Review Article

Functional and nutritional outcomes after gastric cancer surgery

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Abstract: Recent improvements in diagnostic techniques and national screening programs have resulted in increasing number of patients diagnosed with early gastric cancer (EGC). The low incidence rate of lymph node metastasis and excellent survival rates after surgical treatment for EGC enabled the reduction in the extent of lymphadenectomy and the range of gastric resection for function-preserving gastrectomy. Thus, the quality of life (QOL) of patients with gastric cancer (GC) in the curative stage can be maintained. Moreover, these function-preserving procedures have been widely performed by less invasive procedures, such as laparoscopic and robotic approaches. Pylorus-preserving gastrectomy (PPG) and proximal gastrectomy (PG) represent the two main function-preserving surgical procedures for GC. PPG is an alternative to distal gastrectomy (DG) for cT1 N0 EGC located in the middle part of the stomach. Preservation of the pyloric function is expected to prevent post-gastrectomy syndromes such as dumping syndrome. PG is an alternative to total gastrectomy (TG) and can thus be performed for cT1 N0 EGC located in the upper part of the stomach. Preservation of the residual stomach is expected to work as a reservoir for ingested food. The optimal reconstruction method after PG among the three most commonly performed procedures (esophagogastrostomy, jejunal interposition, and double-tract reconstruction) remains controversial. In addition to these three reconstruction methods, the novel double-flap technique (DFT) of esophagogastrostomy has gained attention recently because of its potential usefulness to prevent postoperative esophageal reflux. In this review article, we summarize the current evidence of PPG and PG with esophagogastrostomy by the DFT, focusing on postoperative nutrition and QOL.

Keywords: Function-preserving gastrectomy; gastric cancer (GC); proximal gastrectomy (PG); esophagogastrostomy with double-flap technique (esophagogastrostomy with DFT); pylorus-preserving gastrectomy (PPG)

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Introduction

Advancements in diagnostic techniques and population screening systems in high incidence countries, mainly in Japan and South Korea have resulted in detection of increasing numbers of early gastric cancer (EGC). The low rates of lymph node metastasis and excellent long-term survival after surgical treatment for EGC (1,2) has enabled function-preserving gastrectomy, such as pylorus-preserving gastrectomy (PPG) and proximal gastrectomy (PG) which reduces the extent of lymphadenectomy and gastric resection (3-5). Moreover, these function-preserving procedures have been widely performed as laparoscopic and robotic approaches with the aim of maintaining patients' postoperative quality of life (QOL). Studies utilizing patient questionnaires have demonstrated the

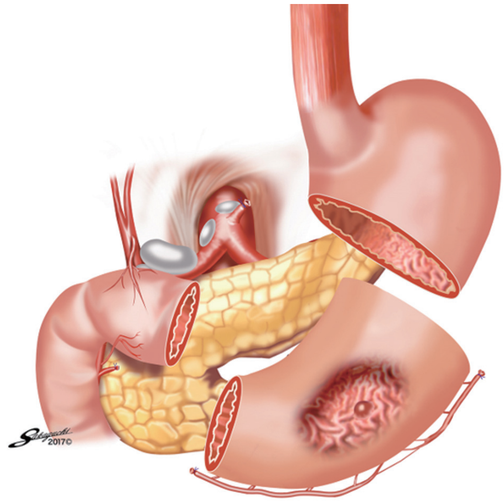

Figure 1 Surgical concept of PPG for GC in the middle stomach. The proximal remnant stomach is transected on the demarcation line between the right and left gastroepiploic arteries. The distal stomach is divided 4 to 5 cm proximal to the pyloric ring. The supra-/infra-pyloric vessels and the pyloric branch of the vagus nerve are preserved to maintain the blood supply and function of the pyloric cuff. PPG, pylorus-preserving gastrectomy; GC, gastric cancer. Reproduced from ref (4).

nutritional and symptomatic benefits of several techniques of function-preserving gastrectomy. In this review article, we present the current evidence of PPG and PG with esophagogastrostomy by the double-flap technique (DFT), focusing on postoperative nutrition and QOL.

PPG

PPG was initially applied to the treatment of benign gastric ulcers in 1967 (6). Since then, PPG has been widely used as a function-preserving procedure for the treatment of EGC (7). By preserving the pyloric ring, PPG is expected to possess several functional and nutritional merits with a lower incidence of post-gastrectomy syndromes, such as bile reflux and dumping syndrome, in comparison with conventional distal gastrectomy (DG) with Billroth I reconstruction (B1).

