Shao et al. World Journal of Surgical Oncology (2025) 23:366
https://doi.org/10.1186/s12957-025-04037-0

World Journal of Surgical Oncology

REVIEW

Open Access

The current landscape and advances in functional-preserving gastric cancer surgery

Qiangzu Shao[1,2], Yinghong Lin[1,2], Fan Zhang[1,2] and Zeping Huang[1,2,3*]

Abstract

With the gradual enhancement of public health literacy and advancements in gastroscopy technology, China has witnessed a steady increase in the detection rate of early-stage gastric cancer. Early-stage gastric cancer is characterized by favorable prognoses and prolonged survival times. In the treatment of early-stage gastric cancer, maintaining postoperative quality of life while ensuring curability without excessive intervention is crucial and remains a focal point in current therapeutic strategies. This can be addressed through minimally invasive, function-preserving gastrectomy. Laparoscopic proximal gastrectomy, pylorus-preserving gastrectomy, segmental gastrectomy, local gastrectomy, and laparoscopic-endoscopic combined surgery are all examples of function-preserving procedures. In proximal gastrectomy, reconstruction typically involves anti-reflux techniques such as esophagogastrostomy, double-tract reconstruction, and jejunal interposition. Currently, the Kamikawa anastomosis, as a method to prevent reflux esophagitis, has become the preferred reconstruction technique in Japan. However, a standardized reconstruction method following proximal gastrectomy has yet to be established. Additionally, sentinel lymph node navigation surgery is essential for maintaining the curability of early-stage gastric cancer through minimally invasive, function-preserving gastrectomy. It aids in intraoperative lymph node localization, assesses lymph node metastasis, and determines the extent of lymphadenectomy, thereby enhancing postoperative quality of life for early-stage gastric cancer patients. Internationally, sentinel lymph node navigation surgery has been established as a treatment option for specific early-stage gastric cancer patients, with its application expected to expand in the future. This article reviews the current research status of function-preserving gastrectomy for gastric cancer both domestically and internationally. It details various function-preserving surgical methods, analyzes and summarizes their clinical efficacy, aiming to provide valuable references for surgeons to better perform such surgeries. This, in turn, will promote the standardized application and further development of function-preserving gastrectomy for gastric cancer in clinical practice.

Keywords: Gastric Cancer; Functional-Preserving Surgery; Gastrectomy; Digestive Tract Reconstruction；Surgical treatment

Introduction

According to the 2022 Global Cancer Statistics released by the International Agency for Research on Cancer of the World Health Organization, GC ranks 5th in incidence and 4th in mortality globally [1]. Traditional surgical

*Correspondence:
Zeping Huang
Ldyy_huangzp@lzu.edu.cn

Full list of author information is available at the end of the article

complications, such as postoperative malnutrition, anemia, and inadequate anti-reflux, significantly impact patients' quality of life. Therefore, reconstructing the anti-reflux barrier and preserving the residual stomach's function during surgical treatment are critical concerns. In recent years, functional preservation surgeries for GC have gained traction, aiming to retain part of the stomach's anatomical and physiological functions while ensuring radical tumor resection, thereby enhancing postoperative quality of life [2]. In functional-preserving gastrectomy, precise assessment of lymph node metastasis status is crucial for determining surgical approaches, predicting prognosis, and guiding subsequent treatments, requiring a balance between tumor radicality and functional preservation. Lymph node metastasis is a pivotal biological behavior in malignant tumor progression, involving tumor cells detaching from the primary site, colonizing lymph nodes via the lymphatic circulation, and proliferating, resulting from interactions between tumor cells and the host microenvironment. The pathophysiological mechanisms involve complex multi-step, multi-factor regulation of tumor cell invasion, migration, and colonization. Diagnosis of lymph node metastasis necessitates clinical, imaging, and pathological methods, with pathological diagnosis serving as the "gold standard" ,including intraoperative frozen section biopsy of suspicious lymph nodes, postoperative paraffin-embedded cases, and sentinel lymph node biopsy. With advancements in molecular diagnostic technologies, future identification of micrometastases and potential metastatic risks will become more precise, providing stronger support for assessing lymph node metastasis. Currently, widely used functional-preserving surgeries include proximal gastrectomy(PG), pylorus-preserving gastrectomy(PPG), segmental gastrectomy(SG), local gastrectomy(LG), and laparoscopic-endoscopic combined surgeries(LECS).

