

WJG 20<sup>th</sup> Anniversary Special Issues (8): Gastric cancer**Current status of function-preserving surgery for gastric cancer**

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Author contributions: All authors contributed to conception and design, acquisition of data, or analysis and interpretation of data.

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Received: May 27, 2014 Revised: July 16, 2014

Accepted: September 5, 2014

Published online: December 14, 2014

**Abstract**

Recent advances in diagnostic techniques have allowed the diagnosis of gastric cancer (GC) at an early stage. Due to the low incidence of lymph node metastasis and favorable prognosis in early GC, function-preserving surgery which improves postoperative quality of life may be possible. Pylorus-preserving gastrectomy (PPG) is one such function-preserving procedure, which is expected to offer advantages with regards to dumping syndrome, bile reflux gastritis, and the frequency of flatus, although PPG may induce delayed gastric emptying. Proximal gastrectomy (PG) is another function-preserving procedure, which is thought to be advantageous in terms of decreased duodenogastric reflux and good food reservoir function in the remnant stomach, although the incidence of heartburn or gastric fullness associated with this procedure is high. However, these disadvantages may be overcome by the reconstruction method used. The other important problem after PG is remnant GC, which was reported to occur in approximately 5% of patients. Therefore, the reconstruction technique used with PG should facilitate postoperative

endoscopic examinations for early detection and treatment of remnant gastric carcinoma. Oncologic safety seems to be assured in both procedures, if the preoperative diagnosis is accurate. Patient selection should be carefully considered. Although many retrospective studies have demonstrated the utility of function-preserving surgery, no consensus on whether to adopt function-preserving surgery as the standard of care has been reached. Further prospective randomized controlled trials are necessary to evaluate survival and postoperative quality of life associated with function-preserving surgery.

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**Key words:** Gastric cancer; Function preserving surgery; Quality of life; Pylorus preserving surgery; Proximal gastrectomy

**Core tip:** We reviewed the current status of two function-preserving surgeries for gastric cancer (GC), pylorus-preserving surgery and proximal gastrectomy (PG). Although both procedures appear to be oncologically safe for early GC, issues regarding postoperative quality of life remain, especially with PG. The effect of the reconstruction method after PG on postoperative quality of life was analyzed, including the novel double tract reconstruction method, which is expected to overcome disadvantages associated with esophagogastrectomy and jejunal interposition reconstruction. Although some reports showed a benefit with function-preserving surgery, further randomized trials are needed.

Saito T, Kurokawa Y, Takiguchi S, Mori M, Doki Y. Current status of function-preserving surgery for gastric cancer. *World J Gastroenterol* 2014; 20(46): 17297-17304 Available from: URL: <http://www.wjgnet.com/1007-9327/full/v20/i46/17297.htm> DOI: <http://dx.doi.org/10.3748/wjg.v20.i46.17297>

## INTRODUCTION

Recent developments in screening programs and endoscopic techniques have allowed the diagnosis of gastric cancer (GC) at an early stage<sup>[1]</sup>. Early GC (EGC) makes up 50% of the diagnosed cases and the five-year survival rate of EGC treated with surgery is over 90% in Japan<sup>[2]</sup>. Due to the low incidence of lymph node metastasis and the favorable prognosis of EGC, areas of gastric resection and lymph node dissection areas could be reduced to preserve postoperative gastric function. Although the Japanese GC treatment guidelines advocate resection of at least two-thirds of the stomach with D2 node dissection as the standard treatment for most stages of advanced GC, the guidelines also describe less invasive procedures such as pylorus-preserving gastrectomy (PPG), proximal gastrectomy (PG), and other minimally invasive procedures as investigational treatments (Figure 1)<sup>[3]</sup>.

Here we review PPG and PG as function-preserving procedures for GC.

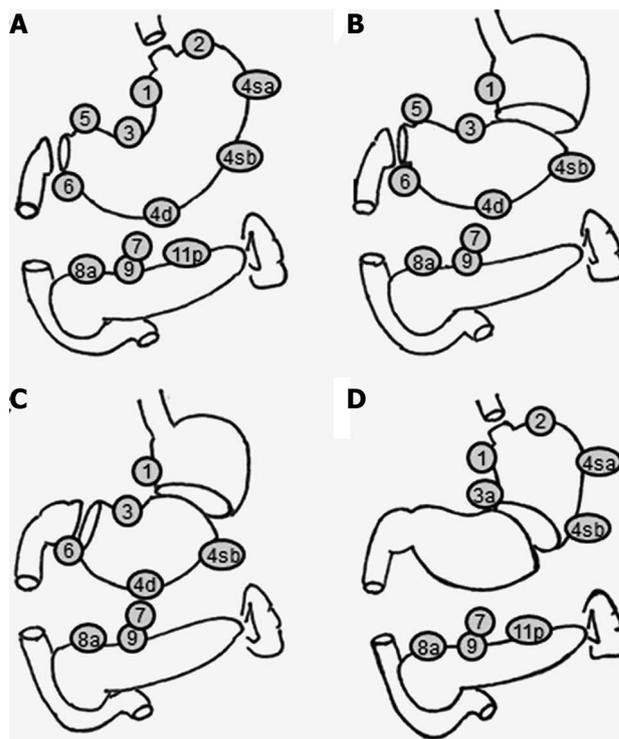
## PPG

PPG was initially used to treat peptic ulcers<sup>[4]</sup>. Starting in the late 1980s, some surgeons performed PPG in selected patients with EGC to improve postoperative gastric function and maintain patient quality of life<sup>[5]</sup>. PPG is generally thought to offer several advantages over conventional distal gastrectomy (DG) with Billroth I reconstruction in terms of the incidence of dumping syndrome, bile reflux gastritis, and the frequency of flatus, although the operative duration of PPG is longer than that of DG.

