Surg Today (2016) 46:517–527
DOI 10.1007/s00595-015-1185-4

REVIEW ARTICLE

Reconstruction after proximal gastrectomy for gastric cancer in the upper third of the stomach: a review of the literature published from 2000 to 2014

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Received: 26 February 2015 / Accepted: 28 April 2015 / Published online: 19 May 2015

Abstract Proximal gastrectomy (PG) is occasionally performed to preserve the physiological function of the remnant stomach with the aim of maintaining a gastric reservoir for patients with early gastric cancer in the upper third of the stomach. Many reconstructive procedures after PG have been reported, including esophagogastrostomy (EG), jejunal interposition, jejunal pouch interposition, and double tract. However, no general agreement exists regarding the optimal reconstructive procedure. This article reviews the current reconstructive procedures available for PG. We examined the surgical outcomes, postoperative complications, endoscopic findings, and quality of life (QOL) according to the reconstructive procedures. We found no significant difference in anastomotic leakage and anastomotic stricture among the procedures. The frequency of reflux esophagitis was higher with simple EG compared with the other reconstructive procedures. Some additional procedures, such as fundoplication, the use of a narrow gastric conduit, and placement of a gastric tube in the lower mediastinum on EG, could decrease the frequency of reflux esophagitis and reflux symptoms. These additional procedures may improve the QOL; however, the previous studies were small and could not adequately compare the reconstructive procedures. Prospective randomized controlled trials that involve a longer trial period and more institutions are needed to clarify the optimal reconstructive procedures after PG.

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Keywords Gastric cancer · Proximal gastrectomy · Reconstruction · Reflux esophagitis · Quality of life

Abbreviations

PG	Proximal gastrectomy
EG	Esophagogastrostomy
JI	Jejunal interposition
JPI	Jejunal pouch interposition
DT	Double tract
OPG	Open proximal gastrectomy
LAPG	Laparoscopy-assisted proximal gastrectomy
LPG	Laparoscopic proximal gastrectomy
QOL	Quality of life

Introduction

In recent decades, the incidence of gastric cancer in the upper third of the stomach has steadily increased worldwide [1, 2]. Function-preserving surgery for the treatment of early gastric cancer has mainly focused on minimizing postgastrectomy problems and improving the quality of life (QOL) after gastrectomy [3–5]. Proximal gastrectomy (PG) is occasionally performed to preserve the physiological function of the remnant stomach with the aim of maintaining a gastric reservoir for patients with early upper-third gastric cancer [6, 7]. For cT1cN0 tumors, the Japanese gastric cancer treatment guidelines [8] indicate PG and D1+(D1) lymphadenectomy for proximal tumors to preserve more than half of the distal stomach. However, after PG, the loss of the lower esophageal sphincter and the acute angle of His occasionally leads to reflux esophagitis through acid reflux and regurgitation, which impair postoperative QOL.

Many reconstructive procedures after PG have so far been reported, including esophagogastrostomy (EG)

Table 1 Literature review of proximal gastrectomy for gastric cancer (EG alone)

References	*N*	Approach	Anastomotic method	Preservation of the vagus nerve system	Pyloric drainage procedure	Length of surgery, min (range)	Blood loss, mL (range)
Ronellenfitsch [34]	50	OPG: 98 LAPG: 2	Hand-sewn	NA	Pyloroplasty: 54 Pyloromyotomy: 36	Median 180 (100–360)	Median 250 (50–2500)
Hosogi [35]	15	LPG	Linear	NA	NA	Mean 315 (217–452)	0–90
Chen [38]	EG: 34 EGJ: 21	OPG	Circular	NA	None	Mean EG: 231.2 EGJ: 235.1	Mean EG: 345.8 EGJ: 349.0
Ichikawa [32]	39	NA	Circular	P, H	NA	Median 240	NA
Okabe [36]	10	LPG	Hand-sewn	C	NA	Mean 299 (174–394)	Mean 65 (0–325)
Tsujimoto [30]	10	LPG	Linear	NA	NA	Mean 224.1	Mean 47.0
Takeuchi [31]	36	LAPG	Circular	NA	none	Mean 271	Mean 26
Kong [28]	15	NA	Circular	NA	Finger fracture	Median 156.5	Median 135
Aihara [22]	14	LAPG	Circular	NA	Finger fracture	Mean 202 (146–271)	Mean 236 (21–455)
Zhang [27]	149 EA: 54 EP: 45 EE: 50	NA	Circular	NA	Pyloroplasty	Mean EA: 166.3 EP: 156.8 EE: 149.7	Mean EA: 263.4 EP: 267.3 EE: 276.9
Hiki [29]	11	LPG	Circular	NA	NA	Mean 237	Mean 39

EG esophagogastrostomy, *EGJ* EG plus gastrojejunostomy, *OPG* open proximal gastrectomy, *LAPG* laparoscopy-assisted proximal gastrectomy, *LPG* laparoscopic proximal gastrectomy, *P* pyloric branch, *H* hepatic branch, *C* celiac branch, *EA* esophagogastric anterior wall end-to-side anastomosis combined with pyloroplasty, *EP* esophagogastric posterior wall end-to-side anastomosis, *EE* esophagogastric end-to-end anastomosis, *NA* not available

[6, 7], jejunal interposition (JI) [9, 10], jejunal pouch interposition (JPI) [11, 12], and double tract (DT) [13, 14]. Historically, EG was widely used for treating early upper-third gastric cancer because EG is a simple and easy reconstruction method [15]. However, because this procedure often leads to severe reflux esophagitis [16, 17], some surgeons instead perform total gastrectomy, while others select other reconstruction methods that do not cause severe reflux esophagitis, such as JI, JPI, and DT [9–14]. Recently, with the increasingly widespread application of laparoscopic gastrectomy as a less-invasive treatment [18, 19], EG has become more common as a reconstruction method after PG. Some studies have reported that an optimal additional procedure could prevent reflux esophagitis in patients undergoing EG [20–23]. However, some investigations have shown that JI, JPI, and DT reconstruction methods are advantageous with regard to their prevention of reflux esophagitis [9, 10, 13]. Although JPI reconstruction was found to be effective for preserving the gastric function after PG [11, 24], some studies have reported dilatation and stasis of the jejunal pouch [25, 26].

