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Function-preserving surgery in gastric cancer: current evidence and implications for the West

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Abstract

Background Gastric cancer remains a significant global health challenge. Surgical resection continues to be the cornerstone of treatment, but traditional gastrectomy is often associated with negative impacts on nutritional status and quality of life. Function-preserving surgical techniques, widely adopted in East Asian countries due to early cancer detection, have shown promise in improving postoperative outcomes. In contrast, Western guidelines have yet to integrate these procedures into routine practice.

Main body Function-preserving surgeries, including pylorus-preserving gastrectomy and proximal gastrectomy, aim to maintain gastric function while ensuring oncological safety. These procedures are primarily indicated for early gastric cancers and have demonstrated comparable survival outcomes to standard resections in well-selected patients. Endoscopic resections and segmental gastrectomy represent additional function-sparing options under investigation. The main functional complications, such as gastric stasis or reflux esophagitis, have prompted the development of various reconstructive techniques, including double-tract methods, jejunal interposition, and pouch reconstructions. Despite their proven benefits in Eastern countries, the implementation of these surgeries in Western settings is limited. Challenges include the lower incidence of early gastric cancer, lack of surgeon experience, and absence of guideline endorsement. However, increased centralization of care, enhanced diagnostic accuracy, and growing emphasis on patient-reported outcomes have reignited interest in adapting these strategies for Western populations. Additionally, emerging evidence suggests that even patients with more advanced disease may benefit from improved short-term functional outcomes, potentially aiding in faster recovery and return to adjuvant therapies.

Conclusion Function-preserving surgery in gastric cancer offers oncologically safe alternatives that may significantly improve postoperative quality of life and nutritional outcomes. As global treatment paradigms evolve, adapting these techniques in the West, particularly within high-volume centers, could represent a significant step forward. Further randomized trials and Western-centric data are essential to validate the broader applicability of these procedures and refine patient selection criteria.

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Introduction

Gastric cancer (GC) ranks as the fifth most common malignancy globally and the fifth cause of cancer death, with an estimated 968,000 new cases diagnosed per year [1]. The incidence of GC varies greatly among countries, with the highest number of cases registered in Eastern Asia and Eastern European regions. Incidence and mortality are highly correlated, reflecting poor overall survival despite the improvements in multimodal treatment strategies across the World [2]. Surgical resection remains the cornerstone of treatment for GC patients. Despite different reconstructive procedures have been proposed, gastrectomy is still aggravated by a considerable impact on global quality of life (QoL) [3]. Therefore, one of the greatest challenges in GC surgery is to guarantee an appropriate function of the residual organ after resection with no impact on the oncological radicality of the procedure. In the East, given the higher incidence of early gastric cancer (EGC), function-preserving surgery for GC patients have been increasingly performed in order to minimize the impact of gastrectomy on QoL. In western countries, treatment strategies for gastric cancer have been traditionally tailored on the more advanced stage at diagnosis, as well as on differences in cancer biology and therapeutic quality [4]. Consequently, the evidence on function-preserving surgery has been predominantly generated in Eastern populations, which represents a limitation when extrapolating these findings to Western contexts with distinct epidemiological patterns, lower EGC incidence, and different treatment paradigms.

The topics of QoL and function-preserving surgery are currently not addressed in the western cancer treatment guidelines as safe and reproducible strategies for the population of patients with GC. However, due to the increasing globalization of the principles of treatment for GC and to drive toward centralization in high-volume centers, there has been renewed attention to the principles to function-preserving surgery in the West. In this context, it could be useful to review the existing function-preserving surgical strategies for the treatment of GC and to determine the patients that could benefit the most from the application of these techniques. In this study, we discuss the current indications and the different procedures of function-preserving surgery for gastric cancer in the East and their implications for the Western clinical practice. Specifically, this review aims to offer (i) a focused synthesis of function-preserving procedures and reconstructions with attention to external validity in Western settings; (ii) a critical appraisal of oncologic safety signals versus functional benefits across techniques; and (iii) a framework highlighting gaps that require contemporary Western primary data.

Methods

For this narrative review, we performed a structured literature search of PubMed using terms related to "gastric cancer" AND "function-preserving surgery," "proximal gastrectomy," "pylorus-preserving gastrectomy," "segmental gastrectomy," and "jejunal pouch". Randomized trials, observational studies, meta-analyses, narrative reviews, and guidelines reporting oncologic or functional outcomes of PPG, PG, SG, or TG-pouch reconstructions were included. Study selection followed title/abstract and full-text screening, with emphasis on original studies comparing function preserving and historical techniques, and relevance to Western clinical practice.

Function preserving procedures

Functional procedures were first introduced after resections for benign lesions of the stomach that did not require lymph node dissection and have been increasingly investigated in cancer surgery to provide improved nutritional and functional outcomes, preserving an adequate quality of life (QoL) after gastric resection. In the East, thanks to screening programs and improved diagnostic techniques, early gastric cancers (EGCs) are being increasingly diagnosed and function-preserving surgery is currently routinely performed for EGC of the body and proximal stomach as well as and Siewert II/III esophagogastric junction cancers [5].

Several function-preserving procedures have been described according to the tumor location and indications for surgery, with proximal gastrectomy (PG) and pylorus-preserving gastrectomy (PPG) representing the two main functional resections as an alternative to total gastrectomy and distal gastrectomy (DG), respectively, for early gastric cancers with specific characteristics. Eastern guidelines also define in parallel the different extent of the lymphadenectomy that should be performed according to the tumor staging and location for each of these techniques. While the oncological safety associated with PPG and PG has been demonstrated for specific subgroups [6, 7], there has been a drive towards investigating a possible expansion of these indications.

Segmental gastrectomy is considered an investigational treatment for cancers of the middle and high gastric body and oncological results are still awaited from large series and trials.