Indications for PPG

As described in the current version of the Japanese Gastric Cancer Treatment Guidelines, PPG is a modified surgery for cT1N0 GC located in the middle portion of the stomach (8). Our basic indications for PPG are (I) a preoperative diagnosis of intramucosal or submucosal carcinoma without lymphatic metastasis; (II) a tumor located in the middle third of the stomach and >5 cm away from the pyloric ring; (III) any histological type; (IV) patient age of ≤75 years; and (V) no hiatal hernia or esophageal reflux (9). In our institution, patients with gastric cardia dysfunction or difficult dietary restrictions do not meet the criteria for PPG because their high risk of postoperative esophageal reflux and subsequent pulmonary aspiration.

Laparoscopic procedures of PPG (Figure 1)

The details of our laparoscopic procedures for PPG have been described previously (10,11). For patients who met the indications for PPG at our institution, we performed D1+ lymphadenectomy, which includes lymph node stations #1/#3a/#3b/#4sb/#4d/#6/#7/#8a/#9 as recommended in the Japanese Gastric Cancer Treatment Guidelines (8). During PPG, the infra-pyloric artery was routinely preserved; its vein was also preserved in surgeries performed after August 2012 to retain venous return in the pyloric cuff (12). The right gastroepiploic vessels were transected after bifurcation of the infra-pyloric vessels, so lymph node dissection of the infra-pyloric area (#6i) was achieved with some limitation (13). The root of the right gastric artery and vein and the supra-pyloric lymph nodes (#5) were routinely left intact, so these vessels were transected after the first branch. The hepatic and pyloric branches of the vagus nerve were routinely preserved, and its celiac branch was preserved in some cases (14).

Gastro-gastro anastomosis was performed either extracorporeally (15) or intracorporeally (16,17) for reconstruction during laparoscopic PPG (LPPG). More recently, we preferentially performed intracorporeal anastomosis using our newly established end-to-end gastrogastrostomy technique (17).

Oncological safety of PPG

As mentioned previously, the supra-/infra-pyloric vessels are preserved during PPG to sustain the blood supply and function of the pyloric cuff. Therefore, safety concerns about possible lymph node metastasis in these areas may arise. Previous reports have already shown relatively low incidence rates of supra-/infra-pyloric lymphatic metastasis, ranging from 0.00% to 0.90% (lymph node station #5) and from 0.45% to 4.80% (lymph node station #6), for early GC located in the middle part of the stomach (13,18-20). Meticulous examination of the supra-/infra-pyloric areas is also important during surgery, and if necessary, it is recommended that sampled #5 and #6 lymph nodes will be sent for intraoperative pathological examination. This can further guide a surgeon's decision to convert to DG. In our experience, there were 2 of 475 conversions to DG (0.42%) in patients for whom LPPG was initially planned between 2006 and 2012 (9).

Another oncological safety concern associated with PPG is the location of the resection lines of the stomach on both the proximal and distal sides. To secure negative margins, the extent of the primary lesion should be accurately diagnosed in the preoperative examinations, including biopsy results. Preoperative placement of marking clips along with intraoperative gastroscopy is considered to be very useful, especially in the laparoscopic approach. Additionally, frozen sections of the resection edges can be helpful in identifying the histological cancer-free margin during the surgery. Several reports have revealed satisfactory long-term survival rates of PPG (95.0–98.4% overall 5-year survival rate) (9,21-24). The survival rate after PPG has also been proven comparable with that after DG (20,21).

Functional and nutritional outcomes after PPG (Table 1)

The findings of previous reports of PPG and LPPG, focusing on nutritional/functional outcomes, are summarized in *Table 1*. The main advantage of PPG is the prevention of post-gastrectomy syndromes such as dumping syndrome and bile reflux. Other advantages include a well-maintained postoperative body weight and nutritional status. Because PPG is an alternative to DG for EGC in the middle third of the stomach, several studies have compared the surgical results of PPG versus DG mainly by B1 (DG-B1). The sizes of the proximal stomach remnant and pyloric cuff were also discussed in some reports. The impact of some branches of the vagus nerve and the venous return of the pyloric cuff were also evaluated.