During the procedure, the distal part of the stomach is resected, but a pyloric cuff 2-3 cm wide is preserved<sup>[6,7]</sup>. The right gastric artery and the infrapyloric artery are preserved to maintain the blood supply to the pyloric cuff. In addition, the hepatic and pyloric branches of the vagal nerves are preserved to maintain pyloric function. The celiac branch of the posterior vagal trunk is sometimes preserved. All regional nodes except the suprapyloric nodes (No. 5) should be dissected as in the standard D2 procedure. However, there are technical challenges associated with completing all of these procedures. Shibata *et al*<sup>[8]</sup> conducted a questionnaire survey on the PPG procedure in Japanese institutions. According to their report, the vagus nerve was preserved at 73.5% of the institutions, the infrapyloric artery was preserved in 49.4%, and partial dissection of the suprapyloric lymph nodes was performed in 56.2%. These differences in the procedure may affect postoperative gastric function after PPG, leading to postoperative symptoms.

## INDICATIONS AND ONCOLOGIC SAFETY OF PPG

Since function-preserving surgeries such as PPG are usually less extensive, patient selection for these procedures should be carefully considered in terms of oncologic



**Figure 1** Extent of D1+ lymph node dissection in pylorus-preserving gastrectomy and proximal gastrectomy. A: Total gastrectomy; B: Distal gastrectomy; C: Pylorus-preserving gastrectomy; D: Proximal gastrectomy. The number of lymph node stations is according to the classification of the Japanese Gastric Cancer Association.

safety. In particular, in order to maintain pyloric cuff function with PPG, lymph nodes at the suprapyloric and infrapyloric stations may be incompletely dissected due to preservation of the right gastric artery, the infrapyloric artery, and the hepatic and pyloric branches of the vagus nerves<sup>[9-11]</sup>.

In general, PPG is performed in patients who are preoperatively diagnosed with cT1N0M0 primary GC in the middle third of the stomach when the distal border of the tumor is approximately 4-5 cm away from the pylorus<sup>[9-12]</sup>. This indication is based on the incidence of lymph node metastasis in patients who have undergone conventional gastrectomy<sup>[13-16]</sup>.

Kim *et al*<sup>[17]</sup> reported that the incidence of lymph node metastasis at the suprapyloric and infrapyloric stations in EGC located in the middle third of the stomach after PPG and conventional DG was 0.45% (1/220) and 0.45% (1/220), respectively. In addition, Kong *et al*<sup>[18]</sup> showed that the incidence of lymph node metastasis at the suprapyloric and infrapyloric stations in EGC located  $\geq 5$  cm from the pylorus was 0.46% (1/219) and 0.90% (2/221), respectively. Both studies also found that the mean number of suprapyloric lymph nodes dissected was significantly lower after PPG than that with conventional DG, but no significant difference was found for infrapyloric lymph nodes. However, incomplete dissection of lymph nodes at the suprapyloric station is considered acceptable because of the low incidence of metastasis. Therefore, patients who are clinically diagnosed with T1N0 disease

**Table 1** Postoperative symptomatic outcomes after pylorus-preserving surgery

Ref.	Procedure	No. of patients	Endoscopic findings (%)				Symptom (%)			Change of body weight (%)
			Esophagitis	Food residue	Bile reflux	Gastritis	Reflux	Fullness	Dumping	
Matsuki <i>et al</i> <sup>[21]</sup> , 2012	PPG	433	11	19	3	11	6	2		94
Morita <i>et al</i> <sup>[24]</sup> , 2013	PPG	408	6	28	12	10	6	9	4	92
Ikeguchi <i>et al</i> <sup>[25]</sup> , 2010	PPG	24	35	71			0	4	0	97
	DG-B1	30	26	16			3	10	10	90
Park do <i>et al</i> <sup>[26]</sup> , 2008	PPG	22			0	0	32	32		
	DG-B1	17			25	17	46	40		
Nunobe <i>et al</i> <sup>[27]</sup> , 2007	PPG	194	6	22	7	12	7	10		93.9
	DG-B1	203	2	13	8	8	6	13		90.2
Tomita <i>et al</i> <sup>[28]</sup> , 2003	PPG	10	0	60		10	0	40	0	94.3
	DG-B1	22	23	18		64	68	18	23	91.3
Yamaguchi <i>et al</i> <sup>[29]</sup> , 2004	PPG	28		61		28	20	44	12	94.6
	DG-B1	58		33		57	27	36	36	91.3
Nakane <i>et al</i> <sup>[30]</sup> , 2000	PPG	25	4	56	4	8	4	35	0	90
	DG-B1	25	8	36	40	68	0	0	4	93

PPG: Pylorus-preserving surgery; DG: Distal gastrectomy; B1: Billroth-I reconstruction.

could be candidates for PPG without suprapyloric lymph node dissection.

The five-year survival rate after PPG with modified D2 lymph node dissection ranges from 95% to 98%<sup>[10,11,19-21]</sup>. This rate is comparable to the five-year survival rate after gastric resection for EGC, which ranges from 90% to 98%<sup>[2,22,23]</sup>. In terms of oncologic safety, PPG seems reasonably safe for EGC when the accuracy of preoperative diagnosis can be assured.