Thus, the most effective surgical reconstruction method after PG remains controversial, and the optimal procedure is currently unclear. Although many groups have studied reconstructive procedures for PG, to the best of our knowledge, no reviews have summarized the findings from all large studies. We believe that a summary of these results is necessary to establish the efficacy of PG for gastric cancer.

We herein review the short-term and long-term outcomes of PG for gastric cancer, focusing on the surgical outcomes, postoperative complications, endoscopic findings, and QOL according to the reconstructive procedures. This article is intended to review the current clinical data on the different types of reconstructive procedures following PG and to examine the effective and safe reconstructive procedures for PG.

Methods

An English literature search was performed using the PubMed database with the terms “proximal gastrectomy” and “gastric cancer” along with their synonyms or abbreviations for the years 2000 through 2014. Comparative studies including randomized controlled trials (RCTs) and case series were reviewed. Comparative studies of different reconstructive procedures including more than 10 patients in a single group and retrospective series including more than 10 patients published in peer-reviewed journals were selected. We excluded comparative studies between PG

Table 2 Literature review of proximal gastrectomy for gastric cancer (EG alone)

References	Reflux esophagitis (%)	Anastomotic stricture (%)	Food residues (%)	Leakage (%)	Morbidity (%)	Change in body weight (%)	Reflux symptoms (%)
Ronellenfitsch [34]	29	NA	NA	4 (Grade III**)	26 (Grade III or higher**)	NA	21.4 (early follow-up) 33.3 (late follow-up)
Hosogi [35]	30.8 (1 year)	20 (Grade IIIa*)	NA	6.7 (Grade IIIa**)	6.7 (Grade II** wound infection) 6.7 (Grade II** pneumonia)	NA	0
Chen [38]	EG: 35.3 EGJ: 9.6 ($p = 0.019$)	EG: 17.6 EGJ: 9.6 ($p = 0.462$)	NA	EG: 8.8 EGJ: 4.8 ($p = 0.354$)	NS	NS	NA
Ichikawa [32]	25 (M: 10, A: 10, D: 5*) (1 year)	2.6	NA	0	10	NA	PG = TG
Okabe [36]	12.5 (Grade B*) (18 months)	10	NA	0	0	10.4 (4.5–14.3) (12 months)	0
Tsujimoto [30]	NA	0	NA	0	10.0	NA	NA
Takeuchi [31]	NA	13.9	NA	0	NA	NA	3
Kong [28]	NA	13.3	NA	0	13.3	NA	0
Aihara [22]	14.3	28.6	NA	7.1	35.7	NA	14
Zhang [27]	NA	NA	NA	NA	EA: 22.2 EP: 24.4 EE: 26	Body weight recovery:EA > EP, EE (24 months)	EA < EP, EE (6 months)
Hiki [29]	NA	18	NA	0	NA	NA	NA

EG esophagogastrostomy, *EGJ* EG plus gastrojejunostomy, *EA* esophagogastric anterior wall end-to-side anastomosis combined with pyloroplasty, *EP* esophagogastric posterior wall end-to-side anastomosis, *EE* esophagogastric end-to-end anastomosis, *TG* total gastrectomy, *NA* not available, *NS* not significant

* Los Angeles classification

** Clavien–Dindo classification

Table 3 Literature review of proximal gastrectomy for gastric cancer (JI alone)

References	N	Approach	Preservation of the vagus nerve system	Pyloric drainage procedure	Length of jejunal limb or jejunal pouch, cm	Length of surgery, min (range)	Blood loss, mL (range)
Kinoshita [39]	90	LPG ($n = 22$) OPG ($n = 68$)	H, P	None	15	Median LPG: 233 (190–321) OPG: 201 (125–272)	Median LPG: 20 (0–174) OPG: 242 (75–776)
Katai [10]	128	NA	H, P (1997–) H, P, C (2003–)	Truncal vagotomy with pyloroplasty (–1996)	10–20	NA	NA
Katai [9]	45	NA	H, P (1997–)	Truncal vagotomy with pyloroplasty (–1996)	10–20	NA	NA

References	Reflux esophagitis (%)	Anastomotic stricture (%)	Food residues (%)	Leakage (%)	Morbidity (%)	Change in body weight (%)	Reflux symptoms (%)
Kinoshita [39]	LPG: 0 OPG: 1.1	LPG: 9.1 OPG: 5.9	NA	LPG: 9.1 OPG: 7.4	LPG: 27 OPG: 32	NA	0
Katai [10]	1.7	10.2	8.5	0.8	15.6	11.1 (8.0–27.5) (1 year)	5.5
Katai [9]	0	NA	NA	NA	0	11.5 (2.0–27.5) (1 year)	4.4

JI jejunal interposition, *OPG* open proximal gastrectomy, *LPG* laparoscopic proximal gastrectomy, *P* pyloric branch, *H* hepatic branch, *NA* not available

and total gastrectomy. The length of surgery, intraoperative blood loss, morbidity, reflux esophagitis, anastomotic stricture, gastric stasis, nutrition status, and QOL were examined. As a result, eight comparative studies and 15 case series were included in this review.