Endoscopic resections

Endoscopic resections (i.e. Endoscopic Mucosal Resection - EMR, and Endoscopic Submucosal Dissection - ESD) are considered as treatment options for EGC when the tumor is feasible of complete removal with the procedure and the harbouring of lymph node metastasis is negligible (less than 1%). Such tumors are identified by the Japanese Gastric Cancer Treatment Guidelines as most

of those clinically diagnosed as T1a: differentiated-type carcinomas without ulcerative findings of any dimension, differentiated-type carcinomas with ulcerative findings of a diameter up to 3 cm, and undifferentiated carcinomas without ulcerative findings with a diameter up to 2 cm. Expanded indications for endoscopic resection also include selected locally recurred T1a differentiated carcinomas. After endoscopic resection, the curative outcome of the procedure is assessed by the eCURA classification that takes into account the state of resection margins, tumor size and the presence of lymphovascular invasion, and the following treatments are codified accordingly [8, 9]. Conversely, the European Society of Medical Oncology guidelines suggest more conservative criteria for endoscopic resection, with absolute indication only for cT1a differentiated, non-ulcerated carcinomas with a diameter up to 2 cm, and cautious consideration for expanded criteria [10, 11].

Treatment of distal GC: pylorus-preserving gastrectomy (PPG)

Pylorus Preserving Gastrectomy (PPG) is currently indicated in the Japanese and Korean guidelines for early gastric cancers of the middle gastric body located > 4 cm from the pylorus. It is associated to a D1 or D1 + gastrectomy (D1: stations 1, 3, 4sb, 4d, 6 (possibly preserving 6i – infrapyloric nodes), 7; D1+: D1 + stations 8a, 9.) [5, 9, 12]. This procedure has demonstrated similar oncological outcomes compared to the standard distal gastrectomy [13], decreasing functional complications such as dumping syndrome, bile reflux, and gallstone formation [14].

The oncological safety of PPG compared with DG has been demonstrated, among others, by a large multicenter propensity score-matched cohort study in Japan. Results from this study, which included 1004 patients with stage 1 GC, showed no significant differences in overall survival (OS) and relapse-free survival (RFS) between PPG and DG after matching (OS hazard ratio 0.475–95% confidence interval – 0.207–1.089; $P = 0.07$ and RFS hazard ratio – 95% confidence interval 0.116–1.331 - $P = 0.12$). The lymph-node dissection was conducted according to the Japanese Gastric Cancer Guidelines, and the preservation of the infrapyloric vessels and abdominal branch of the vagal nerve was left to the surgeon's judgement. Station 5 lymph nodes were not dissected to allow the preservation of the right gastric vessels and part of station 6 (6i) was not dissected to preserve the infrapyloric artery. Since the number of patients treated for N1 and and T2 cancers in the study was small and not sufficient to address the oncological risks of PPG, the authors conclude that the procedure should be restricted to T1N0 gastric cancer [15]. This also contributes to highlight that one of the main criteria for adoption of PPG is clinical, while a pathologic T1N0 may only be known after surgery. In patients with unexpected N1 disease after PPG, the value of completion pyloric resection is still unknown. A meta-analysis of long-term oncological outcomes in 16 studies including 4500 patients with EGC found no differences in the overall survival and relapse-free survival between PPG and DG patients (OS HR = 0.63; 95% CI 0.24 to 1.67; $P = 0.852$ and RFS HR = 0.29; 95% CI 0.03 to 2.67; $P = 0.900$, respectively), with less lymph nodes harvested and shorter resection margins in the PPG group [16].

The main functional complication after PPG is represented by gastric stasis [17]. In order to prevent gastric stasis, the technique has been modified increasing the length of the antral cuff and preserving the infra-pyloric vessels and the hepatic branch of the vagus nerve [18]. Namikawa et al. identified the length of the gastric cuff as a crucial factor in reducing change in body weight, dissatisfaction at the meal, and dissatisfaction for daily life after surgery while others noted that preserving the infra-pyloric vein during PPG is helpful in reducing gastric stasis, the most common complication after PPG [19, 20]. It is still unclear whether preserving the pyloric and hepatic branches of the vagus nerve results in reduction of gallstones formation after PPG, as suggested in a 2009 comparative study by Tomita [21].

In the multicenter randomized KLASS-04 trial comparing laparoscopic PPG (LPPG) and laparoscopic DG (LDG), 256 cT1 N0 GC patients underwent either LPPG or LDG in nine high-volume centers; short-term complications were comparable between the two techniques, with the exception of pyloric/anastomotic stenosis that occurred in 7.4% of LPPG and 1.5% of LDG ($P = 0.026$). The authors concluded that even if those techniques have similar complication rates, whether LPPG is associated with decreased dumping syndrome, bile gastritis and gallstone formation remain to be determined. The number of lymph nodes retrieved, and proximal and distal resection margins showed no significant differences between LPPG and LDG [22]. Recently, the long-term results of KLASS-04 have been published, reporting no difference in 3-year overall survival and disease-free survival (1 case of recurrence in each group, $P = 0.98$), in the 1-year incidence of dumping syndrome (13.2% in LPPG vs. 15.8% in LDG, $P = 0.622$), in the body weight variation and in postoperative quality of life. LPPG was associated to lower gallstone formation (2.33% vs. 8.66%, $P = 0.026$), higher hemoglobin (+ 0.01 vs. −0.76 gm/dL, $P < 0.001$) and serum protein (−0.15 vs. −0.35 gm/dL, $P = 0.002$), while the incidence of reflux esophagitis (17.8% vs. 6.3%, $P = 0.005$) and grade IV delayed gastric emptying (16.3% vs. 3.9%, $P = 0.001$) was lower in LDG [23].

Finally, two retrospective functional studies supported the role of PPG, demonstrating improved quality of life and a lower incidence of postgastrectomy syndrome

compared to LDG [24, 25]. Table1 shows the main studies testing the oncological and functional outcomes of PPG.

Treatment of proximal GC

Proximal gastrectomy (PG)

Oncological safety and indications Total gastrectomy (TG) with D2 lymphadenectomy has been considered the standard procedure for cancer of the upper third of the stomach and esophago-gastric junction carcinomas (EGJC). However, recent studies have demonstrated the oncological safety of proximal gastrectomy for early gastric cancers and its application is cautiously under investigation for more advanced cancers [25–29]. The D2 lymphadenectomy in PG involves retrieval of stations 1, 2, 3a, 4sa, 4sb, 7, 8a, 9, 11p and 11 d, while sparing stations 5, 6 and 12a. This approach is supported by the low incidence of metastases in supra- and infra-pyloric nodes in selected cases and by the feasibility of adequate dissection in high-volume centers [30].

