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REVIEW

Digestive tract reconstruction options after laparoscopic gastrectomy for gastric cancer

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Abstract

In addition to the popularity of laparoscopic gastrectomy (LG), many reconstructive procedures after LG have been reported. Surgical resection and lymphatic dissection determine long-term survival; however, the election of a reconstruction procedure determines the postoperative quality of life for patients with gastric cancer (GC). Presently, no consensus exists regarding the optimal reconstructive procedure. In this review, the current state of digestive tract reconstruction after LG is reviewed. According to the determining influence of the tumor site on the procedures of surgical resection and reconstruction, we divide these reconstruction procedures into three categories consistent with the resection procedures. We focus on the technical tips of every reconstruction procedure and examine the surgical outcomes (length of surgery and blood loss) and postoperative complications (anastomotic leakage and stricture) to facilitate gastrointestinal surgeons to understand the merits and demerits of every reconstruction procedure.

Key words: Digestive tract reconstruction; Laparoscopic gastrectomy; Gastric cancer; Quality of life

Core tip: This article systematically reviews almost all the reconstruction methods currently used and divides them into three categories according to the method of resection (laparoscopic distal gastrectomy, laparoscopic total gastrectomy, and laparoscopic proximal gastrectomy). This review clearly demonstrates the key steps, merits, and demerits of every reconstruction method *via* drawing schematics based on the authors' personal experience.

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INTRODUCTION

Gastric cancer (GC) remains a disease with high incidence and mortality worldwide[1,2]. GC patients demonstrate reliable survival results due to the implementation of D2 lymphadenectomy, which has become the cornerstone of GC treatment in the past decades[3-5]. Kitano *et al*[6] first reported a case of laparoscopic-assisted distal gastrectomy in 1994. GC surgery has gradually changed from open to laparoscopic-assisted and ultimately to total laparoscopic during the past 20 years. Presently, the main indication for laparoscopic gastrectomy (LG) is early GC because recent studies have shown that the oncologic outcomes of LG were comparable to those of open surgery[7-9]. Three multicenter trials, the JLSSG 0901[10], CLASS-01[11], and KLASS-02[12,13] trials, are current large-scale randomized controlled trials (RCTs) to obtain evidence-based oncological outcomes of LG for advanced GC (AGC)[14]. The results of these RCTs were expected to establish concrete evidence of the widely carried out LG in the treatment of AGC. Various new laparoscopic lymph node dissection procedures were reported and have been shown to achieve pathologically reliable lymphadenectomy during this development process. These technical summaries based on the surgeon's clinical experience made lymph node dissection standardized with reliable quality[15-17].

In addition to the improved survival, quality of life (QoL) attracted more attention, and total laparoscopic surgery has gained widespread global popularity owing to its well-known benefits, such as reduced surgical trauma, decreased pain, low rates of morbidities, and a shorter length of hospital stay[14,18]. Digestive tract reconstruction is a key technique in laparoscopic surgery. However, no definitive consensus is currently available regarding how to choose among the various methods. This review focuses on describing technical tips and discussing the merits and demerits of commonly used laparoscopic reconstruction procedures at present.

LITERATURE SEARCH

To eliminate the influence of the learning curve on complications, a literature search was performed using the terms "laparoscopic gastrectomy", "digestive tract reconstruction", and "gastric cancer" along with their synonyms or abbreviations after 2015. Studies on different reconstructive procedures including less than 10 patients were excluded. The length of surgery, intraoperative blood loss, anastomotic leakage and stricture, esophagitis reflux, and gastric stasis were examined. Data extraction was confirmed manually.

DIGESTIVE TRACT RECONSTRUCTION AFTER LAPAROSCOPIC DISTAL GASTRECTOMY (LDG)

Billroth-I (B-I), Billroth-II (B-II), Roux-en-Y, and uncut Roux-en-Y reconstruction are the most popular methods of reconstruction after LDG for GC.

B-I reconstruction

B-I reconstruction, one of the most popular procedures of reconstruction after distal gastrectomy, is associated with the physiological anatomy and involves only one anastomosis site without stump nor input loop. It is often performed using an extracorporeal procedure with a mini-laparotomy scar in laparoscopy-assisted distal gastrectomy or an intracorporeal procedure in total LDG. The delta-shaped anastomosis (DA) is the most common intracorporeal B-I anastomosis for LDG that was first reported by Kanaya *et al*[19] in 2002. DA is completed by side-to-side gastroduodenostomy with laparoscopic linear staplers (LS) intracorporeally (Figure 1A). This procedure is becoming widely used due to its simplicity and safety[20], and it can be performed safely even by an inexperienced surgeon[21]. Several studies have demonstrated that DA resulted in less blood loss and faster recovery than B-I, especially in obese patients. However, no difference was found in the surgical outcomes (operative time, number of harvested lymph nodes, and proximal margin) and postoperative complications (anastomotic leakage, stricture, hemorrhage, and wound complications)[22-24] (Table 1). However, some researchers have indicated that DA may affect the blood supply during cutting and result in an increased risk of anastomosis-related complications[25]. Another limitation of DA is that it is difficult to locate the tumor to obtain a pathologically safe margin; sometimes the tumor location requires being marked preoperatively or intraoperatively[20], a step that is likely the main shortcoming and limitation of the operation. Additionally, the cost of DA procedure is higher as it requires more endoscopic liner stapler cartridges[26].