Single-arm analysis (9,15,25,26)

Favorable symptomatic and nutritional outcomes after PPG have been shown by some groups, including ours. The postoperative body weight was well-maintained after PPG, and the rate of body weight loss reportedly ranged from 6.0% to 6.8% among relatively large sample-size analyses.

Superiority over DG-B1 (20,23,27-36)

As mentioned above, several studies have compared surgical results between PPG and DG-B1. Because of pyloric ring preservation, PPG tends to be associated with lower rates of bile reflux and remnant gastritis and higher rates of food residue in endoscopic findings. In a survey of patient's postoperative symptoms, PPG showed a lower rate of dumping syndrome, as expected; however, it tended to have higher rates of abdominal fullness/distention. Although the results differed among individual reports, PPG showed superiority over DG-B1 in postoperative gallstone formation, body weight changes, and nutritional parameters (20,29,30,33).

QOL analysis according to the postgastrectomy syndrome assessment scale-45 (PGSAS-45) (37,38)

The PGSAS-45 is a questionnaire examination used to assess post-gastrectomy-specific clinical symptoms and QOL, developed by the Japan Postgastrectomy Syndrome Working Party (43). Two multi-center analyses have revealed significantly better outcomes regarding dumping syndrome and diarrhea after PPG, compared with DG.

The size of remnant stomach (39-41)

Namikawa *et al.* compared the QOL scores according to the size of the proximal gastric remnant using the PGASA-45, resulting in no significant differences in symptoms of reflux, dumping and diarrhea (39). The size of the pyloric cuff generally showed no definitive impact on the remnant stomach or patient symptoms per both endoscopic findings and symptom survey, respectively.

Preservation of branches of the vagus nerve (14,42)

Preservation of the hepatic and pyloric branches significantly reduced the incidence rate of postoperative gallstone formation (42). Because the pyloric and hepatic branches are routinely preserved in our institution, we analyzed the influence of preserving the celiac branch of the vagus nerve (14). We found no definite impact of preservation of the celiac branch of the vagus nerve.

Preservation of the infra-pyloric vein (12)