PG

Proximal gastric cancer refers to malignancies occurring in the upper third of the stomach, primarily including adenocarcinoma at the gastroesophageal junction, gastric fundus cancer, and malignant tumors in the upper third of the gastric body. Surgical resection is the primary treatment for proximal GC, with the main surgical approaches being total gastrectomy(TG) and PG. PG, which preserves partial gastric function, demonstrates favorable long-term outcomes in terms of postoperative nutritional status, weight loss, and anemia compared to TG [3].

Indications for PG

PG is primarily indicated for early-stage cancers in the upper third of the stomach, with malignant tumors in the proximal gastric body and cardia being suitable candidates. For adenocarcinoma at the gastroesophageal junction, PG is chosen when the tumor diameter is ≤ 4 cm, regardless of invasion depth; total gastrectomy is considered for larger tumors [4]. The key to PG lies in preserving sufficient functional gastric volume, with the principle being to retain at least half of the original volume.

Lymph node dissection scope in PG

The lymph node dissection scope in PG includes [5]: D1 lymph node dissection: No.1, No.2, No.3a, No.4sa, No.4sb, No.7; D1 + lymph node dissection: D1 + No.8a, No.9, No.11p; D2 lymph node dissection: D1 + No.8a, No.9, No.11p, and No.11d. During lymph node dissection, it is routine to preserve the right gastric artery, right gastroepiploic artery, inferior pyloric artery, and to protect the hepatic branches of the vagus nerve and the pyloric branches.

Postoperative gastrointestinal reconstruction methods and clinical outcomes

The incidence of major complications such as reflux esophagitis and anastomotic stricture after PG is significantly higher than after total gastrectomy [6–8]. Therefore, improvements in gastrointestinal reconstruction are necessary to minimize postoperative complications. However, there is currently a lack of high-level evidence-based medical support for the optimal gastrointestinal reconstruction method after PG. The widely recognized methods of gastrointestinal reconstruction include esophagogastrostomy and esophagojejunostomy [9, 10].

Esophagogastrostomy with gastric remnant

Esophagogastrostomy with gastric remnant, a classical method of gastrointestinal reconstruction, is associated with a high incidence of postoperative reflux esophagitis. Studies indicate that 60%–70% of patients undergoing esophagogastrostomy exhibit reflux symptoms [11]. Therefore, preventing reflux esophagitis is crucial in postoperative gastrointestinal reconstruction. Current mainstream techniques include fundoplication, tubular gastreesophagostomy and its modifications, double-flap anastomosis and its modifications, and side-overlap esophagogastrostomy (also known as SOFY anastomosis) and its modifications. These advancements have reduced postoperative complications to varying degrees in PG patients.

Fundoplication Fundoplication involves wrapping the esophagus with the gastric remnant wall after esophago-