To improve the disadvantages mentioned above, a modified reconstructive procedure using an overlap method for B-I is developed. In general, the anastomosis is performed by overlapping the remnant stomach and duodenal stump *via* LS[27]. Watanabe *et al*[28] believed that this method is safer and easier because the posterior wall of the remnant stomach and anterior wall of the duodenum are anastomosed, and it is not necessary to create a space around the posterior wall of the duodenum. Accordingly, this procedure reduces the possibility of damage to the surrounding structures and duodenum when compared with the formation of anastomosis on the posterior wall in DA[28]. High technical requirements, sufficiently long duodenal stump dissociation, high anastomotic tension, bile reflux, and gastric stump cancer surgery are the inherent shortcomings of B-I reconstruction, and surgeons should consider these issues when choosing this procedure.

Due to a combination of increased screening and improved diagnostic techniques, the diagnostic rate of early GC has increased in recent years. As a result of the satisfactory survival outcomes achieved in the treatment of early GC, surgeons pay more attention to the postoperative QoL[29,30]. Pylorus-preserving gastrectomy (PPG) is a function-preserving surgery for the treatment of patients with cT1N0 middle third GC, aiming to decrease the complication rate and improve the postoperative QoL. The infrapyloric artery and antral cuff (2 cm length) were preserved, D2 lymph node dissection was performed, and the gastrogastrostomy was similar to B-I anastomosis with LS[31-33].

It was reported that PPG has the benefits in postoperative nutrition and can reduce the incidence of bile reflux, dumping syndrome, and cholelithiasis meanwhile[34]. However, some surgeons worry that the intracorporeal reconstruction may lead to micro-dissemination of free cancer cells left over in the remnant gastric lumen[35].

B-II reconstruction

B-II reconstruction is another frequently used method in total LDG. During the procedure, an LS is used to anastomose the greater curvature side of the remnant gastric stomach with the jejunum approximately 10-15 cm from the Treitz ligament.

The main advantages of this method are that the tension of the anastomotic stoma is small, there is no need to dissociate much duodenum, and there is no specific requirement for the location of the tumors. Therefore, B-II is usually used in cases in which B-I is inappropriate. Nevertheless, this method is limited because of a higher risk of complications such as reflux gastritis[36,37]. Considering these reasons, B-II with Braun anastomosis (side-to-side jejunojejunostomy away from the gastrojejunal anastomosis) was applied in total LDG (Figure 1B). Additionally, it can reduce the aï¬erent loop syndrome compared with B-II without Braun anastomosis[38]. Some researchers have revealed that B-II Braun anastomosis cannot reduce the high incidence of bile reflux[39], and Park *et al*[40] reported a high incidence of bile reflux in B-II Braun anastomosis patients (~43.3%). Therefore, some researchers have proposed that Roux-en-Y or uncut Roux-en-Y reconstruction may be an alternative to B-II reconstruction.

Roux-en-Y and uncut Roux-en-Y reconstructions

Roux-en-Y reconstruction (Figure 1C) is a very common procedure in the West, has gained popularity in Asia, and is often preferred if the remnant stomach is relatively small or the tumor is near the pylorus[41]. Previous studies have reported that Roux-en-Y reconstruction can reduce the incidence of food residues, esophagitis, gastritis, and bile reflux in follow-up endoscopic findings than the B-I and B-II groups[39,42,43] (Table 1). However, Roux-en-Y reconstruction in total LDG for GC is a more complicated procedure than B-I or B-II because it involves two anastomoses. Therefore, the operation time and anastomosis time were significantly longer for RY than for B-I[44], and multiple anastomotic lines could increase the probability of anastomotic leakage. Additionally, Roux-en-Y reconstruction has a specific problem named Roux stasis syndrome, which is characterized by vomiting, swelling, nausea, and postprandial pain. Its incidence rate is approximately 10%-30%[45,46]. To solve this problem, uncut Roux-en-Y reconstruction was first carried out in 1988 by Van

Table 1 Summary of reconstruction procedures after laparoscopic distal gastrectomy