## POSTOPERATIVE SYMPTOMATIC OUTCOMES AFTER PPG

The advantage of PPG is the prevention of post-gastrectomy symptoms such as dumping syndrome and bile reflux gastritis, as well as reduced frequency of flatus. As shown in Table 1, the ratio of dumping syndrome and bile reflux gastritis was quite low in PPG compared to DG. However, delayed gastric emptying (DGE) after PPG resulting in patient-reported gastric fullness could be a disadvantage of PPG<sup>[21,24-30]</sup>, which make PPG inappropriate in elderly patients and those with hiatus hernia or esophagitis<sup>[29,30]</sup>. The incidence of gastric stasis after PPG based on endoscopic studies ranges from 19% to 70%, compared to 13% to 36% after DG. Michiura *et al*<sup>[31]</sup> showed that food intake along with DGE was improved with time. Moreover, the reservoir function of the remnant stomach may promote better body weight (BW) recovery after PPG than after DG with Billroth I reconstruction<sup>[21,24,25,27,28]</sup>.

Preserving the vagal nerve and the infrapyloric artery is thought to prevent gastric stasis<sup>[10,32,33]</sup>, although these techniques have not been evaluated in randomized clinical trials. The length of the pyloric cuff is another important factor with regards to preservation of pyloric function. Nakane *et al*<sup>[34]</sup> reported that retaining a pyloric cuff of 2.5 cm results in a lower incidence of postoperative

stasis compared to retaining a pyloric cuff of 1.5 cm as severe postoperative edema of the pyloric cuff might affect gastric wall motility after PPG. Morita *et al*<sup>[24]</sup> showed that retaining a pyloric cuff over 3 cm did not affect the incidence of postoperative stasis compared to retaining a pyloric cuff of less than 3 cm. At Japanese institutions, the retained pyloric cuff is usually between 2 and 4 cm<sup>[8,35]</sup>. Moreover, Hiki *et al*<sup>[6]</sup> argued that the infrapyloric and right gastric veins should be preserved to maintain blood flow in order to prevent postoperative edema of the pyloric cuff. Complete dissection of both veins could induce severe edema of the pyloric cuff, resulting in long-term postoperative retention of food in the residual stomach.

## PG

The incidence of proximal GC has increased in recent years<sup>[36]</sup>. Total gastrectomy (TG) and PG with lymph node dissection are both performed for EGC located in the upper third of the stomach (U-EGC). In a retrospective study of Japanese institutions, Takiguchi *et al*<sup>[37]</sup> found that a quarter of the 586 patients with U-EGC underwent PG.

PG is generally thought to offer advantages over conventional TG with Roux-en-Y reconstruction in terms of retention of food in the remnant stomach. On the other hand, heartburn or gastric fullness due to esophageal reflux or gastric stasis is a potential disadvantage. However, these advantages and disadvantages depend on the reconstruction method used.

During the procedure, all regional nodes except the splenic hilar nodes (No. 10), the distal splenic nodes (No. 11d), the suprapyloric nodes (No. 5), and the infrapyloric nodes (No. 6) are dissected, although the dissection of the distal lesser curvature nodes (No. 3) and the right gastroepiploic artery (No. 4d) is incomplete. The hepatic and pyloric branches of the vagal nerve are preserved to

**Table 2** Postoperative symptomatic outcomes after proximal gastrectomy

Ref.	Procedure	No. of patients	Endoscopic findings (%)			Symptom (%)			Change of body weight (%)
			Esophagitis	Stenosis	Food residue	Reflux	Fullness	Dumping	
Masuzawa <i>et al</i> <sup>[41]</sup> , 2014	PG-EG	49				18	16	0	87
	PG-JI	32				16	0	0	86
	TG-RY	122				12	3	8	85
Nozaki <i>et al</i> <sup>[42]</sup> , 2013	PG-JI	102	3		32				88
	TG-RY	49	2						86
Katai <i>et al</i> <sup>[43]</sup> , 2010	PG-JI	128	2		9	6		3	88.9
Katai <i>et al</i> <sup>[44]</sup> , 2003	PG-JI	45	0			4		9	88.5
Tokunaga <i>et al</i> <sup>[45]</sup> , 2008	PG-EG	36	30						
	short-PG-JI	18	9						
	long-PG-JI	22	0						
Ahn <i>et al</i> <sup>[46]</sup> , 2013	LAPG-EG	50	32	12					
	LATG-RY	81	4	5					
An <i>et al</i> <sup>[47]</sup> , 2008	PG-EG	89	29	38					86.4
	TG-RY	334	2	7					87.4
Yoo <i>et al</i> <sup>[48]</sup> , 2004	PG-EG	74	16	35					
	TG-RY	185	1	8					
Tokunaga <i>et al</i> <sup>[50]</sup> , 2009	PG-EG	38				8	3		86
	PG-JI	45				9	22		86
Ahn <i>et al</i> <sup>[52]</sup> , 2013	LAPG-EG	50		8		32			94
	LAPG-DT	43		5	49	5		12	96.3
Nomura <i>et al</i> <sup>[53]</sup> , 2014	PG-JI	10	10			0	30		91.2
	PG-DT	10	10			10	20		87.1

LAPG: Laparoscopy-assisted proximal gastrectomy; LATG: Laparoscopy-assisted total gastrectomy; PG: Proximal gastrectomy; TG: Total gastrectomy; EG: Esophagogastrostomy reconstruction; RY: Roux-en-Y reconstruction; JI: Jejunal interposition reconstruction; DT: Double tract reconstruction.

maintain the function of the remnant stomach and pylorus as in PPG<sup>[7]</sup>.