Fig. 1 Fundoplication procedure

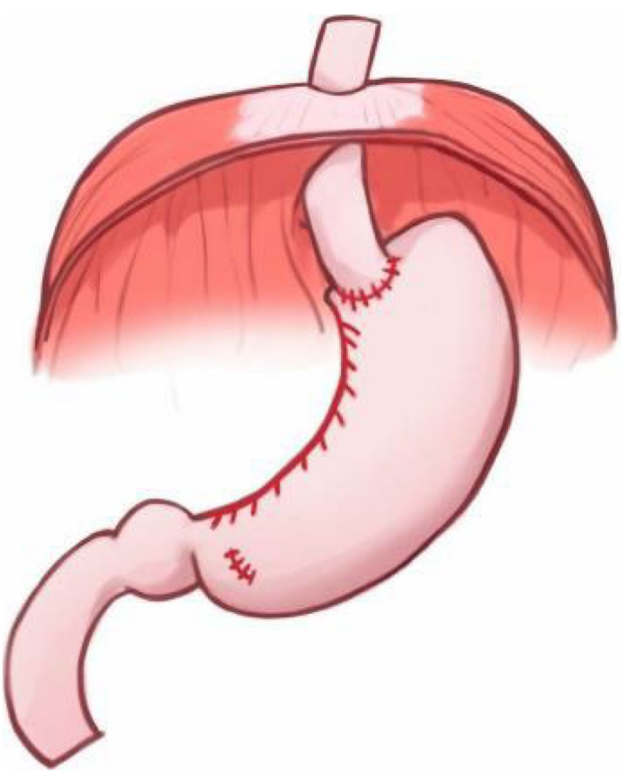

Fig. 2 Tubular gastroesophageal anastomosis

gastrostomy, applying pressure from the gastric remnant wall on the esophagus to achieve anti-reflux effects (Fig. 1). A retrospective study compared 44 patients undergoing fundoplication after PG with 17 undergoing conventional anastomosis [12]. The fundoplication group showed significantly lower rates of grade B (Los Angeles classification) or worse reflux esophagitis compared to the conventional reconstruction group (0% vs. 58.8%). Additionally, the Post-Gastrectomy Symptom Assessment Scale-45 (PGSAS-45), a key tool for evaluating postoperative esophageal reflux, demonstrated significantly better scores in the fundoplication group compared to the conventional reconstruction group (1.5 vs. 2.4). A portion of patients in both groups experienced varying degrees of anastomotic stricture postoperatively (22.7% vs. 23.5%), all of which were alleviated after endoscopic balloon dilation. Ojima successfully performed fundoplication using the da Vinci robotic system in 15 patients after PG, with short-term follow-up showing no gastroesophageal reflux or anastomotic stricture [13].

Tubular gastroesophageal anastomosis and its modifications Tubular gastroesophageal anastomosis was first proposed by Shiraishi [14], which involves reconstruction of the gastric fundus and partial resection of the gastric antrum to reduce gastric acid secretion, thereby decreasing the incidence of reflux esophagitis (Fig. 2). Studies have shownthat PG combined with tubular gastroesophageal anastomosis offers advantages in reflux prevention and nutritional outcomes compared to total gastrectomy [15]. Cheng modified the tubular gastroesophageal anastomosis to propose the “Giraffe” anastomosis [16], which reconstructs the His angle and gastric fundus, achieving favorable anti-reflux effects (Fig. 3). Clinical outcomes of “Giraffe” anastomosis reconstruction in 100 cases have been reported [17], with assessments based on the Gastroesophageal Reflux Disease Questionnaire (RDQ) and postoperative endoscopic examinations to evaluate the occurrence and grading of reflux esophagitis. At six months postoperatively, the RDQ revealed reflux symptoms in eight patients, while endoscopy identified reflux esophagitis in 11 patients, including 6 cases of grade A, 3 cases of grade B, and 2 cases of grade C. All patients were able to manage reflux symptoms through behavioral guidance or oral proton pump inhibitor therapy. The “Giraffe” anastomosis demonstrates favorable outcomes in anti-reflux and gastric emptying; however, the long and narrow configuration of the tubular stomach may increase the risk of anastomotic leakage [18].