Ref.	Publication year	Reconstruction procedure	*n*	Length of surgery, min (mean ± SD or range)	Blood loss, mL (mean ± SD or range)	Anastomotic leakage (*n*)	Anastomotic stricture (*n*)	Stasis (*n*)
Fukunaga *et al*[51]	2018	B-I (augmented rectangle technique)	160	227 ± 75	47.3 ± 50	0	0	0
Lin *et al*[52]	2016	LTDG BI	158	154.4 ± 30.1	51.1 ± 30.9	5	0	NA
		LADG BI	484	155.6 ± 46.2	61.6 ± 78.3	1	0	NA
Jeong *et al*[20]	2015	Intracorporeal B-I	42	116 ± 23	105 ± 69	0	NA	1
		Extracorporeal B-I	179	142 ± 19	50 ± 39	2	NA	5
Jian-Cheng *et al*[53]	2015	DA	24	175.3 ± 64.7	50.8 ± 25.3	NA	NA	NA
Lee *et al*[24]	2015	DA	138	220.4 ± 70.5	99.8 ± 99.0	2	2	NA
		B-I	100	220.5 ± 64.7	133.3 ± 152.1	0	4	NA
Jang *et al*[27]	2015	Overlap	42	228.3 ± 42.5	NA	0	0	5
Watanabe *et al*[28]	2019	B-I	247	203 (107–418)	10 (0–380)	4	0	3
		R-Y	286	257 (134–495)	27.5 (1–915)	5	3	11
Toyomasu *et al*[54]	2018	B-I	123	191.2 ± 51.6	58.2 ± 45.3	1	0	0
		R-Y	24	244.5 ± 40.2	84.8 ± 60.9	0	0	2
Okuno *et al*[55]	2018	R-Y	159	320 ± 65	61 ± 109	4	1	NA
		B-I (β)	78	250 ± 61	70 ± 100	3	3	NA
Kim *et al*[43]	2015	B-I	165	173.4 ± 44.7	92.1 ± 92.1	3	4	NA
		B-II	371	198.7 ± 48.5	172.2 ± 130.8	2	2	NA
		R-Y	161	185.7 ± 55.5	87.1 ± 65.9	1	3	NA
Kim *et al*[56]	2017	B-II LADG	60	205.0 ± 22.4	117.2 ± 81.6	NA	NA	NA
		B-II LTDG	60	197.3 ± 40.1	100.5 ± 36.8	NA	NA	NA
Cui *et al*[57]	2017	R-Y	30	157.3 ± 33.9	89.2 ± 85.5	1	NA	NA
		B-II + Braun	26	134.6 ± 28.8	96.0 ± 89.8	0	NA	NA
In Choi *et al*[58]	2016	B-II + Braun	26	198.1 ± 33.0	161.7±146.6	NA	1	NA
		R-Y	40	242.3±58.1	245.0±207.0	NA	1	NA
Du *et al*[59]	2019	R-Y	24	203.6±26.2	168.3±83.1	0	0	2
Seo *et al*[60]	2018	Uncut R-Y	30	170.0±26.0	122.8±109.0	0	0	4
Ma *et al*[61]	2017	Uncut R-Y	51	170 (135-210)	60 (30-110)	0	0	0
Zang *et al*[62]	2018	Uncut R-Y (ERAS)	20	217.9 ± 52.5	166.1 ± 12.5	NA	0	0
		Uncut R-Y (control)	22	225.4 ± 61.7	150.9 ± 31.7	NA	0	0
Park *et al*[63]	2018	Uncut R-Y	230	185.0 [150.0; 230.0]	100.0 [50.0; 150.0]	NA	6	2
		R-Y	46	200.0 [180.0; 230.0]	100.0 [50.0; 100.0]	NA	0	3
Yang *et al*[50]	2017	Uncut Roux-en-Y	79	154.8 ± 17.8	74.1 ± 26.7	NA	NA	NA
		B-II	79	145.5 ± 15.1	74.0 ± 36.6	NA	NA	NA

NA: Not available; R-Y: Rox-en-Y reconstruction; Uncut R-Y: Uncut-Rox-en-Y reconstruction; DA: Delta-shaped anastomosis.

Stiegmann *et al*[47]. Uncut Roux-en-Y is a simple modification of the B-II with the Braun anastomosis method, in which the jejunogastric pathway is occluded with a nonbladed LS (Figure 1D). It is believed that the mechanism of uncut Roux-en-Y reconstruction can reduce Roux stagnation syndrome by preserving intestinal integrity to facilitate the conduction of myenteric impulse[48]. Park *et al*[40] reported that there was no difference in the incidence of gastritis and bile reflux between the uncut RY and RY group, while the uncut RY group significantly improved stasis compared with the RY group (5.8% *vs* 35.3%). Accordingly, uncut RY reconstruction could

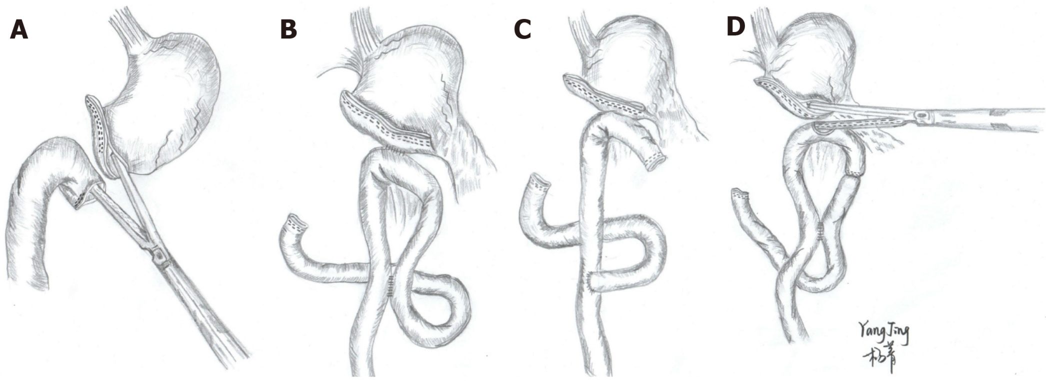

Figure 1 Schematic pictures of digestive tract reconstruction after laparoscopic distal gastrectomy. A: Billroth-I reconstruction; B: Billroth-II reconstruction with Braun anastomosis; C: Roux-en-Y reconstruction; D: Uncut Roux-en-Y reconstruction.