## INDICATIONS AND ONCOLOGIC SAFETY OF PG

In general, to maintain both curability and functional capacity of the remnant stomach, PG is performed in patients who are preoperatively diagnosed with cT1N0M0 primary GC in the upper third of the stomach when at least half of the stomach can be preserved<sup>[38]</sup>.

In patients undergoing PG, the lymph nodes in the lesser curvature (No. 3) and near the right gastroepiploic artery (No. 4d) are incompletely dissected. Thus, the surgical curability of GC may be lower with PG than with TG. However, Ooki *et al*<sup>[50]</sup> reported that proximal GC confined to the muscularis propria (mp) is not associated with lymph node metastasis at the right gastroepiploic artery (No. 4d), suprapyloric (No. 5), or infrapyloric (No. 6) stations. Sasako *et al*<sup>[40]</sup> reported that after curative gastrectomy, lymph node metastasis occurs at the suprapyloric and infrapyloric stations in patients with GC located in the upper third of the stomach in approximately 3% and 7% of cases, respectively. Although these percentages seem high, approximately half of the patients had T2 or more advanced GC and the incidence of metastasis may be lower in patients with EGC. Therefore, patients who are clinically diagnosed with T1N0 disease could be candidates for PG without dissection of the right gastroepiploic artery, suprapyloric, and infrapyloric lymph nodes.

The five-year survival rate after PG ranges from

90.5% to 98.5%<sup>[41-47]</sup>. Some studies have demonstrated that PG confers a survival benefit comparable to that of TG, the standard procedure for GC located in the upper third of the stomach<sup>[41,46-48]</sup>. Therefore, PG seems oncologically safe for EGC.

## POSTOPERATIVE SYMPTOMATIC OUTCOMES AFTER PG

PG is generally thought to offer several advantages over conventional TG with Roux-en-Y reconstruction (Table 2). Ichikawa *et al*<sup>[49]</sup> reported that reduced food intake volume occurred less often in patients who underwent PG compared to TG. Masuzawa *et al*<sup>[41]</sup> reported that postoperative nutritional status as analyzed by blood tests such as serum albumin and hemoglobin was better after PG than TG. However, no studies have shown a superior outcome with PG as compared to TG in terms of postoperative BW, with the exception of one study which compared PG with jejunal interposition (JI) for reconstruction and TG at one year after surgery<sup>[41,42,47]</sup>. Moreover, compared to TG, PG was associated with a much higher rate of complications such as heartburn and anastomotic stenosis, which led An *et al*<sup>[47]</sup> to conclude that PG is not a better option for U-EGC than TG<sup>[46]</sup>. However, the reconstruction method was limited to esophagogastrostomy (EG) in these reports which did not demonstrate that PG was better. Therefore, the evaluation of other reconstruction methods is necessary.

Currently, three procedures, TG with Roux-en-Y reconstruction (TG-RY), PG-EG, and PG-JI, are widely

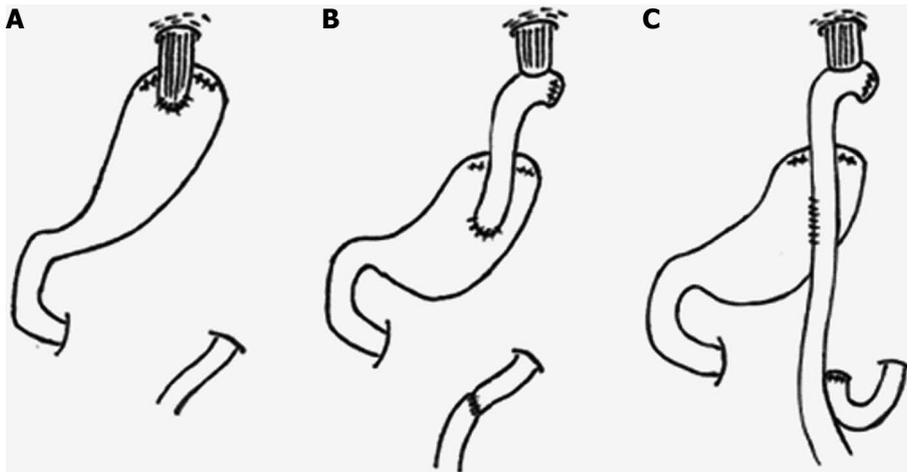


Figure 2 Reconstruction methods after proximal gastrectomy. A: Esophagogastrostomy; B: Jejunum interposition; C: Double tract.

Table 3 Comparison of the reconstruction methods after proximal gastrectomy

	PG-EG	PG-JI	PG-DT
Advantage	Short operation time	Low incidence of reflux esophagitis	Low incidence of reflux esophagitis Low incidence of DGE
Disadvantage	High incidence of reflux esophagitis High incidence of anastomotic stenosis	Long operation time High incidence of DGE	Long operation time Sometimes difficult for endoscopic evaluation of remnant stomach

PG: Proximal gastrectomy; EG: Esophagogastrostomy reconstruction; JI: Jejunal interposition reconstruction; DT: Double tract reconstruction; DGE: Delayed gastric emptying.

used to treat U-EGC in Japan (Figure 2, Table 3)<sup>[37]</sup>. Double tract (DT) reconstruction and jejunal pouch reconstruction have also been used in a small number of patients. A survey of Japanese institutions regarding reconstruction methods after PG showed that the most frequently used method was EG (48%), followed by JI (28%), DT (13%), and pouch reconstruction (7%)<sup>[35]</sup>.

