.233	

China still appear to perform the lymph node dissection of No. 11p. Routine lymph node dissection of No. 11p is also performed at our center.

NO DIFFERENCE WAS SEEN IN THE SURVIVAL RATE BETWEEN PPG AND DG

In cases that fit the indications, the reduced range of lymph node dissection is the main factor in PPG that may affect oncological prognosis. The analysis of lymph node metastasis in early middle gastric cancer and the scope of PPG in lymph node dissection suggests that even if lymph nodes are not dissected or completely dissected, tumor recurrence is not likely to occur. As a result of the low metastatic rate, there is a good survival rate. Table 6 shows the comparison of the survival, metastasis, and recurrence rates of patients who underwent DG or PPG[11-14,54]. Although the number of lymph node dissection was lower in PPG than in DG, the 3-year or 5-year survival rate, in addition to the metastasis and recurrence rates, were not significantly different between the two procedures. Therefore, PPG has the same oncological safety as DG, with no difference in survival.

CONCLUSION

Asia has become a high-incidence area of gastric cancer. The four countries with the highest incidence rate are South Korea, Mongolia, Japan, and China. This is related to Asian dietary habits and genetics. Due to the standardized screening process for EGC in Japan and South Korea, their diagnosis rates are much higher than in China, resulting in a large amount of data for PPG. On the contrary, due to the low diagnostic rate

Table 6. Comparison of the tumor safety between DG and PPG

Reference	Surgical method	Lymph node dissection number (mean)	3-year recurrence-free survival rate (%)	5-year Overall survival rate (%)	Recurrence/ metastasis rate (%)
Zhu *et al.*[11]	PPG	35.1	97.8	——	——
	DG	39.8	94.4	——	——
	P-value	0.027	0.423	——	——
Ikeguchi *et al.*[12]	DG	30.4	——	86	1.1
	PPG	21.9	——	95	0
	P-value	**0.001**	——	0.087	——
Suh *et al.*[13]	LADG	35.2	98.8	——	1.1
	LAPPG	35.9	98.2	——	1.7
	P-value	0.650	0.702	——	0.131
Aizawa *et al.*[14]	PPG	——	99.5	98.4	0.8
	DG	——	98.0	96.6	1.6
	P-value	——	0.12	0.07	0.192
HU *et al.*[54]	PPG			92.3	5.7
	DG			93.1	5.6
	P-value			0.05	0.05

of EGC in China, PPG has not yet been widely applicated. Our center has introduced PPG from Japan and has achieved good clinical results, which are similar to the postoperative outcomes in Japan. Therefore, China, Japan, and Korea should continue conducting large-scale multicenter randomized clinical trials to further evaluate the efficacy and benefit of PPG for early middle gastric cancer. However, present data has thus far shown that PPG is a safe and effective surgical approach as well as a better surgical option compared to DG, largely due to its more improved surgical method, tumor safety, and clinical efficacy following PPG. With the increasing incidence of EGC in China, we believe that PPG surgery should be more widely implemented in the clinical setting.

DECLARATIONS

Author Contributions

Performed the research and designed the article structure: Guo W, He ZP, Orita H
Collected the clinical data from articles: Mei XH, Su S, Wang YY
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Wrote the paper: He ZP
Read and approved the final manuscript: Guo W, He ZP, Su S, Mei XH, Fedor CN, Fukunaga T, Wang YY, Zhang K, Guan XQ, Brock MV, Orita H

Availability of data and materials

Not applicable.

Financial support and sponsorship

There was no financial support for this work.

Conflicts of interest

The authors do not have any potential conflicts of interest to declare.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