technically overcome the gastric stasis, which is a major drawback of RY reconstruction. However, some studies have reported that the recanalization of the uncut stapled line was relatively high, with a rate of 2.9%-13%[49,50]. Future large-scale prospective randomized clinical trials are needed to evaluate the advantages or disadvantages of uncut RY reconstruction.

DIGESTIVE TRACT RECONSTRUCTION AFTER LAPAROSCOPIC PROXIMAL GASTRECTOMY (LPG)

Proximal gastrectomy (PG) was mainly performed in patients with early GC in the upper-third of the stomach to preserve the physiological function of the remnant stomach[64,65]. Many reconstructive procedures have been reported, including esophagogastrostomy (EGS), jejunal interposition (JI)[66], jejunal pouch interposition (JPI)[67], and double tract reconstruction (DTR)[68,69]. The clinical applications of laparoscopic JI and JPI have not been popularized due to the complexity of the operations, and this review mainly focuses on the methods of EGS and DTR.

EGS is the most popular and a classical reconstruction method because it includes only one anastomosis site and is widely used worldwide. The EGS technique is similar to the esophagojejunostomy (EJS) mentioned above. It was widely recognized that the EGS procedure often leads to severe reflux esophagitis due to resection of the cardiac sphincter and some surgeons choose to perform total gastrectomy (TG)[70,71]. However, patients with early-stage GC usually have good survival outcomes and require higher QoL. Accordingly, there were some improved methods of EGS, such as gastric tube reconstruction after PG. This procedure showed advantages in the operating time and blood loss and could lead to a similar prognosis in patients compared with TG–Roux-en-Y reconstruction. More importantly, preservation of the duodenal passage could contribute to better iron uptake and may ameliorate body weight loss and nutritional status postoperatively[72]. Yamashita *et al*[73] developed a new method of side overlap with fundoplication (SOFY) for EGS that could be easily performed laparoscopically. Reflux esophagitis was rarely observed in the SOFY group (1/14) but was common in the non-SOFY group (5/16). Anastomotic stenosis was also more frequent in the non-SOFY group. One shortcoming was that the number of clinical cases using this method was too small, and a larger sample with higher levels of evidence is needed in the future to observe actual effects[74]. Double-flap (DF), also named Kamikawa's method, is another novel technical development. Briefly, a DF window with a dimension of 2.5 cm × 3.0-3.5 cm (width × height) is created at the anterior wall of gastric remnant. Next, the posterior wall of the esophagus and superior opening of the mucosa on the gastric remnant are manually anastomosed laparoscopically. The anastomotic site is finally covered by the flaps to create the anastomotic valve[74]. Obviously, DF can significantly reduce the symptoms of esophageal reflux. However, a longer operative time is needed and the anastomotic stricture rate remained in a high range from 4.7% to 17.5% in different centers. Otherwise, DF requires complicated intracorporeal suturing and leads to a longer learning curve[75-77]. Additionally, gastric retention was also common in EGS due to vagotomy, and the simple EGS was gradually replaced by other reconstruction procedures.

DTR

DTR is thought to be the best reconstruction procedure with respect to postoperative reflux esophagitis and is commonly used presently. Technically, a conventional Roux-en-Y EJS similar to TG is performed first. A side-to-side gastrojejunostomy is subsequently performed 10-15 cm below the EJS by LS (Figure 2). Reflux esophagitis can be theoretically reduced due to the interposition of the 10- to 15-cm jejunum between the remnant stomach and esophagus[58]. As reported by Aburatani *et al*[78], the DTR group (10.5%) had a lower incidence of reflux symptoms in the first year postoperatively than the EGS group (54.5%). Both EJS and EGS were completed with circular staplers (CS), and the frequency of anastomotic stenosis was also higher in the EG group (27.3% *vs* 0%) in that study[78]. The possible causes of benign anastomotic stenosis were different vascularization and erosive effects of the refluxed duodenal and gastric contents. The distance of anastomosis between gastrojejunostomy and EJS was also considered a risk factor for anastomosis-related late complications[79]. Similar to JI, the DTR procedure was also aimed to maintain gradual intestinal absorption and helped to improve QoL compared with TG. As reported by Nomura *et al*[80], the intestinal absorption and hormonal secretion in the DTR group were largely unaffected by the posture of the meal intake than JI. In the present literature, the DTR did not show a longer operation time and more blood loss. Anastomotic leakage was rarely or even not evident, the incidence of anastomotic stricture ranged from 0% to 6.67%, and the incidence of esophagitis reflux was reported from 0% to 20% (Table 2). These results indicate that DTR is a safe and feasible surgical procedure. In terms of the long-term effects, Cho *et al*[81]'s results showed similar hematologic and nutritional outcomes between the two procedures. However, other studies reported that DTR has advantages in hemoglobin change and vitamin B12 deficiency compared with laparoscopic total gastrectomy (LTG)[79,82,83]. Long-term results in a multicenter study with a larger number of patients should be evaluated in the future to fully elucidate the controversy.