Double muscle flap anastomosis and its modification Kamikawa first introduced the double muscle flap anastomosis, also known as the Kamikawa anastomosis (Fig. 4), in 1998. Kuroda reported that among 33 patients

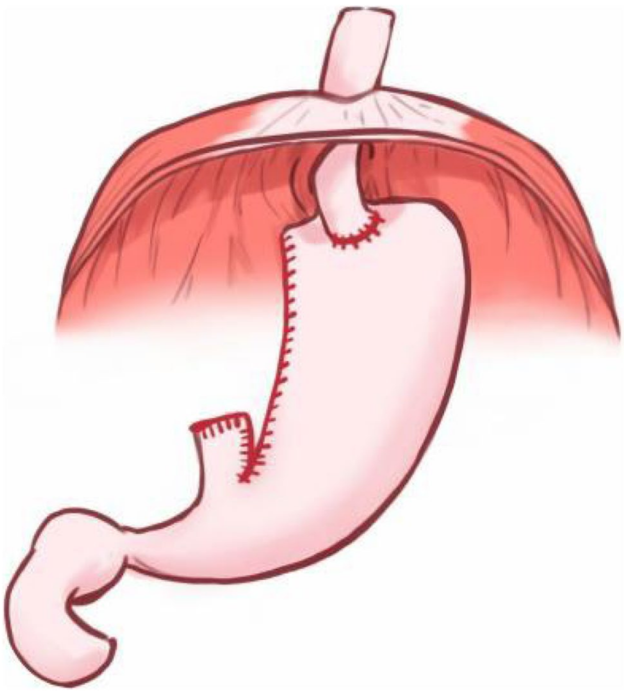

Fig. 3 Cheng's"Giraffe" anastomosis

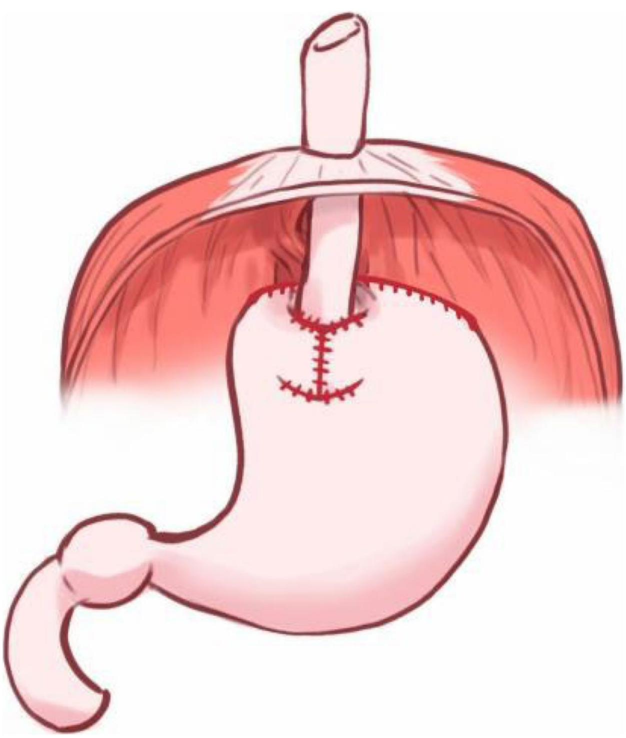

Fig. 4 Kamikawa anastomosis

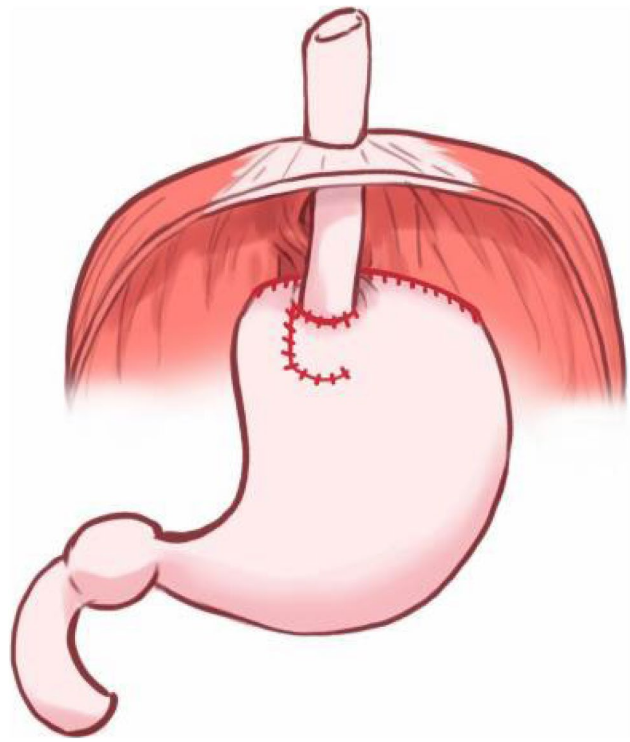

Fig. 5 "Arch Bridge" style anastomosis

who underwent double muscle flap anastomosis, none developed reflux esophagitis one year postoperatively, demonstrating excellent anti-reflux efficacy [19]. A multicenter study evaluated the clinical outcomes of 464 patients following double muscle flap anastomosis, revealing a reflux esophagitis incidence of 10.6%, with 6% of these cases being grade B or above [20]. This indicates that the double muscle flap anastomosis effectively reduces the occurrence of reflux esophagitis. Additionally, 5.5% of patients experienced anastomotic stricture, possibly due to the higher pressure associated with double muscle flap anastomosis. Other researchers have found that only 4.2% of patients post-double muscle flap anastomosis exhibited symptoms of grade B or above reflux esophagitis, but 8.3% required balloon dilation due to anastomotic stricture [21]. This suggests that while the double muscle flap anastomosis offers good anti-reflux effects, the incidence of anastomotic stricture is relatively high, potentially related to postoperative scar contraction at the anastomotic site.

Despite its excellent anti-reflux efficacy, the double muscle flap anastomosis is technically challenging, time-consuming, and requires a high level of surgical skill, significantly limiting its dissemination and adoption. The current focus is on simplifying surgical procedures and reducing complexity while maintaining anti-reflux effectiveness. Ji Jiafu's team at Peking Universityhas modified the double muscle flap anastomosis, proposing