Surgical procedures for PG

Vagal nerve preservation

Preservation of the vagal nerve system was reported in 11 studies. Among these reports, five documented the preservation of the hepatic branch and pyloric branch of the vagal nerve, and six documented the preservation of the celiac branch as well (Tables 1, 3, 4, 5).

Pyloric drainage procedure

Pyloric drainage procedure was reported in 6 studies. Among these reports, one performed pyloromyotomy and the others performed pyloroplasty, such as the finger fracture method (Tables 1, 3, 4, 5).

Esophagogastrostomy

Esophagogastrostomy is a simple reconstruction method compared with the other reconstruction methods because it includes only one anastomotic site. The results of EG were reported in 17 studies (Tables 1, 2, 5, 6). An esophagogastric anastomosis was performed using circular stapling in 11 studies, linear stapling in three studies, and the hand-sewn method in two studies.

Zhang et al. [27] compared three types of EG: esophagogastric anterior wall end-to-side anastomosis (EA), esophagogastric posterior wall end-to-side anastomosis (EP), and esophagogastric end-to-end anastomosis (EE). They found that the EA procedure seemed to confer clinical benefits in terms of the postoperative QOL, specifically in the form of an improved meal intake, reduced gastroesophageal reflux, and improved body weight.

Recently, with the increasingly widespread application of laparoscopic gastrectomy as a less-invasive treatment [18], simplicity and ease of surgery are required for reconstruction methods. Kong et al. [28] and Hiki et al. [29] reported a fast and feasible double-stapling anastomotic technique, which is particularly useful for laparoscopic gastric surgery. Tsujimoto et al. [30] showed that a side-to-side (so-called "overlap") anastomosis using a linear stapler after LPG was safe and feasible and did not require additional minilaparotomy; this procedure may result in less pain and favorable cosmetic outcomes.

Table 4 Literature review of proximal gastrectomy for gastric cancer (DT alone)

Reference	*N*	Approach	Preservation of the vagus nerve system	Pyloric drainage procedure	Length of surgery, min (range)	Blood loss, mL (range)
Ahn [13]	43	LPG	H, P	NA	Mean 180.7 (115–260)	Mean 120.4 (12–300)

Reference	Reflux esophagitis (%)	Anastomotic stricture (%)	Food residues (%)	Leakage (%)	Morbidity (%)	Change in body weight (%)	Reflux symptoms (%)
Ahn [13]	0 (3 months)	4.65	48.9	0	Early complications: 11.6 Major complications (≧Grade IIIa*): 2.3 Late complications: 11.6	2.9 (1 month) 5.9 (6 months)	4.6

DT double tract, *LPG* laparoscopic proximal gastrectomy, *P* pyloric branch, *H* hepatic branch, *NA* not available

* Clavien–Dindo classification

Optimal additional procedures were reported for the prevention of reflux esophagitis in patients undergoing EG. Some studies reported PG with a subtotal or semicircular wrap of the abdominal esophagus by the residual stomach, similar to a Toupet fundoplication and showed that the fundoplication was useful for preventing reflux esophagitis after EG [21, 30–33].

Additionally, Ronellenfitsch et al. [34] and Aihara et al. [22] showed that EG using a narrow (3–4 cm) gastric conduit to limit its receptive capacity and to reduce postoperative reflux was capable of preventing reflux esophagitis. Moreover, Hosogi et al. [35] reported preparing a gastric tube of 35 mm width and making an esophagogastric tube anastomosis with pseudo-fornix with a no-knife linear stapler to prevent postoperative reflux esophagitis. Okabe et al. [36] reported their experience of PG with a hand-sewn esophagogastric anastomosis using a knifeless endoscopic linear stapler to contribute to an easier hand-sewn anastomosis and completion of the fundoplication under laparoscopy. Yasuda et al. [37] reported laparoscopy-assisted PG with EG with a reliable angle of His by placing a gastric tube in the lower mediastinum and showed its simplicity and low incidence of residual food and bile reflux.

Moreover, Chen et al. [38] reported PG followed by EG plus gastrojejunostomy to prevent bile reflux esophagitis and showed that this procedure reduced the incidence of reflux esophagitis, most likely through resolving the problem of delayed gastric emptying.

Jejunal interposition

Ten studies reported the results of JI reconstruction, which is generally performed as follows (Tables 3, 5, 6). A jejunal limb is brought up via either the antecolic or the retrocolic route and anastomosed with the esophagus and the remaining stomach. The length of the jejunal limb is 10–20 cm. An esophagojejunal anastomosis is performed with an end-to-side anastomosis, and a jejunogastric anastomosis is made with an end-to-side or side-to-side anastomosis on the anterior wall of the remnant stomach.

Tokunaga et al. [17] reported that JI with a 10-cm or shorter length jejunal limb should be performed after PG because it could prevent reflux esophagitis and was advantageous in evaluating the remnant stomach. Katai et al. [9, 10] reported that PG with JI was well tolerated, with excellent outcomes in the postoperative complications and lower mortality for patients with suspected early gastric cancer. Moreover, Kinoshita et al. [39] reported that LPG with JI had equivalent safety and curability, which may lead to faster recovery, better cosmesis, and improved QOL in the short-term compared to OPG with JI.

Jejunal pouch interposition

The results of JPI were reported in two previous studies (Tables 5, 6). JPI reconstruction is generally performed as follows. To construct a 10- to 15-cm-long reverse U-shaped jejunal pouch, a 25- to 35-cm jejunal limb is brought up via the retrocolic route and anastomosed side-to-end with the esophagus and end-to-side with the remaining stomach.