PG-EG is the simplest procedure since there is a single anastomotic site, but it is associated with a high incidence of reflux esophagitis<sup>[46,47]</sup>. PG-JI may prevent regurgitation of the gastric contents, resulting in a lower incidence of reflux esophagitis, but the procedure is slightly complicated. Several studies have compared the postoperative outcomes of PG-EG and PG-JI. The incidence of esophageal reflux as evaluated by endoscopic findings and symptoms was reported to be lower after PG-JI compared to PG-EG<sup>[41,45]</sup>. However, the questionnaire conducted by Tokunaga *et al.*<sup>[50]</sup> showed that abdominal fullness was more frequently observed after PG-JI than after PG-EG, because the interposed jejunum may prevent the smooth passage of food. The length of interposed jejunum is important in preventing esophageal reflux, but a longer length may induce abdominal fullness.

The other important problem after PG is remnant GC (RGC). Ohyama *et al.*<sup>[51]</sup> reported that RGC was observed in 5% of 316 patients after PG. They also showed that advanced RGC was more likely in patients after PG-JI with a longer length of interposed jejunum (> 15 cm) or PG-DT, and cancer-related death was only observed

in patients who underwent these reconstruction methods. Tokunaga *et al.*<sup>[45]</sup> reported that endoscopic evaluation of the remnant stomach could not be performed in 50% of patients after PG-JI with interposed jejunum > 10 cm, compared to 22% in patients after PG-JI with interposed jejunum ≤ 10 cm. They concluded that a length of 10 cm or shorter is preferable for endoscopic evaluation of the remnant stomach. The type of reconstruction chosen after PG should facilitate postoperative endoscopic examinations for early detection and treatment of RGC.

PG-DT has been attempted to improve postoperative outcomes after PG. PG-DT has three anastomotic sites; esophagojejunostomy, jejunogastrostomy and jejunojejunostomy. The length of interposed jejunum is from 10 to 20 cm between esophagojejunostomy and jejunogastrostomy, and about 20 cm between jejunogastrostomy and jejunojejunostomy. Food passes through the remnant stomach or the jejunum by two routes in PG-DT. PG-DT is thought to offer the same advantages as PG-JI, including the prevention of esophageal reflux, but it is expected to be better than PG-JI with regards to DGE, because an alternative route for food exists if DGE occurs. Only a few studies have analyzed postoperative outcomes after PG-DT. Ahn *et al.*<sup>[52]</sup> evaluated postoperative complications after PG-DT compared to PG-EG; they concluded that PG-DT is a feasible, simple, and novel method. They showed that the incidence of anastomotic stenosis and reflux symptoms was lower after PG-DT than PG-EG and BW was better maintained. Nomura *et al.*<sup>[53]</sup> evaluated

postoperative outcomes after PG-DT *vs* PG-JI. Although their study had a small sample size, they showed that the BW ratio was significantly higher in the PG-JI group than in the PG-DT group. The incidence of esophageal reflux was 10% in both groups. Further studies are needed to assess the clinical utility of PG-DT.

## CONCLUSION

Function-preserving surgery has already been performed in some of the high volume institutions in Japan and South Korea, and it seems to be useful in terms of postoperative quality of life and oncologic safety. However, indications should be carefully considered, because function-preserving surgery usually involves less extensive procedures, resulting in the possibility of inadequate treatment for more deeply invasive tumors. Preoperative evaluation is very important in selecting the appropriate candidates for function-preserving surgery.

Laparoscopy-assisted PPG and PG has several advantages over conventional PPG and PG in terms of reduced intraoperative blood loss, postoperative pain and fast recovery from invasive surgery<sup>[54,55]</sup>. Since some studies reported that the oncological curability was assured<sup>[33,56,57]</sup>, laparoscopic function-preserving gastrectomy is considered to be feasible by surgeons with sufficient experience in laparoscopic gastrectomy.

Many retrospective studies have shown the usefulness of function-preserving surgery, but there has been no consensus to adopt function-preserving surgery as the standard of surgery. To establish function-preserving surgery as the gold standard for patients with EGC, prospective randomized controlled trials that compare PPG or PG with conventional gastrectomy and evaluate survival and postoperative quality of life are necessary.