an "arch-style" anastomosis method [22] (Fig. 5). Preliminary studies involving 15 patients demonstrated a 0% incidence of anastomotic leakage and good short-term anti-reflux effects. Long-term clinical outcomes require further follow-up. The "arch-style" anastomosis offers significant advantages over the double muscle flap anastomosis, including simplicity of operation, controllable muscle flap quality, and good blood supply. It holds promise for significantly reducing surgical complexity and duration while maintaining anti-reflux efficacy. However, large-scale clinical studies are currently lacking to validate these benefits.

SOFY anastomosis and its modification In 2016, Yamashita pioneered the introduction of the SOFY anastomosis technique—an anti-reflux reconstruction procedure [23]. This method involves suturing and fixing both sides of the gastric remnant to the left and right diaphragmatic crura. The distal esophagus is then fully mobilized, pulled downward, and overlapped over the residual stomach with an overlap length of at least 5 cm. The right wall of the esophageal stump is subsequently sutured and anchored to the anterior gastric wall to prevent retraction of the esophagus. Finally, a living flap is created using the dorsal esophageal segment to cover the anastomotic site. This reconstruction design leverages biomechanical principles to mitigate reflux: when intragastric pressure rises, the posterior esophageal wall is compressed against the flap, leading to closure of the anastomotic lumen and thus reducing the incidence of postoperative gastroesophageal reflux. (Fig. 6). Among 14 patients who underwent SOFY anastomosis, none experienced anastomotic leakage or stricture. However, one patient developed severe reflux esophagitis, likely due to the anastomotic site shifting towards the lesser curvature, misalignment between the left anastomotic line and the long axis of the remnant stomach, and insufficient rotation.