According to Japanese guidelines [9], PG may be considered for EGC when at least half of the stomach can be preserved. For more advanced GC (i.e., T2 or higher) cancers of the upper third of the stomach, the role of PG is yet to be established. Concerns include the relatively high incidence of local recurrence, often in the remnant stomach or anastomosis, highlighting the importance of careful margin assessment [31]. In a recent large multicenter Japanese study, the incidence of lymph node metastases for T2-4 EGJC was found to be less than 5% when the tumor extension into the esophagus was less than 2 cm and the diameter was less than 6 cm [32]. Some authors propose that T2 cancers < 4 cm have a negligible risk of lymph node metastases in stations number 4, 5, 6 and 12, making PG feasible in this subgroup [33]. The hypothesis has been encouraged by results from other studies that demonstrated that lymph node dissection at these stations has extremely low therapeutic indexes (i.e. the relation between the frequency of metastasis at a determined site and the 5-year survival) and no survival benefit for T2-3 cancers [28, 34]. Conversely, risk factors such as mid-lower body infiltration, tumor size > 7 cm, Borrmann type IV, and serosal invasion contraindicate PG 24. Tang et al. compared the outcomes of 4831 patients with locally advanced proximal GC who underwent PG and TG after neoadjuvant therapy or as an upfront strategy, using the American College of Surgeons (ACS) National Cancer Database. Locally advanced cancers were defined > = T2 or N + at the clinical or pathological staging. Metastatic gastric cancers were excluded from the analysis. The PG group was more likely to have R0 resection and well or moderately differentiated tumor grade, whereas the TG group was more likely to have

Table 1 Main studies testing the oncological and functional outcomes of PPG

Study author, year	Design	Patients		Intervention and comparison	Outcomes	Outcomes (detail)	Results
Kong et al., 2009 [13]	*retrospective*	*PPG 64*	*DG 1380*	*PPG vs. DG*	*Lymph node harvesting*	*Mean number of retrieved nodes*	*Number of retrieved lymph-nodes in* *- station 5: PPG 0.19 vs. DG 0.8 p = 0.001* *- station 6: PPG 4.84 vs. DG 5.1, p = 0.528*
Aizawa et al., 2016 [15]	*retrospective, PSM*	*PPG 502*	*DG 502*	*PPG vs. DG*	*Oncological outcomes in EGC surgery*	*5-year survival rate*	*No significant difference. PPG 98.4%, DG 96.6%.*
Hosoda et al., 2017 [24]	*restrospective, PSM*	*PPG 32*	*DG 32*	*PPG vs. DG*	*QoL in EGC surgery*	*PGSAS-45 scale*	*PPG > DG for dumping symptoms and abdominal pain* *DG > PPG for acid reflux symptoms*
Park et al., 2021; Lee et al.2025 [22, 23]	*multicenter RCT*	*PPG 124*	*DG 129*	*PPG vs. DG*	*Postoperative complications. Survival and recurrence. Nutritional parameters. Functional results. Postoperative quality of life.*	*30-day morbidity and 90-day mortality.* *Primary outcome: Dumping syndrome at 1 year* *Secondary outcomes (at 3 years):* *- Overall and disease-free survival.* *- Hemoglobin, serum proteins* *- reflux esophagitis (endoscopic finding).* *- QOL measured by EORTC-QLQ30 and STO-22*	*No significant difference in:* *- morbidity and mortality.* *- dumping syndrome at 1 year.* *– 3-Y overall and disease-free survival.* *- changes in body weight and postoperative quality of life.* *Gallstone formation lower in LPPG (P = 0.026). Hemoglobin (P < 0.001) and serum protein (P = 0.002) significantly preserved after LPPG. Reflux esophagitis (P = 0.005) and grade IV delayed gastric emptying (P = 0.001) more common in LPPG.*
Huang et al.,2020 [25]	*retrospective*	*PPG 40*	*DG 51*	*PPG vs. DG*	*Quality of life*	*EORTC-QLQC30 and STO22*	*Better QoL after PPG*

more lymph nodes retrieved and lymph node metastasis. No difference was noted among the two groups in terms of short-term surgical outcomes. The long-term survival analysis showed a longer OS of the PG group (HR = 1.13, 95% CI: 1.03–1.25; p = 0.0109). Among patients who underwent TG, preoperative chemotherapy (HR = 0.74, 95% CI: 0.59–0.92; p = 0.0078) was associated with improved survival compared to surgery alone, while adjuvant therapy was associated with improved OS compared to surgery alone in the PG group (HR = 0.70, 95% CI: 0.52–0.92; p = 0.0114). The interpretation of these results is not straightforward, given a high likelihood of indication bias in this retrospective study. The authors however suggested that PG could be a reasonable extent of resection for locally advanced gastric cancer, even though TG still leads to better survival benefits after neoadjuvant treatment [35]. In a multicenter retrospective propensity score-matched cohort study, Yuan et al. analysed the postoperative and oncological outcomes in patients that underwent TG and PG after neoadjuvant treatment between 2009 and 2022, finding no differences in postoperative major complication rates (21.3% vs. 17.5%, P = 0.689), 5-year OS (66.0% vs. 68.4%, P = 0.881) and 5-year RFS (61.9% vs. 64.8%, P = 0.571) [36]. These results await confirmation from randomized clinical trials.

Functional outcomes and technical considerations As a function-preserving procedure, PG resulted in reduced postoperative weight loss and higher total serum proteins value when compared with TG in two cohort studies. The authors suggested a role of the preservation of the gastric fundic gland region in PG, leading to sustained gastric-acid secretion and preserved production of Castle intrinsic factor and ghrelin, that would reduce iron and vitamin B12 malabsorption and preserve appetite [37, 38]. Furthermore, another study suggested that a lower incidence of dumping symptoms detected after PG might contribute to a lower incidence of anorexia and improved QoL [39]. Reflux esophagitis is the main functional complication after PG, given the preserved acid production of the antral region and the absence of the cardia [40]. To prevent reflux esophagitis, different techniques have been proposed to lower the incidence of this complication. The main reconstruction options after PG are represented by esophago-gastrostomy and esophago-gastrostomy with double flap technique, jejunal interposition, jejunal pouch interposition and double tract method. Table 2 synthesises the main investigating the oncological and functional outcomes of PG.