Preservation of the infra-pyloric vein can help to prevent

Table 1 Functional and nutritional outcomes after PPG

Study concept	Ref.	Author	Year	Study design	Procedure	Number of patients	Endoscopic findings				Symptom				Gastric stasis	Gallstone formation	Body weight change)	Nutrition				
							Esophagitis	Food residue	Bile reflux	Remnant gastritis	Reflux/ heartburn	Fullness/ distention	Dumping	Diarrhea				TP	Alb	Hb	T-Chol	Lymphcyte count
Single arm	(15)	Jiang	2011	Retrospective	LPPG	307									6.2%			7.1 g/dL	4.3 g/dL			
Single arm	(25)	Matsuki	2012	Retrospective	PPG	433	10.0%	19.1%	3.0%	11.0%	6.1%	1.5%					94.0%					
Single arm	(26)	Kumagai	2013	Retrospective	TLPPG	60									10.0%							
Single arm	(9)	Tsujiura	2017	Retrospective	LPPG	465									5.2%		93.2%	7.15 g/dL	4.27 g/dL	13.28 g/dL		
Vs. DG	(27)	Imada	1998	Retrospective	PPG	20			15.0%	25.0%							91.2%	NS		NS		
					DG-B1	25			68.0%	64.0%							88.9%					
					P value				<0.001	<0.01							NS					
Vs. DG	(28)	Nakane	2000	Retrospective	PPG	25	4.0%	56.0%	4.0%	8.0%	4.3%	34.8%	0%				90%	N/A	N/A		N/A	
		(Data of 1 year)			DG-B1	25	8.0%	36.0%	40.0%	68.0%	0%	0%	4.00%				93%	N/A	N/A		N/A	
					P value		NS	NS	<0.01	<0.01	NS	<0.01	NS				NS	NS	NS		NS	
Vs. DG	(29)	Hotta	2001	Retrospective	PPG	19	5.3%		15.8%	26.3%	15.8%	26.3%	5.3%				98.7%	7.2±0.4 g/dL	4.2±0.2 g/dL	14.2±1.5 g/dL		
					DG-B1	45	11.1%		53.3%	62.2%	42.2%	28.9%	28.9%				96.0%	7.0±0.5 g/dL	4.1±0.3 g/dL	13.5±1.2 g/dL		
					P value		NS		0.006	0.013	0.049	NS	0.048				0.019	NS	0.037	0.484		
Vs. DG	(30)	Tomita	2003	Retrospective	PPG	10	0%	60.0%		10.0%	0%	40.0%	0%			0	94.3%					
					DG-B1	22	22.7%	18.1%		63.6%	68.2%	18.1%	22.7%			18.1%	91.3%					
					P value		0.101	0.018		0.005	0.044	0.018	0.101			0.149	0.084					
Vs. DG	(31)	Shibata	2004	Prospective, randomized	PPG	36							8.3%			6.3%	93.3%	7.0±0.1 g/dL		13.6±0.3 g/dL		
					DG-B1	38							33.3%			7.1%	93.1%	6.9±0.1 g/dL		13.3±0.3 g/dL		
					P value								0.037			NS	NS	NS		NS		
Vs. DG	(32)	Yamaguchi	2004	Retrospective	PPG	28		61.1%		27.8%	20.0%	44.0%	12.0%				94.6%					
					DG-B1	58		33.3%		57.1%	26.7%	35.6%	35.6%				91.3%					
					P value			0.052		0.04	NS	NS	<0.05				0.1					
Vs. DG	(33)	Nunobe	2007	Retrospective	PPG	194	6.2%	21.6%	7.2%	12.4%	7.2%	10.8%				10.8%	93.9%					
					DG-B1	203	2.5%	13.3%	8.4%	8.4%	6.4%	12.3%				13.3%	90.2%					
					P value		0.143	0.028	0.667	0.191	0.748	0.643				0.449	<0.001					
Vs. DG	(34)	Park do	2008	Retrospective	PPG	22			0%	0%	31.8%	31.8%							4.1 g/dL			
					DG-B1	17			25.0%	16.6%	47.1%	41.1%							4.1 g/dL			
					P value				N/A	N/A	N/A	N/A							NS			
Vs. DG	(35)	Ikeguchi	2010	Retrospective	PPG	24	35.7%	71.4%	0%	42.9%	0%	4.2%	0%				97%		N/A		N/A	N/A
					DG-B1	30	26.3%	15.8%	57.9%	57.9%	3.3%	10.0%	10.0%				90%		N/A		N/A	N/A
					P value		0.562	0.001	N/A	0.913	0.367	0.416	0.111				0.377		NS		NS	NS

Table 1 (*continued*)

Table 1 (*continued*)

Study concept	Ref.	Author	Year	Study design	Procedure	Number of patients	Endoscopic findings				Symptom				Gastric stasis	Gallstone formation	Body weight change	Nutrition				
							Esophagitis	Food residue	Bile reflux	Remnant gastritis	Reflux/heartburn	Fullness/distention	Dumping	Diarrhea				TP	Alb	Hb	T-Chol	Lymphcyte count
Vs. DG	(23)	Ikeguchi	2010	Retrospective	PPG	46									6.5%							
					DG	87									6.9%							
					P value										NS							
Vs. DG	(36)	Tomikawa	2012	Retrospective	LAPPG	9					1.1[a]			1.2[a]						13.3 g/dL		
		[a] GSRS score (gastrointestinal symptom rating scale)			LADG	12					1.1[a]			1.4[a]						11.6 g/dL		
					P value						0.91			0.52						0.04		
Vs. DG	(20)	Suh	2014	retrospective	LAPPG	176									7.8%	0%		+3.8%	+3.9%			
		[b] subscale in PGASA-45			LADG	116									1.7%	6.5%		+0.6%	+0.3%			
					P value										0.015	0.038		0.015	0.014			
Vs. DG, QOL	(37)	Fujita	2016	Retrospective	PPG	313					1.7[b]		1.8[b]	1.8[b]			93.1%					
		[b] subscale in PGASA-45			DG-B1	909					1.7[b]		2.0[b]	2.1[b]			92.1%					
					P value						NS		0.003	<0.0001			0.052					
vs. DG, QOL	(38)	Hosoda	2017	Retrospective, PSM	LAPPG	32					2.0[b]		1.5[b]	1.9[b]			93.1%					
		[b] subscale in PGASA-45			LADG-B1	32					1.8[b]		2.0[b]	2.4[b]			91.8%					
					P value						0.57		0.042	0.028			0.45					
Size of the proximal gastric remnant, QOL	(40)	Namikawa	2014	Retrospective, multicenter	PPG (more than half[c])	73					1.7[b]		1.9[b]	1.7[b]			93.9%					
		[b] subscale in PGASA-45			PPG (around one-third[c])	222					1.7[b]		1.8[b]	1.8[b]			93.2%					
		[c] size of the proximal gastric remnant			PPG (less than one-quarter[c])	12					1.7[b]		2.2[b]	1.9[b]			88.1%					
					P value						NS		NS	NS			0.03					
Size of pyloric cuff	(41)	Nakane	2002	Retrospective	PPG (cuff size, 1.5 cm)	20	5.0%	55.0%	5.0%	5.0%		50.0% (6 m)/26.3 (2 y)	0%				88% (6 m)/92% (2 y)	WNL	WNL		WNL	
					PPG (cuff size, 2.5 cm)	10	0%	10.0%	10.0%	0%		10.0% (6 m)/11.1 (2 y)	0%				95% (6 m)/96% (2 y)	WNL	WNL		WNL	
					P value		NS	<0.05	NS	NS		<0.05 (6 m)/NS (2 y)	NS				<0.02 (6 m)/NS (2 y)	NS	NS		NS	