As reviewed, the DTR, improved EGS, and JI methods were used to prevent reflux esophagitis. LPG with DTR maintains comparable oncological safety and anastomosis-related late complications compared with LTG and is preferred as a reasonable alternative to LTG if oncological safety is assured. However, its advantage in nutrition postoperatively remains controversial compared with LTG. Accordingly, surgeons should be aware that LPG should be strictly limited to performance under the premise of radical resection.

DIGESTIVE TRACT RECONSTRUCTION AFTER LAPAROSCOPIC TOTAL GASTRECTOMY (LTG)

The Roux-en-Y procedure is most commonly method for reconstruction between the esophagus and jejunum after LTG. EJS is difficult, and multiple intracorporeal techniques for EJS have been developed that can be divided into two categories: Those using a CS and those using an LS. Only a few reports exist concerning the hand-sewn technique for EJS, which is currently only safely performed in few high-volume centers because it is too difficult to be popularized and is not discussed in this review[87,88].

CS METHOD

Similar to conventional open TG, the CS method of EJS is completed in an end-to-side manner using a CS. In the early LTG surgeries, the anvil was inserted into the esophagus stump using the purse-string instrument[89,90] or hand-sewn method[91,92]. In addition to the improvement in the laparoscopic devices and accumulation of experience, the application of these two methods has decreased and has been gradually replaced by other methods. Presently, the maneuver of inserting the anvil is commonly performed transorally or transabdominally, referred to as the OrVil™ or reverse puncture method (RPM), respectively. The OrVil™ was first reported by Jeong *et al*[93] in 2009. Briefly, the anvil connected to the OrVil™ tube was transorally introduced into the esophagus (Figure 3A) and intracorporeal EJS was consecutively performed with a CS through a minilaparotomy incision that was used to remove the stomach (Figure 3D). The RPM is another common method that was first reported by Omori *et al*[94] in 2009. The main steps of this procedure are as follows: Semicircumferential esophagotomy is performed at the anterior esophageal wall and the anvil secured with a prolene suture that is then inserted into the esophagus.

Table 2 Summary of reconstruction procedures after laparoscopic proximal gastrectomy

Ref.	Publication year	Reconstruction procedure	n	Length of surgery, min (mean ± SD or range)	Blood loss, mL (mean ± SD or range)	Esophagitis reflux (n)	Anastomotic leakage (n)	Anastomotic stricture (n)
Nomura et al[80]	2019	DTR	15	352.5 ± 67.3	90.5 ± 105.5	1	0	1
		JI	15	322.5 ± 24.2	46.8 ± 69.8	1	0	1
Aburatani et al[78]	2017	DTR	19	325.7 ± 66.9	131.4 ± 118.7	2	0	0
		EGS	22	290.3 ± 55.1	132.0 ± 129.7	12	0	6
Tanaka et al[84]	2017	DTR	10	285 (146–440)	0 (0–25)	20	0	0
Yang et al[85]	2015	DTR	16	219.6 ± 48.6	101.5 ± 71.6	0	0	0
Hong et al[86]	2015	DTR	21	173.8 ± 21.8	109.2 ± 96.3	1	0	0
Cho et al[81]	2018	DTR	38	217.7 ± 53.0	100.2 ± 92.0	0	1	0
		TG	42	226.9 ± 66.2	118.8 ± 157.2	3	4	2
Park et al[82]	2018	DTR	34	212.9 ± 32.6	30 (6-600)	NA	NA	NA
		TG	46	240.7 ± 43.9	59 (20-85)	NA	NA	NA
Jung et al[79]	2017	DTR	92	198.3 ± 38.8	84.7 ± 81.7	1	2	3
		TG	156	225.4 ± 51.6	128.3 ± 112.5	3	3	2
Kim et al[83]	2016	DTR	17	268.2±40.9	NA	2	0	0
		TG	17	270.2±43.4	NA	1	0	1

NA: Not available; TG: Total gastrectomy; EGS: Esophagogastrostomy; JI: Jejunal interposition; DTR: Double tract reconstruction.

Thereafter, the needle is reversely sutured out and the center rod of the anvil penetrates the esophageal wall by drawing the suture (Figure 3B and C). Finally, the esophagus is transected using a linear cutter, and EJS is achieved with a CS under laparoscopic monitoring.