Esophago-gastrostomy (EG) Esophago-gastrostomy (EG) consists of one anastomosis and allows the assessment of the gastric stump during follow-up endoscopies. It is currently the most common technique used in Japanese institutions. The main functional complication after this procedure is represented by gastro-esophageal reflux leading to esophagitis, with an incidence that varies from 4.5% to 28.6%[40]. For that reason, anti-reflux procedures such as the double flap technique are performed after PG and esophagogastrostomy.

Table 2 – Main studies testing the oncological and functional outcomes of PG

Study author, year	Design	Patients			Intervention	Outcomes	Results
Nozaki et al., 2013 [41]	*retrospective*	*PG* 102		*TG* 49	*PG with JI vs. TG for cT1-2 GC*	*OS and late complications*	*No difference in OS, better body weight maintenance in the first three years after PG.*
Jung et al.,2017 [29]	*retrospective*	*LPG* 92		*LTG* 156	*Proximal gastrectomy with double tract reconstruction vs. Total gastrectomy in EGC*	*Short and long-term clinical outcomes*	*No significant differences in complications, reflux symptoms or survival between the groups. The LPG group had a shorter operative time and lower estimated blood loss than the LTG group ($p < 0.001$ and $p = 0.001$ respectively). Hemoglobin change significantly lower in the LPG group in the first and second postoperative years ($p = 0.004$ and $p = 0.002$, respectively), lower mean amount of vitamin B12 supplements 2 years after operation in the LPG group ($p < 0.001$).*
Masuzawa et al.,2014 [42]	*retrospective*	*TGRY* 122	*PGEG* 49	*PGJI* 22	*TGRY vs. PG with EG or JI reconstruction in upper EGC*	*Short term complications and long-term nutritional status*	*No difference in postoperative complications, better nutritional status after PG.*
Katai et al.,2019 [7]	*prospective non-randomized confirmatory trial*	*PG* 49		*TG* 195	*Laparoscopic PG and TG for stage 1 GC with lymph node dissection*	*Safety of LAPG and LATG for stage I GC. Primary outcome: anastomotic leak*	*LAPG and LATG safe and feasible for Stage I GC. No difference in postoperativecomplications between LAPG and LATG*
Yuan et al.,2024 [36]	*retrospective, PSM*	*PG* 80		*TG* 80	*PG vs. TG for stage 1–3 GC after NACT*	*OS, DFS, postoperative complications*	*No difference between PG and TG.*
Yamasaki et al., 2021 [43]	*multi-center cross-sectional study*	*PG* 159		*TG* 93	*PG vs. TG for early gastric cancer*	*%BWL at 1 year after surgery*	*Lower %BWL in PG patients with higher incidence of reflux esophagitis.*

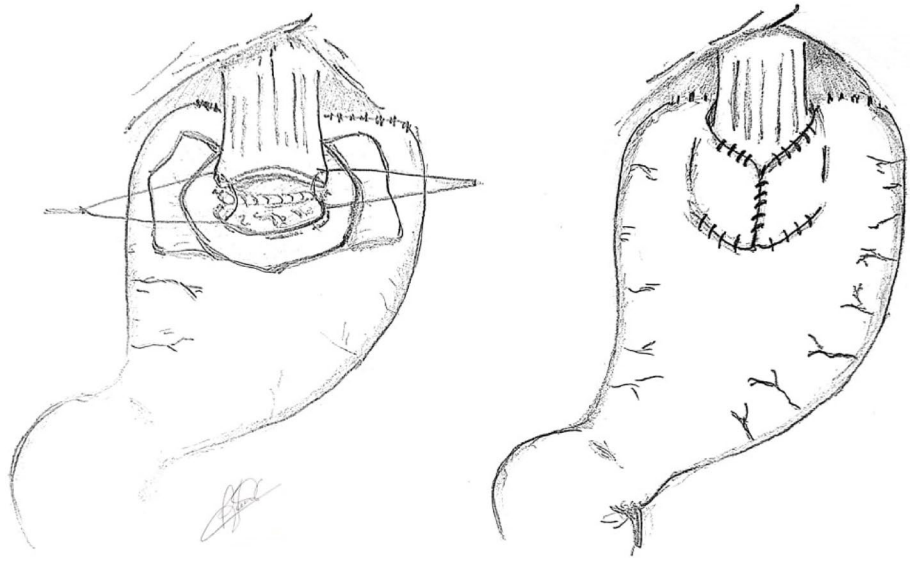

Fig. 1 Esophagogastrectomy with double flap reconstruction after proximal gastrectomy. The figure shows the fashioning of the anastomosis

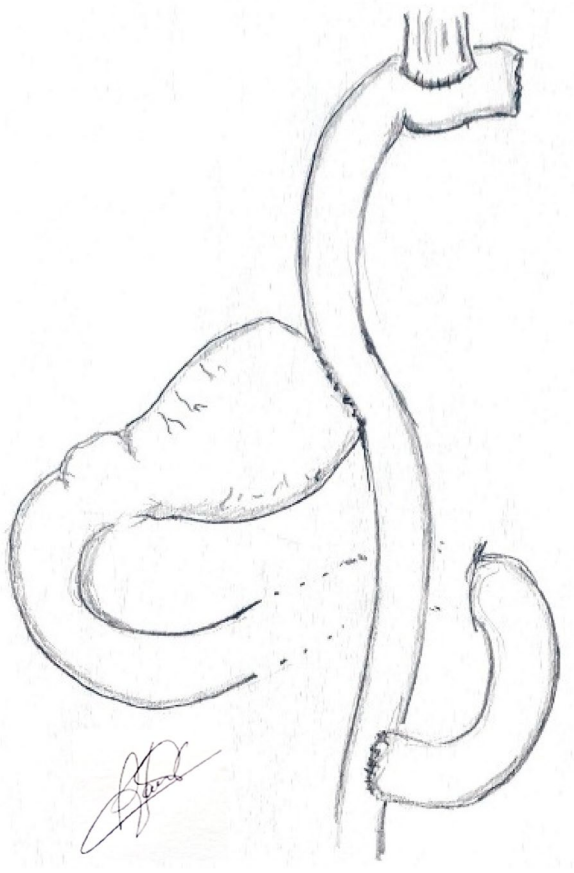

Fig. 2 Double tract reconstruction method after proximal gastrectomy. The figure shows the reconstruction with the esophago-jejunal anastomosis, the jejuno-gastric anastomosis, and the jejuno-jejunal anastomosis