Table 1 (*continued*)

Table 1 (*continued*)

Variable	Ref.	Author	Year	Study design	Procedure	Number of patients	Endoscopic findings				Symptom				Gastric stasis	Gallstone formation	Body weight change	Nutrition				
							Esophagitis	Food residue	Bile reflux	Remnant gastritis	Reflux/ Heartburn	Fullness/ Distention	Dumping	Diarrhea				TP	Alb	Hb	T-Chol	Lymphcyte count
Size of pyloric cuff	(42)	Morita	2010	Retrospective	PPG (all cases)	408	6.2%	28.1%	10.6%	9.6%	3.7%	8.1%			9.3%		92.0%					
					PPG (cuff size, within 3 cm)	300	6.6%	27.9%	11.1%	10.2%	4.0%	8.0%			10.0%		92.9%					
					PPG (cuff size, more than 3 cm)	108	4.5%	28.8%	9.1%	7.6%	2.8%	8.3%			7.40%		91.7%					
					P value		0.388	0.885	0.647	0.528	0.406	0.913			0.427		0.145					
Vagal nerve preservation	(43)	Tomita	2009	Retrospective	PPG (PHBVN preserved)	18	5.6%	50.0%		11.1%	0%	50.0%	5.6%			0%	94.7%					
		[d] PHBVN: pyloric and hepatic branches of the vagal nerve			PPG (PHBVN non-preserved)	24	8.3%	41.7%		16.7%	8.3%	41.7%	8.3%			20.8%	93.7%					
					P value		0.729	0.591		0.611	0.209	0.591	0.291			0.039	0.264					
Vagal nerve preservation	(14)	Furukawa	2018	Retrospective, PSM	LPPG (CBVN preserved)	116	13.5%	48.7%	0.9%	54.1%					7.8%	7.8%	92%	7.1 g/dL	4.2 g/dL	13.5 g/dL		
		[e] CBVN: celiac branches of the vagal nerve			LPPG (CBVN non-preserved)	58	11.3%	47.2%	1.9%	50.9%					5.2%	10.6%	90%	7.1 g/dL	4.3 g/dL	13.5 g/dL		
					P value		1	0.869	0.527	0.866					1	0.758	NS	NS	NS	NS		
IPV preservation	(12)	Kiyokawa	2016	Retrospective	LPPG (IPV preserved)	56									0%							
		IPV			LPPG (IPV non-preserved)	94									8.5%							
					P value										0.03							

[a], GSRS score (gastrointestinal symptom rating scale); [b], subscale in PGASA-45 (The postgastrectomy syndrome assessment scale-45); [c], size of the proximal gastric remnant. PHBVN, pyloric and hepatic branches of the vagal nerve; CBVN, celiac branches of the vagal nerve; IPV, infrapyloric vein; DG-B1, DG with Billroth I reconstruction; LADG, laparoscopic-assisted DG; LAPPG, laparoscopic-assisted PPG; LPPG, laparoscopic PPG; PSM, propensity score matching; TLPPG, totally laparoscopic PPG.

postoperative gastric stasis after LPPG by reducing venous stasis and edema of the pyloric cuff. Therefore, the infra-pyloric vein has been preserved in all patients treated since August 2012 in our institution. In Korea, the ongoing randomized controlled trial "KLASS 04" is comparing postoperative QOL and surgical outcomes between LPPG and laparoscopic DG (44). The results are expected to expound on the potential advantages of PPG in the near future.