One RCT reported more favorable short-term and mid-term outcomes following JPI compared with JI after PG and significantly more frequent postoperative short-term morbidity with JI than JPI [11]. Moreover, the incidence of gastrointestinal complaints was more frequent in the JI group until 6 months after surgery. By contrast, the caloric intake was more favorable in the JPI group until 1 year after surgery. This RCT showed that JPI reconstruction

Table 5 Comparative studies of different reconstructive procedures (EG vs JI, JI vs JPI, and EG vs DT)

References	Reconstruction	Trial type	Approach	Anastomotic method on EG	Preservation of the vagus nerve system	Pyloric drainage procedure	Length of jejunal limb or jejunal pouch, cm	Length of surgery, min (range)	Blood loss, mL (range)
Yasuda [37]	EG ($n = 25$) JI ($n = 21$)	Non-RCT	LAPG	Circular	H, C	None	JI: 15	Mean EG: 286.4 JI: 268.8	Mean EG: 294.2 JI: 307.4
Nakamura [33]	EG ($n = 64$) JI ($n = 25$) JPI ($n = 12$)	Non-RCT	OPG/LAPG EG: 38/26, JI: 22/3, JPI: 10/2	Circular	H, C	None	JI: 10–15 JPI: 10-15	Mean EG: 198 JI: 281 JPI: 311 ($p < 0.05$)	Mean EG: 179 JI: 393 JPI: 402 ($p < 0.05$)
Nomura [14]	DT ($n = 10$) JI ($n = 10$)	Non-RCT	LPG	–	NA	NA	15	NA	NA
Masuzawa [40]	EG ($n = 49$) JI ($n = 32$)	Non-RCT	NA	NA	NA	NA	10–15	Median EG: 185 JI: 230 (EG vs JI: $p = 0.0001$)	Median EG: 280 JI: 331
Takagawa [11]	JI ($n = 19$) JPI ($n = 19$)	RCT	OPG/LAPG JI: 9/10, JPI: 7/12	–	H	NA	JI: 10 JPI: 10	Mean JI: 308 JPI: 335	Mean JI: 456 JPI: 287
Sakuramoto [21]	EG ($n = 26$) DT ($n = 10$)	Non-RCT	LAPG	Linear	NA	None	–	Median EG: 292 (225–410) DT: 235 (205–357)	Median EG: 90 (10–535) DT: 60 (10–420)
Tokunaga [41]	EG ($n = 38$) JI ($n = 45$)	Non-RCT	NA	Circular	H, C	NA	JI: 14	Mean EG: 203 JI: 267 ($p < 0.001$)	Mean EG: 252 JI: 287
Tokunaga [17]	EG ($n = 36$) JI ($n = 40$)	Non-RCT	NA	Circular	H, C	NA	Short-JI: ≤10 Long-JI: >10	Mean EG: 195.8 JI: 256.5 ($p < 0.001$)	Mean EG: 294.2 JI: 299.3

EG esophagogastrostomy, *JI* jejunal interposition, *JPI* jejunal pouch interposition, *DT* double tract, *OPG* open proximal gastrectomy, *LAPG* laparoscopy-assisted proximal gastrectomy, *LPG* laparoscopic proximal gastrectomy, *P* pyloric branch, *H* hepatic branch, *C* celiac branch, *NA* not available

Table 6 Comparative studies of different reconstructive procedures (EG vs JI, JI vs JPI, and EG vs DT)

References	Reflux esophagitis (%)	Anastomotic stricture (%)	Food residues (%)	Leakage (%)	Morbidity (%)	Change in body weight (%)	Reflux symptoms (%)
Yasuda [37]	EG: 59.1/4.5/22.7/4.5/9.1 JI: 58.8/17.6/ 23.5/0/0 (Grades N/M/A/B/C or D*) ($p = 0.416$)	Early complications: EG: 0 JI: 14.3 ($p = 0.088$) Late complications: EG: 21.7 JI: 10 ($p = 0.298$)	EG: 18.2 18/4/0/0/0 JI: 58.8 7/0/2/3/5 (Grades 0/1/2/3/4*) ($p = 0.009$)	EG:0 JI:9.5 ($p = 0.203$)	Early complications: EG: 16 JI: 28.6 ($p = 0.251$) Late complications EG: 21.7 JI: 25.0 ($p = 0.801$)	NA	EG: 4.3 JI: 5
Nakamura [33]	EG: 21.8 JI: 0, JPI: 8.3 ($p = 0.0401$) EG with $a > 180°$ wrap: 3.6 (Grades B/C*) (12 months)	EG: 21.8 JI: 31.8 JPI: 8.3	EG: 21.8 JI: 31.8 JPI: 91.7 (Grade ≧ 2**)	EG:0 JI:4 JPI:0	EG: 3.1 JI: 20 JPI: 25	EG: 12.9 JI: 17.5 JPI: 19.7 ($p < 0.05$) (3 years)	NA
Nomura [14]	DT: 10 JI: 10	DT: 10 JI: 20	NA	NA	NA	DT: 87.1 JI: 91.2 ($p < 0.05$) (12 months)	Heartburn DT: 10 JI: 0
Masuzawa [40]	NA	EG: 4.1 JI: 3.1	NA	EG:0 JI:0	Early complications: EG: 8.2 JI: 9.4	NS	Heartburn: EG: 18.4 JI: 15.6
Takagawa [11]	JI: 15.8 JPI: 15.8 (24 months)	JI: 21.1 JPI: 10.5	JI: 10.5 JPI: 21.1	JI: 15.8 JPI: 5.3	Short-term JI: 31.6 JPI: 5.3 ($p = 0.036$)	JI: 80.0 JPI: 86.7 ($p = 0.095$) (24 months)	Heartburn JI: 5.3 JPI: 5.3 (24 months)
Sakuramoto [21]	EG: 30 DT: 25 (12 months)	EG: 0 DT: 10	NA	EG: 7.7 (Grades II, III*) DT: 0	EG: 7.7 DT: 20	EG: 92.2 (93.2, 74.8–101.6) DT: 88.5 (88.2, 81.7–92.9) (12 months)	Heartburn EG: 15, DT: 12.5 Regurgitation EG: 5, DT: 0 (12 months)
Tokunaga [41]	NA	NA	NA	NA	NA	EG: 86 JI: 86 (1 year) ($p = 0.489$)	Heartburn EG: 8, JI: 9 Regurgitation EG: 8, JI: 7
Tokunaga [17]	EG: 32.4 JI: 5 ($p = 0.001$)	NA	NA	NA	EG: 8 JI: 15	NA	NA