REFERENCES

1. Azagra JS, Sarriugarte A, Ibañez FJ. Current status of gastrectomy for cancer: "less is often more". *Cir Esp* 2018;96:603-5. DOI PubMed
2. Huang C, Yu F, Zhao G, Xia X. Postoperative quality of life after laparoscopy-assisted pylorus-preserving gastrectomy compared with laparoscopy-assisted distal gastrectomy for early gastric cancer. *J Gastroenterol Hepatol* 2020;35:1712-9. DOI PubMed
3. Nomura E, Okajima K. Function-preserving gastrectomy for gastric cancer in Japan. *World J Gastroenterol* 2016;22:5888-95. DOI PubMed PMC
4. Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2018 (5th edition). *Gastric Cancer* 21;24:1-21. DOI PubMed PMC
5. Choi J, Kim S, Chung H, et al. Safety of pylorus-preserving gastrectomy for gastric cancer combined with antral high-risk lesions: a comparison with endoscopic submucosal dissection. *Surg Endosc* 2023;37:2987-96. DOI
6. Maki T, Shiratori T, Hatafuku T, Sugawara K. Pylorus-preserving gastrectomy as an improved operation for gastric ulcer. *Surgery* 1967;61:838-45. PubMed
7. Kodama M, Koyama K. Indications for pylorus preserving gastrectomy for early gastric cancer located in the middle third of the stomach. *World J Surg* 1991;15:628-33; discussion 633. DOI PubMed
8. Nomura E, Isozaki H, Fujii K, et al. Postoperative evaluation of function-preserving gastrectomy for early gastric cancer. *Hepatogastroenterology* 2003;50:2246-50. PubMed
9. Xia X, Xu J, Zhu C, Cao H, Yu F, Zhao G. Objective evaluation of clinical outcomes of laparoscopy-assisted pylorus-preserving gastrectomy for middle-third early gastric cancer. *BMC Cancer* 2019;19:481. DOI PubMed PMC
10. Park DJ, Lee HJ, Jung HC, Kim WH, Lee KU, Yang HK. Clinical outcome of pylorus-preserving gastrectomy in gastric cancer in comparison with conventional distal gastrectomy with Billroth I anastomosis. *World J Surg* 2008;32:1029-36. DOI PubMed
11. Zhu CC, Cao H, Berlth F, et al. Pylorus-preserving gastrectomy for early cancer involving the upper third: can we go higher? *Gastric Cancer* 2019;22:881-91. DOI
12. Ikeguchi M, Hatada T, Yamamoto M, et al. Evaluation of a pylorus-preserving gastrectomy for patients preoperatively diagnosed with early gastric cancer located in the middle third of the stomach. *Surg Today* 2010;40:228-33. DOI
13. Suh YS, Han DS, Kong SH, et al. Laparoscopy-assisted pylorus-preserving gastrectomy is better than laparoscopy-assisted distal gastrectomy for middle-third early gastric cancer. *Ann Surg* 2014;259:485-93. DOI
14. Aizawa M, Honda M, Hiki N, et al. Oncological outcomes of function-preserving gastrectomy for early gastric cancer: a multicenter propensity score matched cohort analysis comparing pylorus-preserving gastrectomy versus conventional distal gastrectomy. *Gastric Cancer* 2017;20:709-17. DOI
15. Eom BW, Park B, Yoon HM, Ryu KW, Kim YW. Laparoscopy-assisted pylorus-preserving gastrectomy for early gastric cancer: a etrospective study of long-term functional outcomes and quality of life. *World J Gastroenterol* 2019;25:5494-504. DOI PubMed PMC
16. Han WH, Eom BW, Yoon HM, Ryu KW, Kim DH, Kim YW. A comparison of totally laparoscopic pylorus preserving gastrectomy and laparoscopy-assisted pylorus preserving gastrectomy for early gastric cancer. *J Minim Invasive Surg* 2019;22:113-8. DOI PubMed PMC
17. Akiyama Y, Sasaki A, Iwaya T, et al. Feasibility of totally laparoscopic pylorus-preserving gastrectomy with intracorporeal gastro-gastrostomy for early gastric cancer: a retrospective cohort study. *World J Surg Oncol* 2020;18:170. DOI PubMed PMC
18. Hiki N, Shimoyama S, Yamaguchi H, Kubota K, Kaminishi M. Laparoscopy-assisted pylorus-preserving gastrectomy with quality controlled lymph node dissection in gastric cancer operation. *J Am Coll Surg* 2006;203:162-9. PubMed
19. Lee SW, Nomura E, Bouras G, Tokuhara T, Tsunemi S, Tanigawa N. Long-term oncologic outcomes from laparoscopic gastrectomy for gastric cancer: a single-center experience of 601 consecutive resections. *J Am Coll Surg* 2010;211:33-40. DOI PubMed
20. Tsujiura M, Hiki N, Ohashi M, et al. Should pylorus-preserving gastrectomy be performed for overweight/obese patients with gastric cancer? *Gastric Cancer* 2019;22:1247-55. DOI
21. Park DJ, Kim YW, Yang HK, et al. Short-term outcomes of a multicentre randomized clinical trial comparing laparoscopic pylorus-preserving gastrectomy with laparoscopic distal gastrectomy for gastric cancer (the KLASS-04 trial). *Br J Surg* 2021;108:1043-9. DOI
22. Nunobe S, Hiki N, Fukunaga T, et al. Laparoscopy-assisted pylorus-preserving gastrectomy: preservation of vagus nerve and infrapyloric blood flow induces less stasis. *World J Surg* 2007;31:2335-40. DOI