PG with esophagogastrostomy by DFT

PG is an alternative procedure to total gastrectomy (TG) for cT1 cN0 GC in the upper part of the stomach as described in the Japanese Gastric Cancer Treatment Guidelines (8). Because of the growing trend of the incidence of proximal GC (45), the demand for PG is increasing. In terms of reconstruction after PG, three major procedures have been described: esophagogastrostomy, jejunal interposition, and double-tract reconstruction. These three procedures have their respective pros and cons, and the optimal reconstruction method continues to be controversial (5,46,47).

Esophagogastrostomy is the simplest reconstruction procedure after PG; however, it is associated with a risk of reflux esophagitis and anastomotic stenosis. A novel esophagogastrostomy method with the DFT, first reported by Kamikawa *et al.* (48) in 2001, is a hand-sewn procedure that very effectively prevents postoperative reflux. In recent years, several reports have shown the potential advantages of esophagogastrostomy with the DFT. In the present study, we focused on this promising reconstruction method and summarized its surgical outcomes and functional/nutritional advantages.

Laparoscopic procedures of PG with esophagogastrostomy by DFT

The details of our laparoscopic procedures for PG have been described previously (4,49). D1+ lymphadenectomy which includes lymph node stations #1/#2/#3a/#4sa/#4sb/#7/#8a/#9/#11p was performed as recommended in the Japanese Gastric Cancer Treatment Guidelines (8). The right gastric and right gastroepiploic vessels were routinely preserved during PG. The hepatic and pyloric branches of the vagus nerve were routinely preserved, and its celiac branch was preserved in some cases.

Intraoperative gastroscopy was performed in all cases of laparoscopic PG (LPG). During the endoscopy, the locations of the esophagogastric junction, primary lesion, and preoperatively placed marking clips were confirmed to secure proper resection margins during surgery. In some cases, an intraoperative frozen section of the resection edge was examined to identify the histological cancer-free margin.

The remnant stomach was extracted from the umbilical port site and the seromuscular double-flaps (2.5 cm wide × 3.5 cm high) were created on the anterior wall using electric cautery (*Figure 2A*). After creation of the double flaps, the gastric mucosa was opened at the inferior edge for anastomosis. The posterior wall of the esophagus was fixed to the superior edge of the mucosal window (*Figure 2B*, red arrows). Continuous suturing was applied between all layers of the posterior esophageal wall and the superior opening of the mucosa on the gastric remnant (*Figure 2B*). Layer-by-layer anastomosis was performed between the anterior wall of the esophagus and the inferior opening of the gastric wall by interrupted or continuous sutures (*Figure 2C*). Finally, the esophagogastric anastomosis was fully covered by seromuscular flaps, and the completed anastomosis was Y-shaped (*Figure 2D*).

Functional and nutritional outcomes after PG with esophagogastrostomy by DFT (Table 2)

Previous reports of esophagogastrostomy by the DFT are summarized in *Table 2* (49-56). This new DFT technique was first described by Kamikawa *et al.* (48) in 2001, and its clinical and surgical outcomes have been published in the English-language literature since 2015. Most of these reports describe the surgical results for GC located in the upper stomach; a few reports describe the results for esophagogastric junctional cancer (50,56). Mine *et al.* (50) performed this reconstruction method for esophagogastric junctional cancers and indicated its potential usefulness for intrathoracic anastomosis.