The CS method has been widespread, especially in the introductory period, because it is similar to the conventional open surgeries. CS also has other merits compared with LS, such as no requirement for intracorporeal suturing and excessive esophageal dissociation[95]. Comparing the two CS methods, the device of OrVil™ is easier and very convenient to perform intracorporeal EJS. Otherwise, the RPM needs laparoscopic suturing and more esophagus may be sacrificed[96]. In terms of the surgical outcomes and postoperative course, no significant difference was found in the surgical time and blood loss between OrVil™ and RPM, and the incidence of anastomotic leakage was also similar. However, the incidence of anastomotic stricture was higher when performing OrVil™, ranging from 0% to 8.3% (Table 2)[97-100]. As reviewed by Inokuchi *et al*[101], the incidence was decreased compared with the results from early surgeries. This progress might be attributed to the standardization of the procedures and accumulation of skills to use the OrVil™ device. Additionally, the anastomotic complications might be related to the insertion site in the abdominal wall for CS[102]. However, higher cost, possibility of bacterial contamination, and injury of the esophageal mucosa are important factors limiting the popularity of the OrVil™ method[96,103]. Many surgeons, including the authors, would choose the RPM after mastering laparoscopic techniques. The determination of the CS method should be selected by the preference and experience of the surgeons.

As described, all CS require a mini incision to finally complete the EJS, and these CS methods are actually laparoscopic-assisted surgeries. Furthermore, it is sometimes difficult to complete anastomosis through this mini incision, especially in obese patients. Additionally, in patients with a small esophageal diameter, the CS method is extremely difficult and would increase the risk of anastomotic complications that could be overcome by LS methods.

LS METHOD

The LS methods are total laparoscopic surgeries because EJS is completed in a side-to-side manner using a LS without any assisted incisions. The main procedures include functional end-to-end anastomosis (FEEA), overlap method, and π-type anastomosis. The FEEA method, also called "inverse-peristaltic anastomosis", was first reported by Uyama *et al*[104] in 1999. First, the distal jejunum loop is pulled to the left side of the

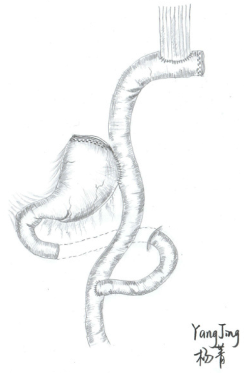

Figure 2 Schematic picture of double tract reconstruction after laparoscopic proximal gastrectomy.

esophageal stump after lymphadenectomy. A functional side-to-side anastomosis is subsequently completed with an LS *via* the stump of the esophagus and jejunum (Figure 4A). The common entry hole is finally closed by LS. The overlap method proposed by Inaba *et al*[105] in 2010 is similar to FEEA. The hole used for overlap anastomosis is not opened at the jejunal stump, and side-to-side anastomosis is completed along the peristaltic direction of the esophagus (Figure 4B). Another difference from FEEA is the closure of the common entry hole that is performed *via* an intracorporeal suture. The π-type anastomosis is an improvement of FEEA. Technically, neither the esophagus nor the jejunum is transected, and a side-to-side EJS is performed with an LS. The esophageal division, common entry hole closure, and jejunal division are subsequently performed using a single 60-mm LS (3-in-1 technique) (Figure 4C)[106].

Comparing these three LS methods, FEEA is time-saving because the common entry hole can be closed with an LS. However, the jejunal limb needs to be lifted further up when performing FEEA, and this step might lead to the tension of the jejunal limb of the mesentery, which might increase the risk of anastomotic leakage[107]. Second, the procedure of FEEA needs more working space than overlap as the jejunum is folded up when performing anastomosis (Figure 4A). No significant difference was found between the two methods in terms of actual anastomotic complications (Table 2). However, the anastomotic oral end tended to have greater tension, which was the high incidence site of anastomotic leakage. Moreover, this site is located in the mediastinum, and it is difficult to strengthen by laparoscopic suture. Accordingly, surgeons should pay more attention to this point, especially for beginners. The surgical procedure is simplified, and the surgical time is reduced by performing π-type anastomosis. However, the largest deficiency of this method is that the margin could not be checked until the reconstruction is completed, limiting its popularity.

Compared with the CS method, LS method shows some merits in surgical outcomes (Table 3): Being time-saving and less blood loss[108-110], with fewer intraoperative events and intraoperative anastomosis events[109]. Regarding anastomotic complications, LS methods seem to have less anastomotic stricture[97,111,112]. Additionally, LS can be performed in the narrow mediastinum because the tips are thinner and can achieve a suitable anastomotic size regardless of the esophageal diameter. Furthermore, the rotary connecter of LS enables the LS method to be performed in real time to reduce the jejunal tension by changing the anastomotic position and direction to improve the quality of anastomosis. Therefore, the LS methods have been favored by more surgeons in the past few years.

CONCLUSION AND PROSPECTS

Almost all the literature included in this review originated from the East and was mainly reported from Japan and Korea. This highlights the prominent position of these two countries in the field of GC treatment, while Western surgeons have less experience in treating GC laparoscopically due to the low incidence and respectability[113]. The results of the RCTs[9,11,12] mentioned above were expected to establish concrete evidence of widely carried out LG in the treatment of AGC. Therefore, LG will encounter a period of rapid development, and controversy concerning reconstruction is expected to be resolved by large-scale and multicenter RCTs in the near future.