Esophago-gastrostomy with double-flap technique (DFT) This procedure was proposed in 1998 by Kimikawa as an anti-reflux technique after PG. After proximal gastrectomy, an H-shaped incision is performed on the gastric stump to dissect the seromuscular layer on the site of the EG [44, 45]. The esophagus is then fixed at the edge of the seromuscular dissection and the anastomosis is performed with interrupted sutures or running sutures. The anastomotic site is covered by the seromuscular flaps to include the lower esophagus in order to fashion the valvuloplasty (Fig. 1). With this technique, the reported incidence of reflux esophagitis of all grades reaches 10.6% and 6% for grade B or higher esophagitis. To date, DFT is mainly performed by a hand-sewn technique requiring a mini-laparotomy and can be challenging when performing a totally minimally-invasive procedure, especially when the anastomosis needs to be fashioned in the mediastinum. For that reason, it is suggested that laparoscopic DFT should be carried out in high-volume centers by experienced surgeons [45].

Double tract method (DTR) In this procedure, first introduced in 1988 [46], the continuity of the gastrointestinal tract is achieved with an esophago-jejunal anastomosis, a gastro-jejunal anastomosis and a jejuno-jejunostomy (Fig. 2). The technique has been developed to overcome complications such as gastro-esophageal reflux and stenosis of the anastomosis after PG, typically occurring in esophago-gastrostomy patients. Some authors suggest that DTR after PG leads to better nutritional outcomes compared to esophago-gastrostomy, with an incidence of reflux esophagitis varying between 3.4% and 12.7% [47–49].

Jejunal interposition (JI) The JI procedure, based on the DTR, consists of the interposition of a jejunal flap between the esophagus and the stomach. In the JI technique, a jejunal limb is sectioned 25–30 cm from the ligament of Treitz, and interposed between the esophagus and remnant distal stomach, with one anastomosis with the distal esophagus and one with the gastric stump being fashioned (Fig. 3). A jejuno-jejunostomy is then performed to join the proximal and distal stumps of the jejunal flap [50]. Unlike DTR, with JI the gastrointestinal transit is entirely directed towards the stomach. In DTR, on the other hand, part of the ingested food content passes directly into the small intestine. A recent meta-analysis of randomized controlled trials, in which DTR and JI were compared in terms of operative and nutritional outcomes, showed no significant differences between the techniques in terms of postoperative complications but significantly better nutritional outcomes in the JI arm, specifically a higher body weight at 6 months after surgery (weighted mean difference 3.90; 95% CI (0.56, 7.23), p = 0.02) [51]. These results were suggested to possibly reflect a role for hormone secretion from the remnant stomach, stimulated by the food transit via the unique pathway created in JI. Furthermore, the preserved duodenal transit of JI could stimulate a greater secretion of cholecystokinin and secretin improving the coordination of food digestion. On the other hand, DTR has shown some advantages in glucose control in glucose-intolerant patients. In a recent study, Nomura et al. described a more stable plasma levels of AAP, insulin, and gastrin when compared to JI [52]. Both DTR and JI have shown positive nutritional outcomes when compared to TG, but we could conclude that JI should be preferred over DTR, with the exception of patients with impaired glucose intolerance.

Fig. 3 Jejunal interposition reconstruction method after proximal gastrectomy. The figure shows the interposition of a pedunculated jejunal loop between the esophageal and the gastric stump, and the jejuno-jejunal anastomosis to restore jejunal continuity

Jejunal pouch interposition (JPI) Jejunal pouch interposition has been proposed to increase the capacity of the gastric stump and to prevent reflux esophagitis after distal gastrectomies as well as proximal gastrectomies.

In this technique, a 25 to 35 cm jejunal limb is usually brought up via the retrocolic route, a 10 to 15 cm U-shaped jejunal pouch is then formed and anastomosed end-to-side to the esophagus and to the gastric remnant [53] (Fig. 4) The functional results vary in different studies, with an overall incidence of reflux esophagitis and food stasis of 13.8% and 58.6%, respectively [54].

In Japan, the number of institutes that are using JPI is decreasing due to concerns for meal stasis due to hypomotility of the jejunal pouch [55], even though benefits on quality of life have been recorded by other authors, especially in the first year after surgery when compared to TG with Roux-en-Y (RY) [56–58]. Therefore, a comparison of functional outcomes between this and other types of reconstruction would be needed.

Novel techniques: tri double-flap hybrid method Since the debate on the better reconstruction method after PG is still open, other techniques have been proposed to overcome the limitations of the pre-existing procedures. One example is the Tri-double flap hybrid method proposed by Omori [59] that aims to overcome the technical difficulties in the antireflux valvuloplasty after lower esophagectomy and proximal gastrectomy. In this technique, that can be carried out with a minimally invasive approach, a gastrostomy is performed on the gastric stump at the site of the anastomosis; the anastomosis is performed stapling the esophageal stump to the gastrostomy, laparoscopically. The esophagostomy is then closed including in the staple line the inferior border of the gastrotomy.

Total gastrectomy with Roux-en-Y esophagojejunal pouch reconstruction

TG with esophago-jejunal anastomosis (EJ) remains the main surgical procedure and oncological gold standard for proximal gastric cancer in all stages, both in the East and West [43].