Most previous reports are retrospective, small-scale, and single-arm analyses; however, they have shown extremely lower incidence rates of anastomotic complications and gastroesophageal reflux compared with other types of esophagogastrostomy (5,46,47). In a large-sample analysis, Kuroda *et al.* (56) accumulated surgical outcomes of more than 500 DFT cases from multiple institutes between 1996 and 2005. The authors reported low incidence

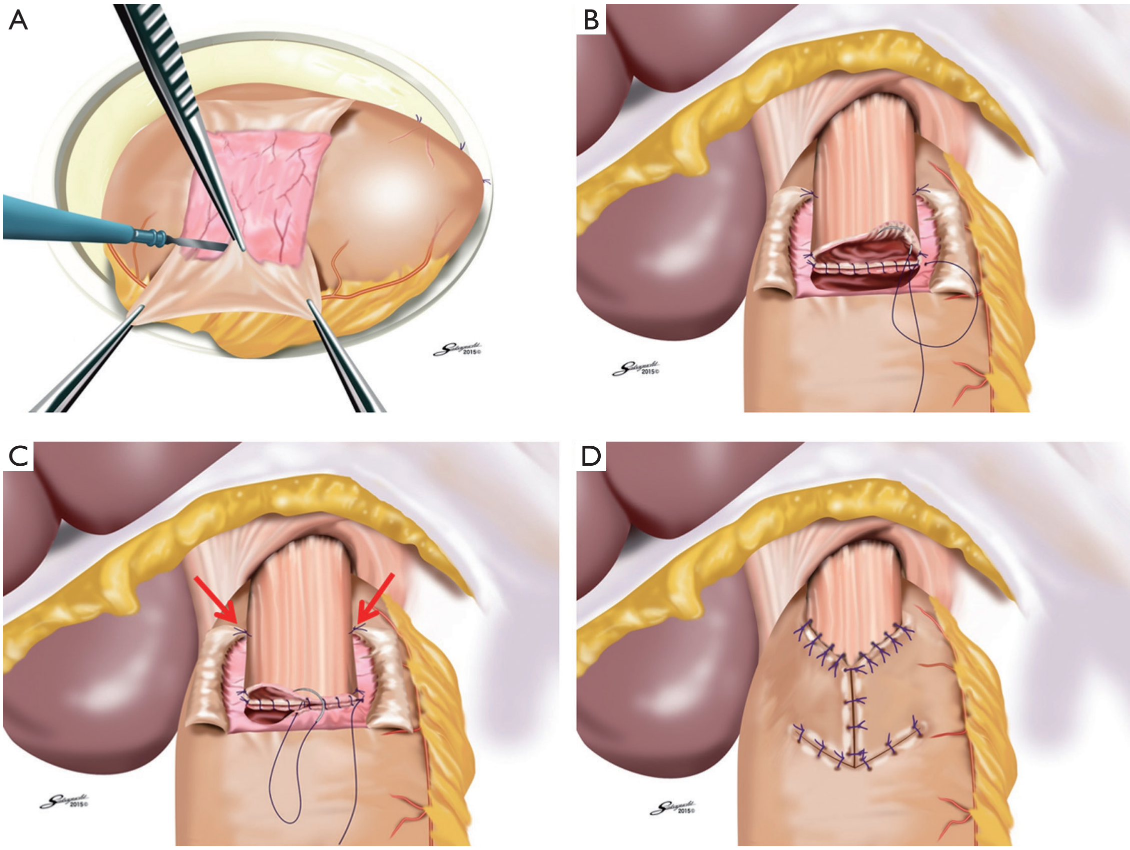

Figure 2 Esophagogastrostomy with double-flap technique (DFT). (A) Creation of the seromuscular double flaps (2.5 cm wide × 3.5 cm high) on the anterior wall of the remnant stomach. (B) Fixation between the posterior wall of the esophagus and the superior edge of the mucosal window (red arrows). Suturing between all layers of the posterior esophageal wall and superior opening of the mucosa on the gastric remnant. (C) Suturing between the anterior wall of the esophagus and the inferior opening of the gastric wall. (D) Coverage of the esophagogastric anastomosis by seromuscular flaps. The completed anastomosis is Y-shaped. Reproduced from ref (4).

rates of not only anastomotic complications (7.2% of all anastomosis-related complications), but also severe reflux esophagitis (only 6.0% of grade B or higher by the Los Angeles classification), suggesting a safe and steady anti-reflux mechanism of DFT. With respect to anastomotic complications, the incidence rates of anastomotic leakage are relatively low, ranging from 0.0% to 7.7%. However, the rates of anastomotic stricture are reportedly as high as 29.1%. Shibasaki *et al.* (54) showed the negative relationship between anastomotic stenosis and the total number of stitches. In performing this DFT technique, an excessive number of stiches should be avoided because of the possibility of anastomotic stenosis.