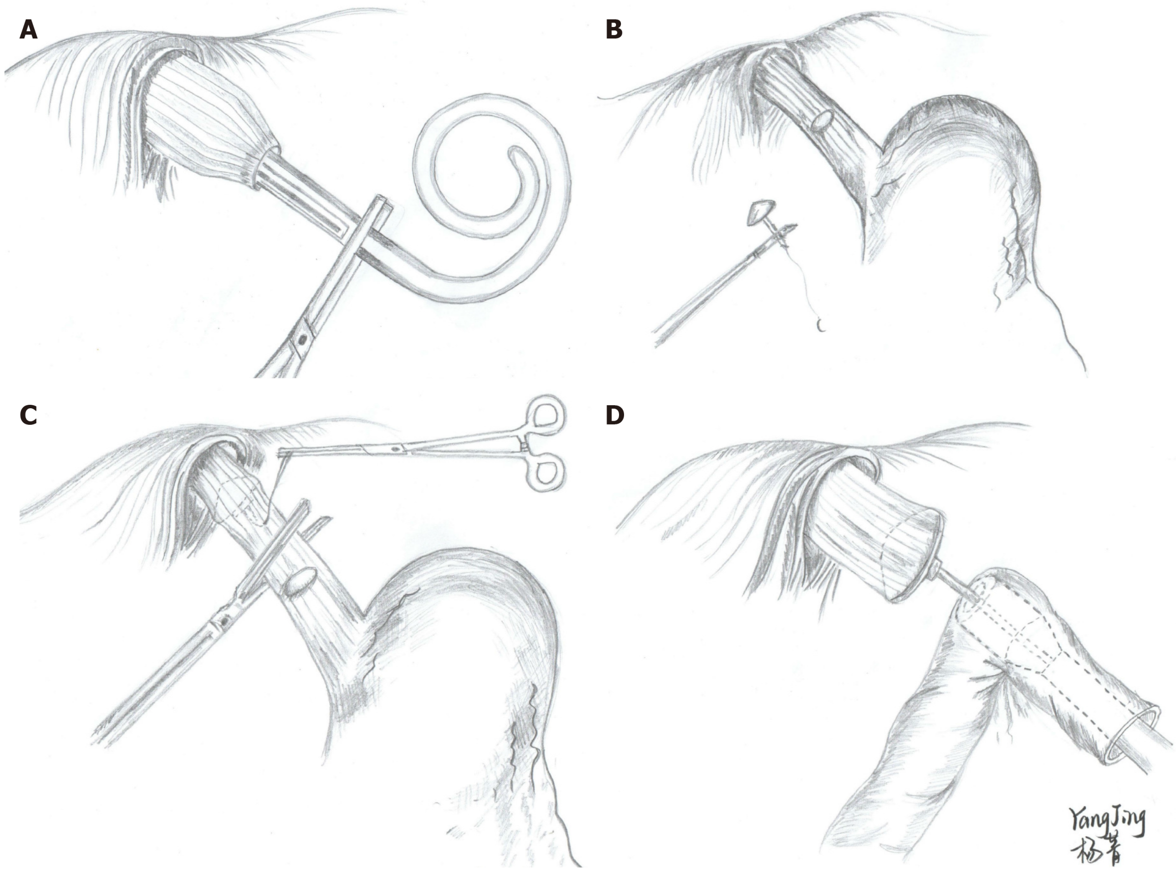

Figure 3 Esophagojejunostomy *via* circular stapler methods. A: OrVil™; B: Semicircumferential esophagotomy performed at the anterior esophageal wall (reverse puncture method); C: The center rod of the anvil penetrates the esophageal wall by drawing the suture; D: Esophagojejunostomy accomplished with a circular stapler under laparoscopic monitoring.

In conclusion, the choice of specific reconstruction method remains unclear presently, and surgeons must understand the merits and demerits of every anastomotic device and procedure. Under the premise of radical gastrectomy and lymphadenectomy, a reasonable reconstruction procedure should be selected to improve the QoL postoperatively by considering the following factors: Safety (anastomosis with sufficient blood supply and free tension), efficiency (simple and time-saving), minimal invasion (less blood loss), stability (surgeon's preference and experience), and QoL (function preservation, if possible, reflux prevention, and nutrition).

Table 3 Summary of reconstruction procedures after laparoscopic total gastrectomy