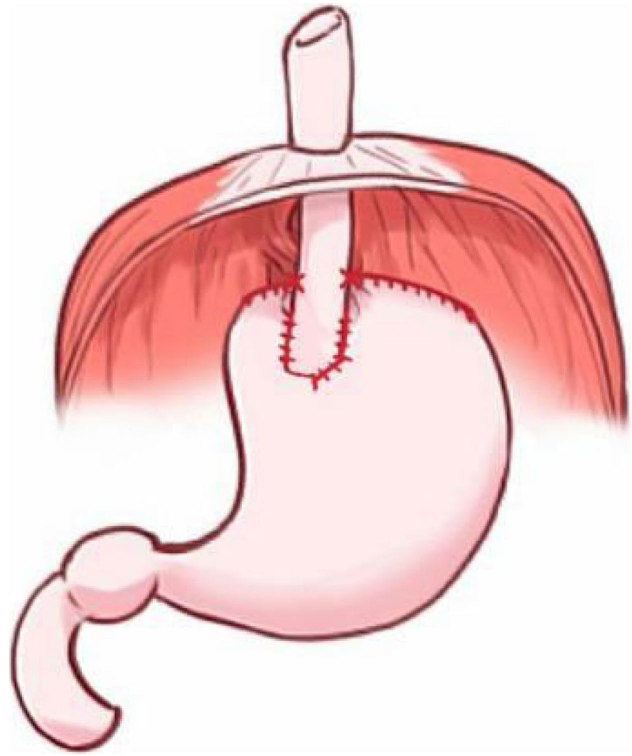

Fig. 6 SOFY anastomosis

In 2022, Yamashita introduced a modified version of the SOFY anastomosis [24], termed the mSOFY anastomosis (Fig. 7). The key refinement in this technique involves anastomosing the right wall of the esophagus to the anterior wall of the gastric remnant, followed by closure of the common opening. Subsequently, the left wall of the esophagus is sutured and fixed to the anterior gastric wall, ensuring it lies flush and adheres closely to the stomach. The anti-reflux mechanism of the mSOFY anastomosis remains fundamentally similar to that of the original SOFY procedure.Among 36 patients who underwent the modified procedure (mSOFY), 10.7% exhibited reflux symptoms rated B or above, while only 2.8% experienced anastomotic stricture. The mSOFY anastomosis not only effectively controls the occurrence of reflux esophagitis but also significantly reduces the complexity of the surgical procedure and shortens the operative time. However, as a novel anti-reflux technique, the clinical application of mSOFY anastomosis remains limited, and its anti-reflux efficacy and safety still need to be confirmed by higher-level evidence-based medical evidence.

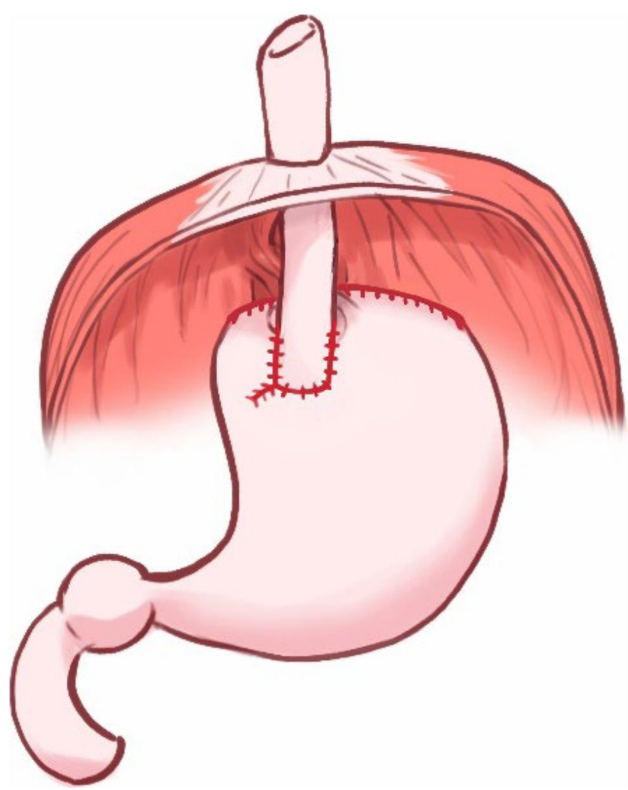

Fig. 7 mSOFY anastomosis

Esophagojejunostomy

In the reconstruction of the digestive tract following PG, esophagojejunostomy is widely employed, in addition to esophagogastrostomy, due to its more definitive anti-reflux effects. The primary methods of esophagojejunostomy currently include jejunal interposition, jejunal interposition with a reservoir, and double-tract anastomosis.