## REFERENCES

- 1 Sano T, Hollowood A. Early gastric cancer: diagnosis and less invasive treatments. *Scand J Surg* 2006; **95**: 249-255 [PMID: 17249273]
- 2 Isobe Y, Nashimoto A, Akazawa K, Oda I, Hayashi K, Miyashiro I, Katai H, Tsujitani S, Kodera Y, Seto Y, Kaminishi M. Gastric cancer treatment in Japan: 2008 annual report of the JGCA nationwide registry. *Gastric Cancer* 2011; **14**: 301-316 [PMID: 21894577 DOI: 10.1007/s10120-011-0085-6]
- 3 Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2010 (ver. 3). *Gastric Cancer* 2011; **14**: 113-123 [PMID: 21573742 DOI: 10.1007/s10120-011-0042-4]
- 4 Maki T, Shiratori T, Hatafuku T, Sugawara K. Pylorus-preserving gastrectomy as an improved operation for gastric ulcer. *Surgery* 1967; **61**: 838-845 [PMID: 5338114]
- 5 Sawai K, Takahashi T, Suzuki H. New trends in surgery for gastric cancer in Japan. *J Surg Oncol* 1994; **56**: 221-226 [PMID: 8057646]
- 6 Hiki N, Nunobe S, Kubota T, Jiang X. Function-preserving gastrectomy for early gastric cancer. *Ann Surg Oncol* 2013; **20**: 2683-2692 [PMID: 23504120 DOI: 10.1245/s10434-013-2931-8]
- 7 Katai H. Function-preserving surgery for gastric cancer. *Int J Clin Oncol* 2006; **11**: 357-366 [PMID: 17058133 DOI: 10.1007/s10147-006-0613-2]
- 8 Shibata C, Saijo F, Kakyō M, Kinouchi M, Tanaka N, Sasaki I, Aikou T. Current status of pylorus-preserving gastrectomy for the treatment of gastric cancer: a questionnaire survey and review of literatures. *World J Surg* 2012; **36**: 858-863 [PMID: 22350486 DOI: 10.1007/s00268-012-1491-6]
- 9 Jiang X, Hiki N, Nunobe S, Fukunaga T, Kumagai K, Nohara K, Sano T, Yamaguchi T. Postoperative outcomes and complications after laparoscopy-assisted pylorus-preserving gastrectomy for early gastric cancer. *Ann Surg* 2011; **253**: 928-933 [PMID: 21358534 DOI: 10.1097/SLA.0b013e3182117b24]
- 10 Hiki N, Sano T, Fukunaga T, Ohyama S, Tokunaga M, Yamaguchi T. Survival benefit of pylorus-preserving gastrectomy in early gastric cancer. *J Am Coll Surg* 2009; **209**: 297-301 [PMID: 19717032 DOI: 10.1016/j.jamcollsurg.2009.05.027]
- 11 Morita S, Katai H, Saka M, Fukagawa T, Sano T, Sasako M. Outcome of pylorus-preserving gastrectomy for early gastric cancer. *Br J Surg* 2008; **95**: 1131-1135 [PMID: 18690631 DOI: 10.1002/bjs.6295]
- 12 Hiki N, Kaminishi M. Pylorus-preserving gastrectomy in gastric cancer surgery--open and laparoscopic approaches. *Langenbecks Arch Surg* 2005; **390**: 442-447 [PMID: 16096761 DOI: 10.1007/s00423-005-0573-4]
- 13 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**: 628-633; discussion 633-634 [PMID: 1949863]
- 14 Shimoyama S, Mafune K, Kaminishi M. Indications for a pylorus-preserving gastrectomy for gastric cancer with proper muscle invasion. *Arch Surg* 2003; **138**: 1235-1239 [PMID: 14609873 DOI: 10.1001/archsurg.138.11.1235]
- 15 Shimoyama S, Seto Y, Yasuda H, Mafune K, Kaminishi M. Concepts, rationale, and current outcomes of less invasive surgical strategies for early gastric cancer: data from a quarter-century of experience in a single institution. *World J Surg* 2005; **29**: 58-65 [PMID: 15599744 DOI: 10.1007/s00268-004-7427-z]
- 16 Kodera Y, Yamamura Y, Kanemitsu Y, Shimizu Y, Hirai T, Yasui K, Morimoto T, Kato T. Lymph node metastasis in cancer of the middle-third stomach: criteria for treatment with a pylorus-preserving gastrectomy. *Surg Today* 2001; **31**: 196-203 [PMID: 11318120]
- 17 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**: 533-538 [PMID: 24008556 DOI: 10.1245/s10434-013-3252-7]
- 18 Kong SH, Kim JW, Lee HJ, Kim WH, Lee KU, Yang HK. The safety of the dissection of lymph node stations 5 and 6 in pylorus-preserving gastrectomy. *Ann Surg Oncol* 2009; **16**: 3252-3258 [PMID: 19639365 DOI: 10.1245/s10434-009-0646-7]
- 19 Ikeguchi M, Hatada T, Yamamoto M, Miyake T, Matsunaga T, Fukuda K, Saito H, Tatebe S. 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**: 228-233 [PMID: 20180075 DOI: 10.1007/s00595-009-4043-4]
- 20 Jiang X, Hiki N, Nunobe S, Fukunaga T, Kumagai K, Nohara K, Katayama H, Ohyama S, Sano T, Yamaguchi T. Long-term outcome and survival with laparoscopy-assisted pylorus-preserving gastrectomy for early gastric cancer. *Surg Endosc* 2011; **25**: 1182-1186 [PMID: 20844895 DOI: 10.1007/s00464-010-1336-z]
- 21 Matsuki A, Nashimoto A, Yabusaki H, Nakagawa S. Long-term clinical outcome and survival after pylorus-preserving gastrectomy. *Hepatogastroenterology* 2012; **59**: 2012-2015 [PMID: 22193434 DOI: 10.5754/hge11785]
- 22 Sano T, Sasako M, Kinoshita T, Maruyama K. Recurrence of early gastric cancer. Follow-up of 1475 patients and review of the Japanese literature. *Cancer* 1993; **72**: 3174-3178 [PMID: 8242540]
- 23 Sue-Ling HM, Johnston D, Martin IG, Dixon MF, Lansdown