Ref.	Publication year	LS or CS	EJS procedure	N	Length of surgery, min (mean ± SD or range)	Blood loss, mL (mean ± SD or range)	Anastomotic leakage (*n*)	Anastomotic stricture (*n*)
Tokuhara *et al*[99]	2018	CS	OrVil™	24	NA	NA	1	2
Brenkman *et al*[114]	2016	CS	OrVil™	47	301 (148–454)	300 (30–900)	7	NA
Ali *et al*[115]	2016	CS	RPM	58	199.8 ± 57.0	81.6 ± 40.3	3	5
Wang *et al*[96]	2015	CS	OrVil™	42	287.8 ± 38.4	96.4 ± 32.7	0	2
			RPM	42	271.8 ± 46.1	88.2 ± 36.9	1	2
Li *et al*[103]	2017	CS	OrVil™	19	NA	NA	0	1
			RPM	24	NA	NA	1	0
Lu *et al*[98]	2016	CS	OrVil™	25	216.5 ± 24.9	141.2 ± 121.1	0	0
			LATG-PSI	25	224.0 ± 30.5	138.8 ± 79.9	0	0
Duan *et al*[116]	2017	CS	End-to-side EJS	176	250.0 ± 54.1	114.1 ± 74.0	7	11
			Semi-end-to-end EJS	92	238.0 ± 50.4 0.079	110.5 ± 82.8	1	0
Kyogoku *et al*[108]	2018	CS	OrVil™ / RPM	83	330 (123–627)	100 (0–1108)	3	6
		LS	FEEA/overlap	208	297 (171–553)	23 (0–1070)	4	7
Lee *et al*[117]	2017	LS	Overlap	50	144.6 ± 29.9	NA	0	0
Son *et al*[118]	2017	LS	Overlap	27	171.1 ± 50.9	119.4 ± 107.1	0	0
Kitagami *et al*[119]	2016	LS	Overlap	100	379 (248–649)	65 (5–750)	0	0
Miura *et al*[107]	2017	LS	FEEA	120	350.8	0	2	1
			Overlap	48	402.5	6.5	3	0
Yoshikawa *et al*[112]	2018	CS	OrVil™	36	345 ± 9.9	45 ± 15	0	3
		LS	Overlap	47	398 ± 8	126 ± 13	2	0
Kawamura *et al*[97]	2017	CS	OrVil™	49	259.5 ± 51.4	53.3 ± 70.0	2	2
		LS	Overlap	139	276.5 ± 53.0	69.7 ± 116.6	1	0
Yasukawa *et al*[100]	2017	CS	OrVil™	51	346.1 ± 52.7	34 (10-556)	2	0
		LS	FEEA	18	348.4 ± 53.5	35 (10-750)	0	1
Gong *et al*[109]	2017	CS	NA	266	170 (65-453)	NA	15	3
		LS	NA	421	149 (75-342)	NA	15	2
Huang *et al*[110]	2017	CS	NA	456	203.6 ± 49.3	98.4 ± 149.1	22	4
		LS	IJOM (overlap)	51	209.3 ± 41.0	48.3 ± 38.5	1	0
Chen *et al*[111]	2016	CS	RPM	18	305.6 ± 45.9 (250-380)	80.6 ± 29.4 (50-160)	1	1
		LS	FEEA	22	266.8 ± 38.7 (230-360)	86.4 ± 39.7 (50-200)	0	0
Kim *et al*[120]	2016	CS	PSI	29	230.3 ± 56.5	106.3 ± 70.3	0	1
		LS	Overlap	27	228.9 ± 33.6	90.9 ± 46.0	1	0
Chen *et al*[88]	2016	CS + LS	CS + LS	40	284.3 ± 45.6 (230–380)	83.8 ± 35.2 (30–200)	1	3
			Hand-sewn	59	257.4 ± 47.2 (170–350)	87.6 ± 42.4 (30–200)	0	0

CS: Circular stapler; LS: Linear stapler; RPM: Reverse puncture method; EJS: Esophagojejunostomy; FEEA: Functional end-to-end anastomosis; PSI: Purse-string instrument; IJOM: Isoperistaltic jejunum-later-cut overlap method; NA: Not available.

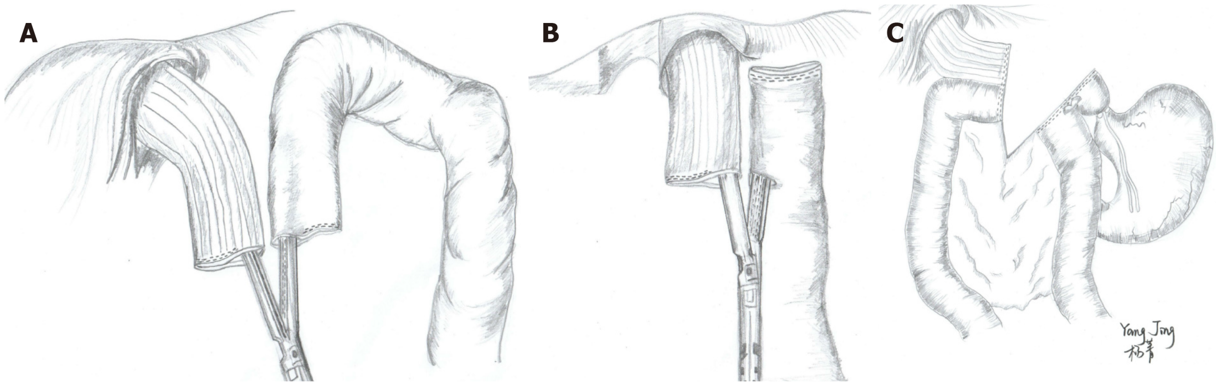

Figure 4 Esophagojejunostomy *via* linear stapler methods. A: Functional end-to-end anastomosis; B: Overlap; C: π-type anastomosis.

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