Jejunal interposition

PG combined with jejunal interposition involves reconstructing the digestive tract by anastomosing both ends of a segment of well-vascularized jejunal loop to the remaining esophagus and remnant stomach. This method leverages the alkaline intestinal secretions produced by the interposed jejunum, along with the length gradient and peristalsis of the jejunal loop, to form an effective anti-reflux barrier between the remnant stomach and esophagus. This reduces symptoms of gastroesophageal reflux and improves postoperative quality of life for patients. Although this anastomotic method demonstrates good clinical efficacy in anti-reflux, its extensive surgical procedures and multiple anastomotic sites increase the incidence of anastomotic leakage and stricture postoperatively, limiting its widespread application.

Jejunal Interposition with a Reservoir, first proposed by Kameyama [25], involves folding a segment of jejunum into a "P" or "U" shape to form a reservoir on the basis of jejunal interposition. Compared to simple jejunal interposition, this method offers superior anti-reflux effects and addresses the deficiency in food storage capacity when the remnant stomach volume is insufficient. However, the critical factor remains the selection of the reservoir length; an excessively short length results in inadequate anti-reflux effects, while a longer length can lead to issues such as food retention. Additionally, the functional outcomes of this surgical approach have yet to be validated.

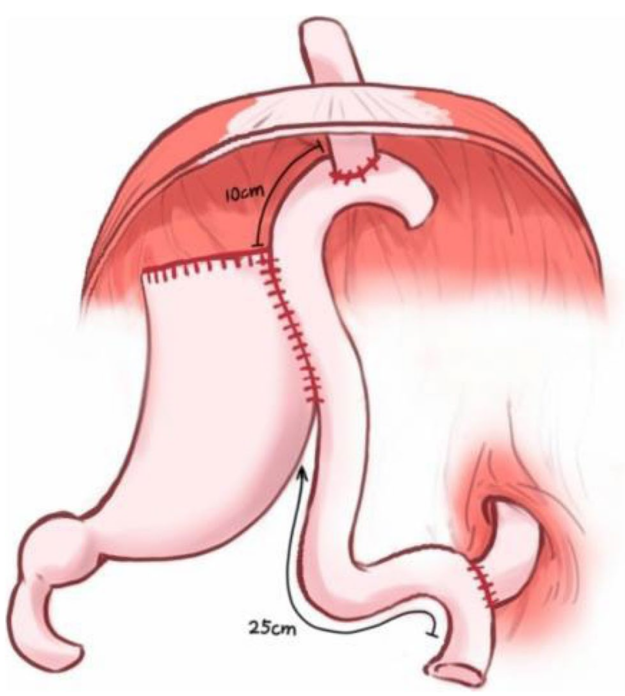

Fig. 8 Double-tract anastomosis

Double-tract anastomosis Double-tract anastomosis is an extension of the esophagojejunostomy in the Roux-en-Y configuration, where the distal remnant stomach is re-anastomosed to the jejunum at a distance of 10–15 cm from the esophagojejunostomy. This allows food to pass through both the remnant stomach and the jejunum into the distal digestive tract, hence the term double-tract anastomosis (Fig. 8).