EG esophagogastrostomy, *JI* jejunal interposition, *JPI* jejunal pouch interposition, *DT* double tract, *NA* not available, *NS* not significant

* Los Angeles classification

** RGB (residue, gastritis, bile) classification

*** Clavien–Dindo classification

may reduce the occurrence of gastrointestinal symptoms in the early postsurgery phase and provide a satisfactory volume of oral intake in the stable postsurgery phase.

Double tract

The results of DT were reported in three previous studies (Tables 4, 5, 6). DT reconstruction is generally performed as follows. A Roux-en-Y esophagojejunostomy is performed with a circular stapler, and the jejunal stump is closed with a linear stapler. Next, side-to-side gastrojejunostomy, 10 cm below the esophagojejunostomy, is performed using linear staplers. Finally, end-to-side jejunojejunostomy, 20 cm below the gastrojejunostomy, is performed with hand-sewn sutures.

One prospective study reported a significantly higher postoperative/preoperative body weight ratio in the JI group than in the DT group and a reflux esophagitis incidence of 10 % in both groups [14]. With respect to postprandial symptoms, no significant differences were observed between the two groups. Ahn et al. [13] reported that DT was a feasible, simple, and novel reconstruction method with exceptional postoperative outcomes in terms of preventing reflux symptoms.

Surgical outcomes

Length of surgery

The duration of surgery has been previously reported in 20 studies. In the reports on EG, the surgery lasted from 100 to 452 min, the median value ranged from 156.5 to 292 min, and the mean value ranged from 149.7 to 315 min (Tables 1, 5). In the reports on JI, the length of surgery ranged from 125 to 321 min, the median value ranged from 201 to 233 min, and the mean value ranged from 256.5 to 308 min (Tables 3, 5). In the reports on JPI, the mean length of surgery ranged from 311 to 335 min (Table 5). In the reports on DT, the length of surgery ranged from 115 to 357 min (Tables 4, 5).

Four previous studies compared EG and JI and reported that the operative time was shorter for EG than for JI [17, 33, 40, 41].

Blood loss

Blood loss results were previously reported in 19 studies. In the reports on EG, the amount of blood loss during surgery ranged from 0 to 2500 mL, the median value ranged from 119 to 280 mL, and the mean value ranged from 26 to 345.8 mL (Tables 1, 5). In the reports on JI, the amount of blood loss ranged from 0 to 776 mL, the median value ranged from 20 to 331 mL, and the mean value ranged from 287 to 456 mL (Tables 3, 5). In the reports on JPI, the mean blood loss during surgery ranged from 287 to 402 mL (Table 5). In the reports on DT, the amount of blood loss ranged from 12 to 357 mL (Tables 4, 5).

Our study compared EG and JI or JPI and reported that the intraoperative blood loss (mL) was significantly lower in the EG group than in the other groups (EG, JI, JPI: 179 ± 158, 393 ± 338, 402 ± 385, respectively, $p < 0.05$; EG vs JI: $p = 0.0009$; EG vs JPI: $p = 0.0001$) [33].

Morbidity

Morbidity was reported in 18 previous studies; 13 reports on EG (incidence range 0–35.7 %; Tables 2, 6), eight reports on JI (incidence range 9.4–32 %; Tables 3, 6), two reports on JPI (incidence range 5.3–25 %; Table 6), and two reports on DT (incidence range 11.6–20 %; Tables 4, 6). Morbidity was calculated using these described data. In three comparative studies, no significant difference was found in the early or late postoperative complications among the procedures [17, 37, 40]. However, one RCT reported that the postoperative morbidity was significantly more frequent in the JI compared with the JIP group, particularly with respect to complications affecting surgical anastomoses ($p = 0.036$) [11]. Our previous study reported that the JI and the JPI groups had significantly more early complications than the EG group, and 8.0 % of the patients in the JI group and 16.7 % of the patients in the JPI group developed intestinal obstruction during the follow-up [33]. This may reflect the complexity of the procedures using the jejunum. Overall, these findings imply that the JI and JPI reconstruction procedures are technically difficult and complex surgeries.

The results of anastomotic leakage were reported in 18 previous studies. Anastomotic leakage was documented in 14 reports on EG (incidence range 0–8.8 %; Tables 2, 6), six reports on JI (incidence range 0–15.8 %; Tables 3, 6), two reports on JPI (incidence range 0–5.3 %; Table 6), and two reports on DT (incidence rate 0 %; Tables 4, 6). Anastomotic leakage was calculated using these described data. In three comparative studies, no significant difference was found in anastomotic leakage among the procedures [33, 37, 40]. Interestingly, the number of anastomoses did not significantly affect the occurrence of anastomotic leakage.