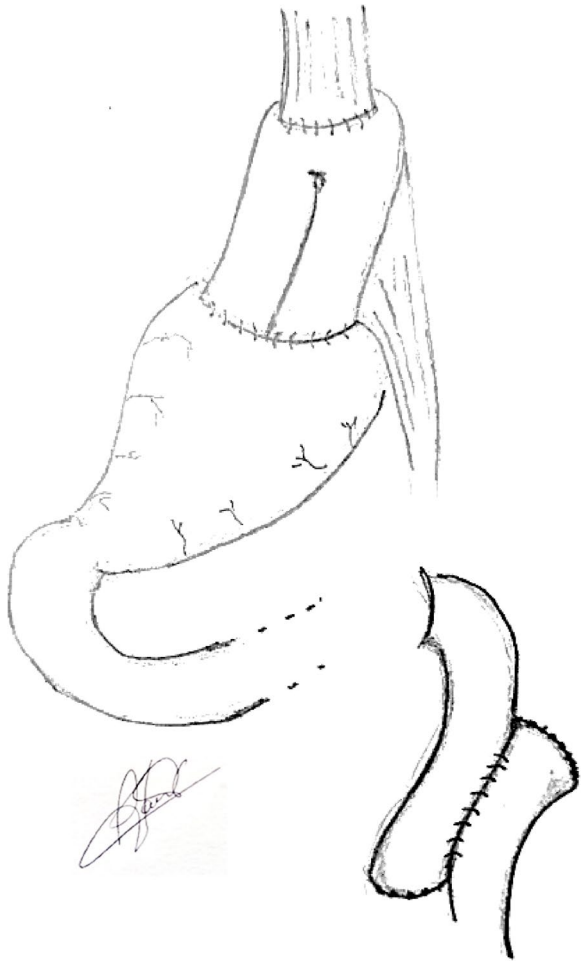

Fig. 4 Jejunal pouch interposition reconstruction method after proximal gastrectomy. The figure shows the interposition of a pedunculated jejunal loop between the esophageal and the gastric stump, and the jejuno-jejunal anastomosis to restore jejunal continuity

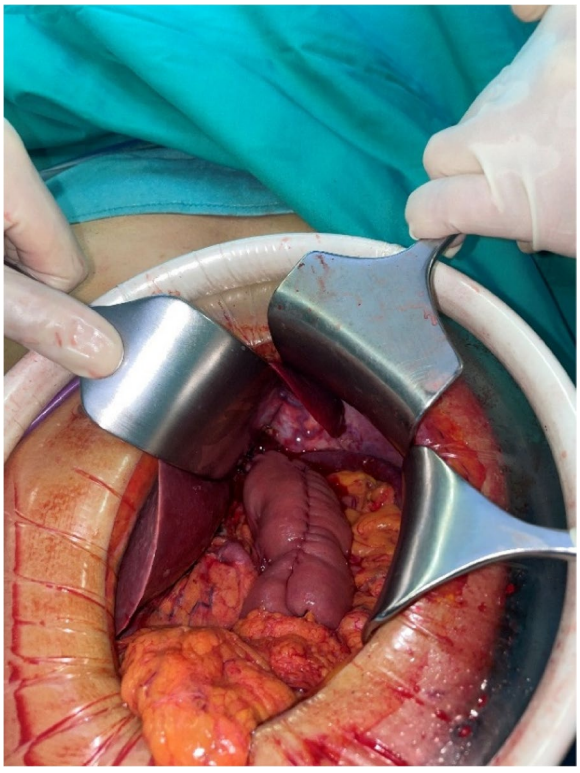

Fig. 5 Jejunal Pouch Reconstruction after Total Gastrectomy: The photograph shows a Lawrence-Hunt jejunal pouch and the esophago-pouch anastomosis

However, this procedure is associated with the highest rate of detrimental functional outcomes, including weight loss (with an average of 15% compared to preoperative weight) [60], dumping syndrome (23.6%), food intake disturbances (43.5%) [61], postoperative sideropenia and anemia (66%) [43], and other nutritional deficiencies as increased risk of osteoporosis [62], and compromised QoL as reported by several studies [63–65].

The Lawrence and Hunt (LH) jejunal pouch is a J pouch proximal in the GI tract reconstruction, with anastomosis between the esophagus and the pouch (EJP) (Fig. 5), however other pouch conformations and locations (i.e., the aboral pouch) have been described, as well as double tract reconstructions and jejunal interposition applied to total gastrectomy. Nevertheless, the LH pouch is the most studied.

Indeed, since its introduction in the 1960s by Lawrence and Hunt [66], several randomized controlled trials have investigated the impact of the EJP reconstruction on nutritional outcomes and global QoL, concluding that pouch formation may lead to reduced weight loss and decreased dumping symptoms after surgery [67–69]. On the other hand, sporadic reports based on manometric studies have suggested that the creation of a pouch may lead to an impaired food transit related to pouch dysmotility that may account for increased food stasis and reflux symptoms [57, 70].

A 2019 meta-analysis of randomized and non-randomized clinical trials conducted by Syn et al. evaluated the impact of all pouch reconstructions (the majority – 13 studies – fashioned as LH J-pouches) vs. Roux-en-Y after TG on perioperative outcomes, postprandial symptoms, nutritional and anthropometric parameters, and overall QOL after surgery. The authors analyzed outcomes from 17 randomized trials and 8 observational studies involving 1621 participants. Of these 25 studies, 12 were from Western countries (mostly Germany and Northern European countries). Results showed that EJP did not carry additional risks in terms of post-operative complications when compared to RYTG (RR 1.13 (0.94 to 1.35), p = 0.76). EJP was associated with a significantly lower rate of dumping syndrome and food intake disturbances at 3–6 months (8.1% vs. 32.4%, RR 0.36 – CI 0.21 to 0.60 and 20% vs. 86.1%, RR 0.43 (0.25 to 0.73), respectively) and persisting better long-term (12–24 months) functional

outcomes, with lower rate of reflux symptoms (2.9% vs. 11.7%, RR 0.37 (0.18 to 0.77)) and dumping syndrome (2.8% vs. 23.6%, RR 0.27 (0.16 to 0.46)), as well as higher GIQLI QoL scores at 12 months (WMD 8.04 (CI 2.40 to 13.69)). In addition, the analysis of nutritional outcomes revealed an advantage of pouch reconstruction in BMI and serum albumin levels at 12–24 months. No differences were found in iron and hemoglobin levels [61]. Following the result of this study, J pouch reconstruction after TG has been more widely recommended, and even included as the preferred method of reconstruction after TG by the French association of surgery [71]. Nevertheless, the application of this technique remains limited in most Western settings, with only sparse real-life reports in the literature to date [72, 73].

In a cross-sectional study conducted by Tsuji et al., different QoL-related outcomes according to the Japan Postgastrectomy Syndrome Working Party (JPGSWP) were evaluated. The authors concluded that oral JP after total gastrectomy has a significant positive impact on QoL, especially when compared to Roux-en-Y reconstruction (RYTG) [74].