23. Nishizawa N, Yamashita K, Shinohara H, et al. Anatomical Knowledge for the Infra-Pyloric Vein Preservation during the Laparoscopy-Assisted Pylorus-Preserving Gastrectomy. *Dig Surg* 2016;33:363-70. DOI PubMed
24. Kaji S, Makuuchi R, Irino T, et al. Preventive effect on delayed gastric emptying of preserving the infra-pyloric vein in laparoscopic pylorus-preserving gastrectomy for early gastric cancer. *Surg Endosc* 2020;34:3853-60. DOI
25. Takahashi R, Ohashi M, Hiki N, et al. Risk factors and prognosis of gastric stasis, a crucial problem after laparoscopic pylorus-preserving gastrectomy for early middle-third gastric cancer. *Gastric Cancer* 2020;23:707-15. DOI
26. Furukawa H, Ohashi M, Honda M, et al. Preservation of the celiac branch of the vagal nerve for pylorus-preserving gastrectomy: is it meaningful? *Gastric Cancer* 2018;21:516-23. DOI
27. Kinami S, Takahashi M, Urushihara T, et al. Background factors influencing postgastrectomy syndromes after various types of gastrectomy. *World J Clin Cases* 2018;6:1111-20. DOI PubMed PMC
28. Nakane Y, Michiura T, Inoue K, et al. Length of the antral segment in pylorus-preserving gastrectomy. *Br J Surg* 2002;89:220-4. PubMed
29. Jiang X, Hiki N, Nunobe S, et al. Postoperative outcomes and complications after laparoscopy-assisted pylorus-preserving gastrectomy for early gastric cancer. *Ann Surg* 2011;253:928-33. DOI
30. Kodama M, Koyama K, Chida T, Arakawa A, Tur G. Early postoperative evaluation of pylorus-preserving gastrectomy for gastric cancer. *World J Surg* 1995;19:456-60; discussion 461. DOI PubMed
31. Imada T, Rino Y, Takahashi M, et al. Postoperative functional evaluation of pylorus-preserving gastrectomy for early gastric cancer compared with conventional distal gastrectomy. *Surgery* 1998;123:165-70. PubMed
32. Namikawa T, Hiki N, Kinami S, et al. Factors that minimize postgastrectomy symptoms following pylorus-preserving gastrectomy: assessment using a newly developed scale (PGSAS-45). *Gastric Cancer* 2015;18:397-406. DOI
33. Hosoda K, Yamashita K, Sakuramoto S, et al. Postoperative quality of life after laparoscopy-assisted pylorus-preserving gastrectomy compared with laparoscopy-assisted distal gastrectomy: a cross-sectional postal questionnaire survey. *Am J Surg* 2017;213:763-70. DOI
34. Tomita R, Fujisaki S, Tanjoh K. Pathophysiological studies on the relationship between postgastrectomy syndrome and gastric emptying function at 5 years after pylorus-preserving distal gastrectomy for early gastric cancer. *World J Surg* 2003;27:725-33. DOI PubMed
35. Shibata C, Shiiba KI, Funayama Y, et al. Outcomes after pylorus-preserving gastrectomy for early gastric cancer: a prospective multicenter trial. *World J Surg* 2004;28:857-61. DOI
36. Nabae T, Takahata S, Konomi H, et al. Effect of prepyloric gastric transection and anastomosis on sphincter of oddi cyclic motility in conscious dogs. *J Gastroenterol* 2001;36:530-7. DOI
37. Fukagawa T, Katai H, Saka M, Morita S, Sano T, Sasako M. Gallstone formation after gastric cancer surgery. *J Gastrointest Surg* 2009;13:886-9. DOI PubMed
38. Montesani C, D'Amato A, Santella S, et al. Billroth I versus Billroth II versus Roux-en-Y after subtotal gastrectomy. Prospective [correction of prespective] randomized study. *Hepatogastroenterology* 2002;49:1469-73. PubMed
39. Hotta T, Taniguchi K, Kobayashi Y, et al. Postoperative evaluation of pylorus-preserving procedures compared with conventional distal gastrectomy for early gastric cancer. *Surg Today* 2001;31:774-9. DOI
40. Tanizawa Y, Tanabe K, Kawahira H, et al; Japan postgastrectomy syndrome working party. specific features of dumping syndrome after various types of gastrectomy as assessed by a newly developed integrated questionnaire, the PGSAS-45. *Dig Surg* 2016;33:94-103. DOI
41. Fujita J, Takahashi M, Urushihara T, et al. Assessment of postoperative quality of life following pylorus-preserving gastrectomy and Billroth-I distal gastrectomy in gastric cancer patients: results of the nationwide postgastrectomy syndrome assessment study. *Gastric Cancer* 2016;19:302-11. DOI
42. Wang F, Liu X, Mao P, et al. Relationship between the body mass index and tumor site postoperative complications and prognosis in gastric adenocarcinoma. *Am Surg* 2018;84:1861-8. DOI
43. Migita K, Takayama T, Matsumoto S, et al. Impact of being underweight on the long-term outcomes of patients with gastric cancer. *Gastric Cancer* 2016;19:735-43. DOI
44. Otake R, Kumagai K, Ohashi M, et al. Reflux esophagitis after laparoscopic pylorus-preserving gastrectomy for gastric cancer. *Ann Surg Oncol* 2023;30:2294-303. DOI
45. Kim JH, Bae YJ, Jun KH, Chin HM. The prevalence and clinical significance of postgastrectomy anemia in patients with early-stage gastric cancer: a retrospective cohort study. *Int J Surg* 2018;52:61-6. DOI PubMed
46. Annibale B, Capurso G, Delle Fave G. The stomach and iron deficiency anaemia: a forgotten link. *Dig Liver Dis* 2003;35:288-95. DOI PubMed
47. Kim BH, Hong SW, Kim JW, Choi SH, Yoon SO. Oncologic safety of pylorus-preserving gastrectomy in the aspect of micrometastasis in lymph nodes at stations 5 and 6. *Ann Surg Oncol* 2014;21:533-8. DOI PubMed
48. Kong SH, Kim JW, Lee HJ, et al. The safety of the dissection of lymph node stations 5 and 6 in pylorus-preserving gastrectomy. *Ann Surg Oncol* 2009;16:3252-8. DOI PubMed
49. Khalayleh H, Kim YW, Yoon HM, Ryu KW. Assessment of lymph node metastasis in patients with gastric cancer to identify those suitable for middle segmental gastrectomy. *JAMA Netw Open* 2021;4:e211840. DOI PubMed PMC
50. Shimada A, Takeuchi H, Ono T, et al. Pylorus-preserving surgery based on the sentinel node concept in early gastric cancer. *Ann Surg*