Two comparative studies reported the survival data in this review, and there was no difference in the 5-year survival rate between the EG group and the JI group [17, 40].

Reflux esophagitis

Reflux esophagitis was reported and evaluated endoscopically in 16 previous studies. Reflux esophagitis was documented in 10 reports on EG (incidence range 9.1–35.3 %; Tables 2, 6), eight reports on JI (incidence range 0–15.8 %; Tables 3, 6), two reports on JPI (incidence range 8.3–15.8 %; Table 6), and three reports on DT (incidence range 0–25 %; Tables 4, 6). The incidence of reflux esophagitis was calculated using these described data. JI, JPI, and DT were associated with a relatively low frequency of reflux esophagitis. In two comparative studies, the frequency of reflux esophagitis in simple EG without additional procedures was higher than in other procedures [17, 33]. Some additional procedures, such as the fundoplication, use of a narrow gastric conduit, addition of gastrojejunostomy, and placement of a gastric tube in the lower mediastinum on EG, were performed to prevent reflux esophagitis. Three comparative studies reported that the frequency of reflux esophagitis in EG with additional procedures was similar to other procedures or that the degree of reflux esophagitis in EG with additional procedures was mild or moderate [21, 33, 37]. Our previous study showed that the frequency of reflux esophagitis (Los Angeles classification grades B and C) in patients with a more than 180-degree wrap of the remnant stomach around the esophagus during EG was 3.6 %, and reflux esophagitis could be prevented when the fundoplication was performed adequately [33]. Additional procedures such as the fundoplication could decrease the frequency of reflux esophagitis.

Anastomotic stricture

Anastomotic stricture was reported in 18 previous studies. Anastomotic stricture was documented in 13 reports on EG (incidence range 0–28.6 %; Tables 2, 6), seven reports on JI (incidence range 3.1–31.8 %; Tables 3, 6), two reports on JPI (incidence range 8.3–10.6 %; Table 6), and three reports on DT (incidence range 4.65–10 %; Tables 4, 6). Anastomotic stricture was calculated using these described data.

Esophagogastric anastomosis on EG was performed using circular stapling in 11 studies and linear stapling in three studies. The incidence range of anastomotic stricture using circular stapling was 2.6–28.6 % and that using linear stapling was 0–20 % (Tables 1, 2, 5, 6).

In six comparative studies, no significant difference occurred in anastomotic stricture among the procedures [11, 14, 21, 33, 37, 40]. Our previous study showed that anastomotic stricture occurred in 22.2 % of the patients with a less than 180-degree wrap and in 21.4 % of the patients with fundoplication of a more than 180-degree wrap after EG. No significant relationships existed between the degree of the wrap and the development of anastomotic stricture [33].

Food residues

With respect to complications arising after pouch reconstruction, some studies have reported pouch stasis resulting from dilatation of the jejunal pouch [25, 26].

Results pertaining to food residues were reported in five previous studies. Food residues were documented in two reports on EG (incidence range 18.2–21.8 %; Table 6), four reports on JI (incidence range 8.5–58.8 %; Tables 3, 6), two reports on JPI (incidence range 21.2–91.7 %; Table 6), and one report on DT (incidence rate: 48.9 %; Table 4). Food residues were calculated using these described data. EG was associated with a relatively low frequency of food residues. Yasuda et al. [37] reported that the frequency of food residues in JI was significantly higher than in EG. Takagawa et al. [11] reported that there was no significant difference in food residues between JI and JPI. They introduced the use of a 10-cm jejunal pouch, and this technique preserved the vagus nerve, helping to maintain motility in the stomach and prevent pouch stasis. However, in our previous study, although the use of a 10- to 15-cm jejunal pouch and preservation of the vagus nerves were similarly performed, residual food was found in 92 % of the patients in the JPI group, 22 % of those in the EG group, and 32 % of those in the JI group; it was significantly more frequently detected in the JPI group than in the other 2 groups ($p < 0.0001$) [33]. Moreover, Tokunaga et al. [41] collected and analyzed the subjective symptoms after PG using a questionnaire survey, and they reported statistically significant differences in the symptoms, indicating delayed emptying syndrome in the JI group compared with the EG group. They concluded that an interposed segment could disturb the food passage. These results suggest that some patients that undergo JP or JPI may have a low QOL due to food residues after gastrectomy.

Changes in body weight

Body weight loss is a defining characteristic of postgastrectomy syndrome and leads to impaired postoperative QOL. Changes in body weight were reported in 12 previous studies and documented in six comparative studies (Tables 2, 3, 4, 6). Body weight was calculated using these described data. Four comparative studies reported that postsurgical weight loss did not differ between the EG group and the JI group [40, 41], between the EG group and the DT

group [21], or between the JI group and the JPI group [11]. However, our study reported that the rate of body weight loss was significantly lower in the EG group than in the JI and JPI groups at 6, 12, and 36 months postoperatively ($p < 0.05$) [33]. Nomura et al. [14] reported a significantly higher postoperative/preoperative body weight ratio in the JI group than in the DT group ($p < 0.05$).

Reflux symptoms

With respect to gastrectomy-associated symptoms, reflux symptoms such as heartburn and regurgitation considerably influence the QOL after PG. Reflux symptoms were reported in 18 previous studies and evaluated by the frequency of heartburn or regurgitation using QOL questionnaires or medical records. Reflux symptoms were documented in 12 reports on EG (incidence range 0–33.3 %; Tables 2, 6), eight reports on JI (incidence range 0–15.6 %; Tables 3, 6), one report on JPI (incidence rate 5.3 %; Table 6), and three reports on DT (incidence range 4.6–12.5 %; Tables 4, 6). Reflux symptoms were calculated using these described data. All six comparative studies reported that the frequency of reflux symptoms did not differ between the EG group and the JI group [37, 40, 41], between the EG group and the DT group [21], between the JI group and the JPI group [11], or between the DT group and the JI group [14]. Moreover, some studies on EG with additional procedures reported that the reflux symptoms were none or mild [31, 34–36]. Therefore, it was suggested that EG with additional procedures could prevent reflux symptoms.