The technique is nowadays safely performed in both open and minimally invasive approaches [72, 73, 75]. However, given the lack of standardization of the EJP technique across large volume centers, surgeon's preferences play a significant role on the fashioning of the pouch and the optimal size of the pouch is still to be determined [76]. In a randomized prospective study, Tsujimoto et al. investigated the optimal length of the jejunal pouch after TG and DTR to achieve the best functional outcomes: in the study, short jejunal pouches (i.e., two stapler firings from a 60-mm linear stapler device) resulted in improved eating capacity and lower weight loss after surgery when compared to long jejunal pouches [77]. Even if no randomized trials are available on the impact of different pouch sizes on functional outcomes after Roux-en-Y EJP, it is reasonable to speculate that results from DTR studies may apply to the RY reconstruction and that smaller pouches may lead to better food progression in the digestive tract with less impact on motility.

Segmental gastrectomy (SG)

Segmental Gastrectomy (SG) has been first proposed as a function-preserving procedure for benign peptic ulcers as an alternative to distal gastrectomy, and involves the resection of the middle part of the stomach with local lymphadenectomy. From the early 2000 s, SG has been investigated as an oncological procedure for early gastric cancer, as well. To date, no definitive evidence is available to determine the safety of SG for gastric cancer. Matsuda et al. described in 2010 a modified D2 lymph node dissection associated with SG when the distance from the distal edge of the resection to the pylorus was more than 4 cm: in this procedure, the lymph node dissection of stations number 6 and 4 d was carried out preserving the right gastroepiploic vessels and the surrounding nerve plexuses, and station number 5 was dissected and the right gastric artery was divided distally to the third branch [78].

At present, this technique is considered an investigational treatment for cancer and it is limited to very early gastric cancer because of concern about lymph node metastases. Recently, Khalayleh et al. investigated the rate of lymph node metastases at the stations that cannot be easily dissected during SG for cancer (i.e., stations 2, 4sa, 5, 6, and 11 d) in a vast cohort of cT1 to cT3 middle and high-body gastric cancer patients in Korea. The incidence of lymph node metastases was negligible in stations 5 and 6 when the tumor was 4 cm or less, regardless of tumor differentiation, as was the incidence of lymph node metastases at station 4sa for cT1-2N0/1M0 cancers, station 2 for cT1N0/1M0 cancers, station 11 d for cT1N1M0-cT2N0/1M0 cancers, and station 12a for cT1N0/1M0-T2N1M0 cancers. The authors concluded that SG with dissection of stations 1, 3, 4sb, 4 d, 7, 8a, 9, 11p, and 12a is feasible for middle and high body cT1N0/1M0 gastric cancers 4 cm or smaller and well-differentiated cT2N0/1M0 cancers [79].

Implications for function-preserving surgery in the West

Clinical treatment guidelines for gastric cancer differ significantly across the world, largely because of the heterogeneity in incidence, stage at diagnosis, and underlying cancer biology. The prognosis of Western gastric cancer patients remains relatively poor overall, mainly due to the more advanced stage at presentation. Compared with Eastern gastric cancer guidelines—namely the Korean KGCA Practice Guidelines, the Japanese JGCA Guidelines, and the Chinese CSCO Guidelines—the American NCCN and the European ESMO guidelines do not include function-preserving resections for EGC [5, 9, 10, 80, 81].

However, in parallel with recent advances in perioperative treatment and surgical strategies, and supported by increasing expertise derived from centralization, the codification of high-volume centers [82] and of the learning curve process, there is also an increase in the attention to optimize the nutritional status after surgery and to assess patient reported outcomes (PROMs) and optimize QoL.

It is increasingly recognized that functional outcomes are relevant for all patients undergoing resection. The drive towards improving long-term functional outcomes has traditionally interested patients that are expected to be long term survivors, such as those with CDH1 mutation receiving prophylactic TG or those with early GC.

These patients often have higher expectations regarding long-term function and are generally optimal surgical candidates, being younger and not requiring preoperative chemotherapy. Nonetheless, even patients with advanced gastric cancer may benefit from improved functional outcomes, which—even in the short term—could theoretically translate into faster resumption of chemotherapy and recovery of preoperative performance status. Therefore, maximal effort should be put in determining the possible Impact on QoL of these techniques, and to assess the balance between a possible increase in risk during the learning curve due to their novel introduction in the West, and short- and long-term functional benefits for each category of patients.

One important challenge in implementing these strategies in the West is the limited number of patients eligible for function-preserving surgery. The population of EGC patients is indeed much smaller in Western countries, which may lead to less accurate staging, inappropriate indications for stomach-sparing procedures, and poorer surgical outcomes due to restricted learning-curve opportunities. These concerns, however, may be addressed through the continued centralization of care in high-volume centers, where accurate staging and the expertise of experienced endoscopists support more precise tailoring of the surgical approach and consideration of function-preserving techniques in selected patients. Another relevant consideration is the resistance commonly encountered when introducing new techniques into clinical practice, that could be hypothesized from the still scarce number of Western trials, as well as original studies of patients treated with function-preserving procedures [72, 73, 83]. These procedures remain novel in most Western settings, making it challenging to integrate them within a structured evaluation framework and to guide their orderly transition through the stages of innovation, development, exploration, and assessment [84].

Other factors could be considered to extend the indications for function-preserving surgery. This includes considerations on the length of the resection margins and the extent of lymph node dissection for T1b and above cancers, according to tumor characteristics. In general, eastern guidelines recommend a D2 resection for tumors T2 and above, while D1 + lymph node dissection is mentioned in ESMO and eastern guidelines for T1 tumors, but not in the NCCN. The NCCN guidelines recommend a resection margin of 4 cm or more for T1b–T3 tumors, while in the ESMO guidelines, DG is indicated if a macroscopic margin of 5 cm for the intestinal type and 8 cm for the diffuse type can be achieved. TG is recommended if the margin length cannot be achieved. The JGCA guidelines take into account the growth pattern of the tumor, when considering resection margins: for T2 and above cancers with expansive growth pattern (Borrmann types 1 and 2) a margin of 3 cm is recommended, while 5 cm are needed in case of infiltrative pattern (types 3 and 4). A recent Italian study assessed the margin adequacy according to the NCCN, ESMO and JGCA guidelines. The predictive value of these margins on the overall survival was evaluated. From the multivariate analysis, JGCA margin adequacy was independently associated with overall survival of the 279 patients enrolled in the study. The application of JGCA recommendations would have allowed for more organ-sparing procedures than NCCN and ESMO, lowering the number of TG compared to DGs (30% versus 31% in NCCN and 47% in ESMO, $p < 0.001$) without compromising patient outcomes. The authors therefore suggest that the implementation of JGCA guidelines in Western patients could lead to better short- and long-term outcomes, thanks to the higher number of organ-sparing procedures [85].