The complexity of the DFT is another one of its negative aspects. Shibasaki *et al.* (54) performed this procedure using a robotic approach and reported a shorter and more acceptable anastomotic time than that achieved by a laparoscopic approach. The usage of knotless barbed absorbable suture may also effectively shorten the anastomotic time (55).

Limited comparison between PG and its alternative technique TG exists (49). Our analysis confirmed that there are several advantages of laparoscopic PG-DFT over laparoscopic TG with Roux-en-Y reconstruction. These superior outcomes of PG over TG include the lower incidence rates of postoperative complications, shorter postoperative hospital stay, and better nutritional status. Level I evidence in support of DFT procedure is expected as prospective studies or randomized clinical trials with a large sample size are performed.

Table 2 Functional and nutritional outcomes after PG with esophagogastrostomy by DFT

Study concept	Ref.	Author	Year	Study design	Procedure/ approach	Number of patients	Postoperative complication: All complication	Postoperative complication: Anastomosis related				Postoperative complication: Not related to anastomosis	Mortality	Postoperative hospital stay (days)	Symptom	pH monitoring test	Endoscopic findings: Esophagitis, LA classification			Endoscopic findings: Food residue	Body weight change	Nutrition			
							Grade III or higher[a]	All	Leakage	Stricture	Bleeding	Grade II or higher[a]			Reflux/ heart burn	Gastroesophageal acid reflux	Grade N or M[b]	Grade A[b]	Grade B or higher[b]			TP	Alb	Hb	PNI index
Single-arm	(50)	Mine	2015	Retrospective	DFT, intrathoracic	4	0%	0%	0%	0%	0%	0%	0%		0%										
Single-arm	(51)	Kuroda	2016	Retrospective	DFT, total cases	33		9.1%	0%	9.1%	0%	3.0%							0%						
Open reconstruction *vs.* Laparoscopic reconstruction					LAPG-DFT	20		5.0%	0%	5.0%	0%	5.0%							0%						
					LPG-DFT	13		15.4%	0%	15.4%	0%	0%							0%						
					P value			NS	NS	NS	NS	NS							NS						
Single-arm	(52)	Muraoka	2016	Retrospective	LPG-DFT	24		33.3%	4.2%	29.1%		4.2%	0%		0%		85.0%	10.0%	5.0%	10.0%					
Vs. TG	(49)	Hayami	2017	Retrospective	LPG-DFT	43	7.0%	4.7%	0%	4.7%	0%		0%	10 [7–31]					2.3%		88%	7.0 g/dL	4.2 g/dL	13.2 g/dL	
					LTG-RY	47	21.3%	17.0%	4.3%	12.8%	0%		0%	13 [8–58]					14.9%		84%	6.7 g/dL	4.1 g/dL	12.3 g/dL	
					P value		0.073	0.093	0.495	0.271	NS		NS	0.002					0.06		0.003	<0.001	0.06	0.003	
Single-arm	(53)	Hosoda	2017	Retrospective	LPG-DFT	20		10.0%	0%	10.0%		10.0%		9 [8–29]	0%	12.5%									
Single-arm	(54)	Shibasaki	2017	Retrospective	RPG-DFT	12		25.0%	0%	25.0%		8.3%		10 [9–30]	0%										
Single-arm	(55)	Saeki	2018	Retrospective	LPG-DFT, using knotless barbed absorbable suture	13		7.7%	7.7%					14 [11–36]	7.7%		92.3%	7.7%							
Single-arm	(56)	Kuroda	2019	Retrospective, multicenter	DFT, total cases	546		7.2%	1.5%	5.5%	0.6%			15 [13–20]			89.4%	4.5%	6.0%		88.7%				–1.8%
					DFT, laparotomy	311																			
					DFT, thoraco-laparotomy	25																			
					DFT, mini-laparotomy	126																			
					DFT, laparoscopy	81																			
					DFT, other approach	3																			

[a], Clavien-Dindo classification; [b], Los Angeles classification. DFT, esophagogastrostomy with double-flap technique; LAPG, laparoscopic-assisted PG; LAPG, laparoscopic-assisted PG; LTG, laparoscopic total gastrectomy with Roux-en-Y; LPG, laparoscopic PG; RPG, robotic PG; TG, total gastrectomy.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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