- MR, McMahon MJ, Axon AT. Gastric cancer: a curable disease in Britain. *BMJ* 1993; **307**: 591-596 [PMID: 8401015]
- 24 **Morita S**, Sasako M, Saka M, Fukagawa T, Sano T, Katai H. Correlation between the length of the pyloric cuff and postoperative evaluation after pylorus-preserving gastrectomy. *Gastric Cancer* 2010; **13**: 109-116 [PMID: 20602198 DOI: 10.1007/s10120-010-0549-0]
- 25 **Ikeguchi M**, Kuroda H, Kihara K, Hatata T, Matsunaga T, Fukuda K, Saito H, Tatebe S. Nutritional assessment of patients after pylorus-preserving gastrectomy for early gastric cancer. *Indian J Surg* 2010; **72**: 453-457 [PMID: 22131654 DOI: 10.1007/s12262-010-0167-4]
- 26 **Park do J**, 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**: 1029-1036 [PMID: 18256877 DOI: 10.1007/s00268-007-9441-4]
- 27 **Nunobe S**, Sasako M, Saka M, Fukagawa T, Katai H, Sano T. Symptom evaluation of long-term postoperative outcomes after pylorus-preserving gastrectomy for early gastric cancer. *Gastric Cancer* 2007; **10**: 167-172 [PMID: 17922094 DOI: 10.1007/s10120-007-0434-7]
- 28 **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**: 725-733 [PMID: 12734683 DOI: 10.1007/s00268-003-6906-y]
- 29 **Yamaguchi T**, Ichikawa D, Kurioka H, Ikoma H, Koike H, Otsuji E, Ueshima Y, Shioaki Y, Lee CJ, Hamashima T, Deguchi E, Ikeda E, Mutoh F, Yamagishi H. Postoperative clinical evaluation following pylorus-preserving gastrectomy. *Hepatogastroenterology* 2004; **51**: 883-886 [PMID: 15143939]
- 30 **Nakane Y**, Akehira K, Inoue K, Iiyama H, Sato M, Masuya Y, Okumura S, Yamamichi K, Hioke K. Postoperative evaluation of pylorus-preserving gastrectomy for early gastric cancer. *Hepatogastroenterology* 2000; **47**: 590-595 [PMID: 10791245]
- 31 **Michiura T**, Nakane Y, Kanbara T, Nakai K, Inoue K, Yamamichi K, Kamiyama Y. Assessment of the preserved function of the remnant stomach in pylorus-preserving gastrectomy by gastric emptying scintigraphy. *World J Surg* 2006; **30**: 1277-1283 [PMID: 16794905 DOI: 10.1007/s00268-005-7983-x]
- 32 **Sawai K**, Takahashi T, Fujioka T, Minato H, Taniguchi H, Yamaguchi T. Pylorus-preserving gastrectomy with radical lymph node dissection based on anatomical variations of the infrapyloric artery. *Am J Surg* 1995; **170**: 285-288 [PMID: 7661298]
- 33 **Nunobe S**, Hiki N, Fukunaga T, Tokunaga M, Ohyama S, Seto Y, Yamaguchi T. Laparoscopy-assisted pylorus-preserving gastrectomy: preservation of vagus nerve and infrapyloric blood flow induces less stasis. *World J Surg* 2007; **31**: 2335-2340 [PMID: 17952497 DOI: 10.1007/s00268-007-9262-5]
- 34 **Nakane Y**, Michiura T, Inoue K, Sato M, Nakai K, Yamamichi K. Length of the antral segment in pylorus-preserving gastrectomy. *Br J Surg* 2002; **89**: 220-224 [PMID: 11856138 DOI: 10.1046/j.0007-1323.2001.01984.x]
- 35 **Kumagai K**, Shimizu K, Yokoyama N, Aida S, Arima S, Aikou T. Questionnaire survey regarding the current status and controversial issues concerning reconstruction after gastrectomy in Japan. *Surg Today* 2012; **42**: 411-418 [PMID: 22391980 DOI: 10.1007/s00595-012-0159-z]
- 36 **Salvon-Harman JC**, Cady B, Nikulasson S, Khettry U, Stone MD, Lavin P. Shifting proportions of gastric adenocarcinomas. *Arch Surg* 1994; **129**: 381-388; discussion 388-389 [PMID: 7512326]
- 37 **Takiguchi S**, Masuzawa T, Hirao M, Imamura H, Kimura Y, Fujita J, Tamura S, Fujiwara Y, Mori M, Doki Y. Pattern of surgical treatment for early gastric cancers in upper third of the stomach. *Hepatogastroenterology* 2011; **58**: 1823-1827 [PMID: 21940352 DOI: 10.5754/hge11161]
- 38 **Ikeguchi M**, Kader A, Takaya S, Fukumoto Y, Osaki T, Saito H, Tatebe S, Wakatsuki T. Prognosis of patients with gastric cancer who underwent proximal gastrectomy. *Int Surg* 2012; **97**: 275-279 [PMID: 23113860 DOI: 10.9738/CC150.1]
- 39 **Ooki A**, Yamashita K, Kikuchi S, Sakuramoto S, Katada N, Hutawatari N, Watanabe M. Clinical significance of total gastrectomy for proximal gastric cancer. *Anticancer Res* 2008; **28**: 2875-2883 [PMID: 19031928]
- 40 **Sasako M**, McCulloch P, Kinoshita T, Maruyama K. New method to evaluate the therapeutic value of lymph node dissection for gastric cancer. *Br J Surg* 1995; **82**: 346-351 [PMID: 7796005]
- 41 **Masuzawa T**, Takiguchi S, Hirao M, Imamura H, Kimura Y, Fujita J, Miyashiro I, Tamura S, Hiratsuka M, Kobayashi K, Fujiwara Y, Mori M, Doki Y. Comparison of perioperative and long-term outcomes of total and proximal gastrectomy for early gastric cancer: a multi-institutional retrospective study. *World J Surg* 2014; **38**: 1100-1106 [PMID: 24310733 DOI: 10.1007/s00268-013-2370-5]
- 42 **Nozaki I**, Hato S, Kobatake T, Ohta K, Kubo Y, Kurita A. Long-term outcome after proximal gastrectomy with jejunal interposition for gastric cancer compared with total gastrectomy. *World J Surg* 2013; **37**: 558-564 [PMID: 23254949 DOI: 10.1007/s00268-012-1894-4]
- 43 **Katai H**, Morita S, Saka M, Taniguchi H, Fukagawa T. Long-term outcome after proximal gastrectomy with jejunal interposition for suspected early cancer in the upper third of the stomach. *Br J Surg* 2010; **97**: 558-562 [PMID: 20169569 DOI: 10.1002/bjs.6944]
- 44 **Katai H**, Sano T, Fukagawa T, Shinohara H, Sasako M. Prospective study of proximal gastrectomy for early gastric cancer in the upper third of the stomach. *Br J Surg* 2003; **90**: 850-853 [PMID: 12854112 DOI: 10.1002/bjs.4106]
- 45 **Tokunaga M**, Ohyama S, Hiki N, Hoshino E, Nunobe S, Fukunaga T, Seto Y, Yamaguchi T. Endoscopic evaluation of reflux esophagitis after proximal gastrectomy: comparison between esophagogastric anastomosis and jejunal interposition. *World J Surg* 2008; **32**: 1473-1477 [PMID: 18264827 DOI: 10.1007/s00268-007-9459-7]
- 46 **Ahn SH**, Lee JH, Park do J, Kim HH. Comparative study of clinical outcomes between laparoscopy-assisted proximal gastrectomy (LAPG) and laparoscopy-assisted total gastrectomy (LATG) for proximal gastric cancer. *Gastric Cancer* 2013; **16**: 282-289 [PMID: 22821182 DOI: 10.1007/s10120-012-0178-x]
- 47 **An JY**, Youn HG, Choi MG, Noh JH, Sohn TS, Kim S. The difficult choice between total and proximal gastrectomy in proximal early gastric cancer. *Am J Surg* 2008; **196**: 587-591 [PMID: 18519129 DOI: 10.1016/j.amjsurg.2007.09.040]
- 48 **Yoo CH**, Sohn BH, Han WK, Pae WK. Long-term results of proximal and total gastrectomy for adenocarcinoma of the upper third of the stomach. *Cancer Res Treat* 2004; **36**: 50-55 [PMID: 20396565 DOI: 10.4143/crt.2004.36.1.50]
- 49 **Ichikawa D**, Ueshima Y, Shirono K, Kan K, Shioaki Y, Lee CJ, Hamashima T, Deguchi E, Ikeda E, Mutoh F, Oka T, Kurioka H. Esophagogastric reconstruction after limited proximal gastrectomy. *Hepatogastroenterology* 2001; **48**: 1797-1801 [PMID: 11813627]
- 50 **Tokunaga M**, Hiki N, Ohyama S, Nunobe S, Miki A, Fukunaga T, Seto Y, Sano T, Yamaguchi T. Effects of reconstruction methods on a patient's quality of life after a proximal gastrectomy: subjective symptoms evaluation using questionnaire survey. *Langenbecks Arch Surg* 2009; **394**: 637-641 [PMID: 19066939 DOI: 10.1007/s00423-008-0442-z]
- 51 **Ohyama S**, Tokunaga M, Hiki N, Fukunaga T, Fujisaki J, Seto Y, Yamaguchi T. A clinicopathological study of gastric stump carcinoma following proximal gastrectomy. *Gastric Cancer* 2009; **12**: 88-94 [PMID: 19562462 DOI: 10.1007/s10120-009-0502-2]
- 52 **Ahn SH**, Jung do H, Son SY, Lee CM, Park do J, Kim HH.