Oncol 2016;23:4247-52. DOI

51. Haruta S, Shinohara H, Ueno M, Udagawa H, Sakai Y, Uyama I. Anatomical considerations of the infrapyloric artery and its associated lymph nodes during laparoscopic gastric cancer surgery. *Gastric Cancer* 2015;18:876-80. DOI PubMed
52. Mizuno A, Shinohara H, Haruta S, et al. Lymphadenectomy along the infrapyloric artery may be dispensable when performing pylorus-preserving gastrectomy for early middle-third gastric cancer. *Gastric Cancer* 2017;20:543-7. DOI
53. Surgery Group, Surgery Branch, Chinese Medical Association, Oncology Surgery Group, Surgical} Branch, Chinese Medical Doctor Association, Upper Gastrointestinal Group, Surgical Branch, Chinese Medical Doctor Association, Cancer Gastroenterology Society, Chinese Anticancer Association. [Chinese expert consensus on function-preserving gastrectomy for gastric cancer (2021 edition)]. *Zhonghua Wei Chang Wai Ke Za Zhi* 2021;24:377-82. DOI PubMed
54. Hu X, Zhang C, Cao L, Zhang J. [Efficacy analysis of laparoscopy-assisted pylorus-vagus nerve preserving gastrectomy in the treatment of early middle gastric cancer]. *Zhonghu Wei Chang Wai Ke Za Zhi* 2016;19:892-7. PubMed