A final consideration is that functional procedures have not yet been evaluated for their cost-effectiveness. Theoretically, they may represent a cost-effective strategy for early gastric cancer (EGC), as they improve quality of life (QoL) and may reduce long-term healthcare costs related to complications such as dumping syndrome, malnutrition, and nutritional deficiencies, despite potentially higher initial surgical costs. Assessing this dimension could represent a promising avenue for future investigations, particularly in the Western setting, where the adoption of new surgical strategies could be supported by specific health-economic evaluations.

Discussion

Early gastric cancer (EGC) is increasingly diagnosed in the Eastern countries thanks to screening programs and improved diagnostic procedures. The low rate of detected lymph node metastases and the good prognosis documented for EGC after surgery has led to an increased interest in quality of life for cancer patients. As a result, limited resections have been increasingly investigated by the surgical oncology community to minimize the functional outcomes of oncological procedures. Several procedures have been proposed according to tumor location, staging, and indications for surgery. For tumors that are not amenable to endoscopic resection, the main functional resections are represented by proximal gastrectomy and pylorus preserving gastrectomy for tumors of the upper third and EGJ cancer and tumors of the body, respectively. PPG with curative intent lymph node dissection have demonstrated comparable long-term outcomes [6, 15, 86] for EGC with an overall advantage in QoL when compared to standard DG, especially in terms of incidence of postoperative dumping syndrome, weight loss, and diarrhea [24, 87].

While PPG has consolidated its role in GC surgery in Eastern countries, PG, in view of the high reported incidence of complications such as anastomotic stenosis and reflux esophagitis, is still raising considerable concern in the surgical oncology community and the best functional reconstruction after PG is to be determined. EG demonstrated some technical advantages and therefore may be preferred due to shorter operative time and learning curves for gastric cancer surgeons, but it is still aggravated by a high incidence of reflux esophagitis because of the preserved acid production in the absence of the cardia.

When EG is performed, the incidence of postoperative reflux esophagitis may be reduced with the use of anti-reflux reconstructions. The DFT provides an effective anti-reflux valvuloplasty creating an H-shaped seromuscular flap on the anterior wall of the gastric stump.

Instead jejunal interposition, as well as double tract reconstruction, aim to put distance between the gastric stump and the esophagus to divert antral secretions from the esophagus, but are still aggravated by complications of the gastric remnant such as delayed gastric-stump emptying and anastomotic stenosis. JI was developed from DTR with the idea of creating maintaining transit of the ingested food exclusively in the stomach. With the DTR, in fact, part of the food transit diverts to the small intestine. A greater food transit into the remnant stomach leads to beneficial effects on postoperative nutritional outcomes such as body weight, plasma iron and vitamins concentration [88].

JPI has been widely used after both TG and PG with the goal of creating a functional reservoir for the bolus to decrease dumping symptoms and improve nutritional status after surgery although after PG, the high recorded rate of food stasis in the denervated jejunal reservoir has raised uncertainties about the role of this reconstruction [41].

Conversely, EJP has been increasingly performed after TG in western countries as an alternative to traditional RYTG to reduce complications such as dumping syndrome and decline in nutritional status. and the current evidence for the benefit of EJP reconstruction after TG is challenging the dogmas about this reconstruction phase in gastric surgery [61].

Moreover, the emerging oncological data on the safety of function-preserving surgery for gastric cancer, alongside with the evidence of better outcomes in terms of nutritional status and overall quality of life for cancer patients after surgery, will face western surgeons with consideration for organ-sparing procedures and implementation of the treatment practice for different categories of patients. A major strength of this review is that it summarizes the broad evidence on function-preserving procedures, systematically describing oncological safety and functional outcomes across techniques and highlighting their potential relevance to Western surgical practice. Our synthesis necessarily leans on recent secondary sources (systematic reviews, guidelines) that themselves are built on relatively recent primary datasets; as such, conclusions should be interpreted as hypothesis-generating and contingent on updated Western primary evidence. Last, it should be emphasized that most of the supporting data are derived from Eastern populations, where incidence patterns, screening practices, and treatment infrastructures differ substantially. At present, more results from randomized trials on the oncological safety of function-preserving procedures (i.e., proximal gastrectomy) for early and more advanced gastric cancer are awaited. Even though most techniques could seem mature for adoption within Western trials in high-volume settings, Western validation through prospective studies will remain crucial to clarify their generalizability and refine patient selection criteria, before all could be safely and broadly integrated in the clinical practice.

Conclusion

Function-preserving surgery in gastric cancer offers oncologically safe alternatives that may significantly improve postoperative quality of life and nutritional outcomes. As global treatment paradigms evolve, adapting these techniques in the West, particularly within high-volume centers, could represent a significant step forward. Further randomized trials and Western-centric data are essential to validate the broader applicability of these procedures and refine patient selection criteria.

Abbreviations

GC	Gastric cancer
QoL	Quality of Life
EGC	Early Gastric Cancer
PG	Proximal Gastrectomy
PPG	Pylorus-Preserving Gastrectomy
DG	Distal Gastrectomy
EMR	Endoscopic Mucosal Resection
ESD	Endoscopic Submucosal Dissection
LPPG	Laparoscopic pylorus-preserving gastrectomy
LDG	Laparoscopic Distal Gastrectomy
EGJ	Esophago-Gastric Junction
EGJC	Esophago-Gastric Junction Carcinoma
TG	Total Gastrectomy
ACS	American College of Surgeons
EG	Esophago-gastrostomy
DFT	Double-Flap Technique
DTR	Double tract method
JI	Jejunal interposition
RY	Roux-en-Y
JPI	Jejunal pouch interposition
EJ	esophago-jejunal anastomosis
LH	Lawrence and Hunt Jejunal Pouch
EJP	Esophago-Jejunal Pouch
RYTG	Roux-en-Y Total Gastrectomy
JPGSWP	the Japan Postgastrectomy Syndrome Working Party
SG	Segmental Gastrectomy

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