- Laparoscopic double-tract proximal gastrectomy for proximal early gastric cancer. *Gastric Cancer* 2014; **17**: 562-570 [PMID: 24052482 DOI: 10.1007/s10120-013-0303-5]
- 53 **Nomura E**, Lee SW, Kawai M, Yamazaki M, Nabeshima K, Nakamura K, Uchiyama K. Functional outcomes by reconstruction technique following laparoscopic proximal gastrectomy for gastric cancer: double tract versus jejunal interposition. *World J Surg Oncol* 2014; **12**: 20 [PMID: 24468278 DOI: 10.1186/1477-7819-12-20]
- 54 **Tanaka N**, Katai H, Saka M, Morita S, Fukagawa T. Laparoscopy-assisted pylorus-preserving gastrectomy: a matched case-control study. *Surg Endosc* 2011; **25**: 114-118 [PMID: 20526619 DOI: 10.1007/s00464-010-1142-7]
- 55 **Kinoshita T**, Gotohda N, Kato Y, Takahashi S, Konishi M, Kinoshita T. Laparoscopic proximal gastrectomy with jejunal interposition for gastric cancer in the proximal third of the stomach: a retrospective comparison with open surgery. *Surg Endosc* 2013; **27**: 146-153 [PMID: 22736285 DOI: 10.1007/s00464-012-2401-6]
- 56 **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**: 162-169 [PMID: 16864028 DOI: 10.1016/j.jamcollsurg.2006.05.003]
- 57 **Suh YS**, Han DS, Kong SH, Kwon S, Shin CI, Kim WH, Kim HH, Lee HJ, Yang HK. Laparoscopy-assisted pylorus-preserving gastrectomy is better than laparoscopy-assisted distal gastrectomy for middle-third early gastric cancer. *Ann Surg* 2014; **259**: 485-493 [PMID: 23652333 DOI: 10.1097/SLA.0b013e318294d142]

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ISSN 1007-9327



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