Treatment with proton pump inhibitors following gastrectomy was reported in eight previous studies [17, 21, 33–37, 41]. Sakuramoto et al. [21] showed that reflux symptoms could be controlled by treatment with proton pump inhibitors.

Conclusion

We herein reviewed the short-term and long-term outcomes of PG for gastric cancer and found no significant difference in anastomotic leakage and anastomotic stricture among the procedures. The number of anastomoses did not significantly affect the occurrence of anastomotic complications. Moreover, although EG is a simple technique, the frequency of reflux esophagitis was higher in simple EG. Additional procedures such as the fundoplication, use of a narrow gastric conduit, and placement of a gastric tube in the lower mediastinum on EG could decrease the frequency of reflux esophagitis and reflux symptoms. Therefore, those additional procedures may be essential for preventing reflux esophagitis and preserving the QOL. However, all studies were small and could not adequately compare the reconstructive procedures. Therefore, prospective RCTs that involve a longer trial period and more institutions are needed to clarify the optimal reconstructive procedures after PG.

Conflict of interest The authors have no conflicts of interest to declare in association with this study.

References

1. Ahn HS, Lee HJ, Yoo MW, Jeong SH, Park DJ, Kim HH, et al. Changes in clinicopathological features and survival after gastrectomy for gastric cancer over a 20-year period. Br J Surg. 2011;98:255–60.
2. Borch K, Jönsson B, Tarpila E, Franzén T, Berglund J, Kullman E, et al. Changing pattern of histological type, location, stage and outcome of surgical treatment of gastric carcinoma. Br J Surg. 2000;87:618–26.
3. Hiki N, Nunobe S, Kubota T, Jiang X. Function-preserving gastrectomy for early gastric cancer. Ann Surg Oncol. 2013;20:2683–92.
4. Koeda K, Nishizuka S, Wakabayashi G. Minimally invasive surgery for gastric cancer: the future standard of care. World J Surg. 2011;35:1469–77.
5. Takayama T, Matsumoto S, Wakatsuki K, Tanaka T, Migita K, Ito M, et al. A novel laparoscopic procedure for treating proximal early gastric cancer: laparoscopy-assisted pylorus-preserving nearly total gastrectomy. Surg Today. 2014;44:2332–8.
6. Harrison LE, Karpeh MS, Brennan MF. Total gastrectomy is not necessary for proximal gastric cancer. Surgery. 1998;123:127–30.
7. Shiraishi N, Adachi Y, Kitano S, Kakisako K, Inomata M, Yasuda K. Clinical outcome of proximal versus total gastrectomy for proximal gastric cancer. World J Surg. 2002;26:1150–4.
8. Association Japanese Gastric Cancer. Japanese gastric cancer treatment guidelines 2010 (ver. 3). Gastric Cancer. 2011;14:113–23.
9. 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;90:850–3.
10. Katai H, Morita S, Saka M, Taniguchi H, Fukagawa T. Longterm outcome after proximal gastrectomy with jejunal interposition for suspected early cancer in the upper third of the stomach. Br J Surg. 2010;97:558–62.
11. Takagawa R, Kunisaki C, Kimura J, Makino H, Kosaka T, Ono HA, et al. A pilot study comparing jejunal pouch and jejunal interposition reconstruction after proximal gastrectomy. Dig Surg. 2010;27:502–8.
12. Iwata T, Kurita N, Ikemoto T, Nishioka M, Andoh T, Shimada M. Evaluation of reconstruction after proximal gastrectomy: prospective comparative study of jejunal interposition and jejunal pouch interposition. Hepatogastroenterology. 2006;53:301–3.
13. Ahn SH, Jung DH, Son SY, Lee CM, Park DJ, Kim HH. Laparoscopic double-tract proximal gastrectomy for proximal early gastric cancer. Gastric Cancer. 2014;17:562–70.
14. Nomura E, Lee SW, Kawai M, Yamazaki M, Nabeshima K, Nakamura K, et al. Functional outcomes by reconstruction technique following laparoscopic proximal gastrectomy for gastric cancer: double tract versus jejunal interposition. World J Surg Oncol. 2014;12:20. doi:10.1186/1477-7819-12-20.

15. Ichikawa D, Ueshima Y, Shirono K, Kan K, Shioaki Y, Lee CJ, et al. Esophagogastrostomy reconstruction after limited proximal gastrectomy. Hepatogastroenterology. 2001;48:1797–801.
16. 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;196:587–91.
17. Tokunaga M, Ohyama S, Hiki N, Hoshino E, Nunobe S, Fukunaga T, et al. Endoscopic evaluation of reflux esophagitis after proximal gastrectomy: comparison between esophagogastric anastomosis and jejunal interposition. World J Surg. 2008;32:1473–7.
18. Kitano S, Shiraishi N, Uyama I, Sugihara K, Tanigawa N, Japanese Laparoscopic Surgery Study Group. A multicenter study on oncologic outcome of laparoscopic gastrectomy for early gastric cancer in Japan. Ann Surg. 2007;245:68–72.
19. Okabe H, Tsunoda S, Tanaka E, Hisamori S, Kawada H, Sakai Y. Is laparoscopic total gastrectomy a safe operation? A review of various anastomotic techniques and their outcomes. Surg Today. 2015;45:549–58.
20. Yamada H, Kojima K, Inokuchi M, Kawano T, Sugihara K, Nihei Z. Preliminary experience using a computer-mediated flexible circular stapler in laparoscopic esophagogastrostomy. Surg Laparosc Endosc Percutan Tech. 2008;18:59–63.
21. Sakuramoto S, Yamashita K, Kikuchi S, Futawatari N, Katada N, Moriya H, et al. Clinical experience of laparoscopy-assisted proximal gastrectomy with Toupet-like partial fundoplication in early gastric cancer for preventing reflux esophagitis. J Am Coll Surg. 2009;209:344–51.
22. Aihara R, Mochiki E, Ohno T, Yanai M, Toyomasu Y, Ogata K, et al. Laparoscopy-assisted proximal gastrectomy with gastric tube reconstruction for early gastric cancer. Surg Endosc. 2010;24:2343–8.
23. Ichikawa D, Komatsu S, Okamoto K, Shiozaki A, Fujiwara H, Otsuji E. Esophagogastrostomy using a circular stapler in laparoscopy-assisted proximal gastrectomy with an incision in the left abdomen. Langenbecks Arch Surg. 2012;397:57–62.
24. Yoo CH, Sohn BH, Han WK, Pae WK. Proximal gastrectomy reconstructed by jejunal pouch interposition for upper third gastric cancer: prospective randomized study. World J Surg. 2005;29:1592–9.
25. Ueno M, Iwahashi M, Nakamori M, Nakamura M, Ueda K, Tani M, et al. Complication of jejunal pouch interposition after proximal gastrectomy: case report. Hepatogastroenterology. 2004;51:916–8.
26. Katsube T, Konno S, Hamaguchi K, Shimakawa T, Naritaka Y, Ogawa K. Complications after proximal gastrectomy with jejunal pouch interposition: report of a case. Eur J Surg Oncol. 2005;31:1036–8.
27. Zhang H, Sun Z, Xu HM, Shan JX, Wang SB, Chen JQ. Improved quality of life in patients with gastric cancer after esophagogastrostomy reconstruction. World J Gastroenterol. 2009;15:3183–90.
28. Kong SH, Kim JW, Lee HJ, Kim WH, Lee KU, Yang HK. Reverse double-stapling end-to-end esophagogastrostomy in proximal gastrectomy. Dig Surg. 2010;27:170–4.
29. Hiki N, Fukunaga T, Yamaguchi T, Nunobe S, Tokunaga M, Ohyama S, et al. Laparoscopic esophagogastric circular stapled anastomosis: a modified technique to protect the esophagus. Gastric Cancer. 2007;10:181–6.
30. Tsujimoto H, Uyama I, Yaguchi Y, Kumano I, Takahata R, Matsumoto Y, et al. Outcome of overlap anastomosis using a linear stapler after laparoscopic total and proximal gastrectomy. Langenbecks Arch Surg. 2012;397:833–40.
31. Takeuchi H, Oyama T, Kamiya S, Nakamura R, Takahashi T, Wada N, et al. Laparoscopy-assisted proximal gastrectomy with sentinel node mapping for early gastric cancer. World J Surg. 2011;35:2463–71.
32. Ichikawa D, Komatsu S, Okamoto K, Shiozaki A, Fujiwara H, Otsuji E. Evaluation of symptoms related to reflux esophagitis in patients with esophagogastrostomy after proximal gastrectomy. Langenbecks Arch Surg. 2013;398:697–701.
33. Nakamura M, Nakamori M, Ojima T, Katsuda M, Iida T, Hayata K, et al. Reconstruction after proximal gastrectomy for early gastric cancer in the upper third of the stomach: an analysis of our 13-year experience. Surgery. 2014;156:57–63.
34. Ronellenfitsch U, Najmeh S, Andalib A, Perera RM, Rousseau MC, Mulder DS, et al. Functional outcomes and quality of life after proximal gastrectomy with esophagogastrostomy using a narrow gastric conduit. Ann Surg Oncol. 2015;22:772–9.
35. Hosogi H, Yoshimura F, Yamaura T, Satoh S, Uyama I, Kanaya S. Esophagogastric tube reconstruction with stapled pseudofornix in laparoscopic proximal gastrectomy: a novel technique proposed for Siewert type II tumors. Langenbecks Arch Surg. 2014;399:517–23.
36. Okabe H, Obama K, Tanaka E, Tsunoda S, Akagami M, Sakai Y. Laparoscopic proximal gastrectomy with a hand-sewn esophagogastric anastomosis using a knifeless endoscopic linear stapler. Gastric Cancer. 2013;16:268–74.
37. Yasuda A, Yasuda T, Imamoto H, Kato H, Nishiki K, Iwama M, et al. A newly modified esophagogastrostomy with a reliable angle of His by placing a gastric tube in the lower mediastinum in laparoscopy-assisted proximal gastrectomy. Gastric Cancer. 2014; [Epub ahead of print].
38. Chen S, Li J, Liu H, Zeng J, Yang G, Wang J, et al. Esophagogastrostomy plus gastrojejunostomy: a novel reconstruction procedure after curative resection for proximal gastric cancer. J Gastrointest Surg. 2014;18:497–504.
39. 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;27:146–53.
40. Masuzawa T, Takiguchi S, Hirao M, Imamura H, Kimura Y, Fujita J, et al. 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;38:1100–6.
41. Tokunaga M, Hiki N, Ohyama S, Nunobe S, Miki A, Fukunaga T, et al. 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;394:637–41.