Multiple studies have demonstrated that PG combined with double-tract anastomosis is a safe and effective method of gastrointestinal reconstruction. Ahn reported a postoperative incidence of reflux esophagitis of 4.6% with double-tract anastomosis [26]. Sato compared the nutritional status of patients after Roux-en-Y anastomosis and double-tract anastomosis, finding that the latter performed well in terms of weight loss, hemoglobin reduction, and quality of life. In the Post-Gastrectomy Syndrome Assessment Scale 37 (PGSAS-37), the double-tract group showed slightly better scores for diarrhea and intake quality [27]. Wang and Tian's studies also indicated that patients undergoing double-tract anastomosis had superior nutritional status compared to those undergoing total gastrectomy, making it a safe and effective method for gastrointestinal reconstruction following PG, potentially serving as a primary option for the surgical treatment of proximal GC [28]– [29]. Aburatani discovered that double-tract anastomosis significantly reduced the incidence of postoperative reflux esophagitis (10.5% vs. 54.5%) and anastomotic stricture (0% vs. 27.0%) compared to conventional esophagogastrostomy [30]. Kim found that patients after double-tract anastomosis had significantly higher levels of vitamin B12 compared to those after total gastrectomy [31], indicating a potential advantage in postoperative anti-anemia. Nomura's prospective study revealed that, in terms of postoperative nutrition, the jejunal interposition and double-tract anastomosis groups outperformed the total gastrectomy group; additionally, the food retention rate in the double-tract reconstruction group was significantly lower than in the other two groups [32].

Compared to traditional simple esophagogastrostomy, double-tract anastomosis effectively prevents postoperative reflux esophagitis, thereby enhancing the quality of life for patients undergoing PG. However, the drawback of this technique is the presence of multiple anastomotic sites, which makes it difficult to maintain long-term food flow through the gastric channel. Despite requiring more anastomotic sites, double-tract anastomosis remains the optimal choice in terms of safety, reproducibility, and operational simplicity, particularly for elderly and high-risk patients.

PPG

PPG is a type of SG that, compared to conventional SG, anatomically retains the upper one-third of the stomach, the pylorus, the right gastric artery, the right gastroepiploic artery, the right gastroepiploic vein, the inferior pyloric artery, the inferior pyloric vein, and the hepatic and pyloric branches of the vagus nerve (Fig. 9). The decision to retain the right gastroepiploic vein depends on the branching pattern of the inferior pyloric vein. Due to the preservation of pyloric function, this procedure has significant advantages in preventing dumping syndrome and bile reflux.

Indications for PPG

PPG is primarily indicated for early-stage GC (without lymph node metastasis) located in the middle one-third of the stomach, with a tumor margin at least 4 cm from the pylorus [33]. Additionally, it requires preserving at least one-third of the proximal stomach. For early-stage GC involving the upper one-third of the stomach, when the upper boundary of the tumor is ≥ 3 cm from the esophagogastric junction and >4 cm from the pylorus, PPG can be considered [34].

Lymph node dissection in PPG

The scope of lymph node dissection in PPG includes: D1 lymphadenectomy (lymph nodes No.1, No.3, No.4sb, No.4d, No.6, and No.7), while D1 + lymphadenectomy additionally includes lymph nodes No.8a and No.9 [5]. Dissection of lymph nodes No.6 is one of the challenges during surgery; care must be taken to protect the inferior pyloric vessels in this region. Lymph nodes No.6 are further divided into subgroups: No.6a, No.6i, and No.6v; among these, No.6i is where the inferior pyloric vessels are located and rarely shows lymph node metastasis; therefore, to ensure adequate blood supply to both sides of the distal antrum during dissection of lymph nodes No.6, it is necessary to preserve subgroup No.6i without complete dissection [3].

Exploration of optimal length for pyloric sleeve retention in PPG

In PPG, preventing postoperative functional disorders of the pylorus is crucial; key factors include selecting an appropriate length for retaining the pyloric sleeve. Studies have shown that compared to retaining 1.5 cm during surgery, retaining 2.5 cm significantly reduces postoperative gastric retention rates (35% vs. 10%). Retaining more than 3 cm does not affect long-term postoperative gastric emptying dysfunction rates; thus, an optimal length for retaining the pyloric sleeve is between 3 and 4 cm [35]– [36].

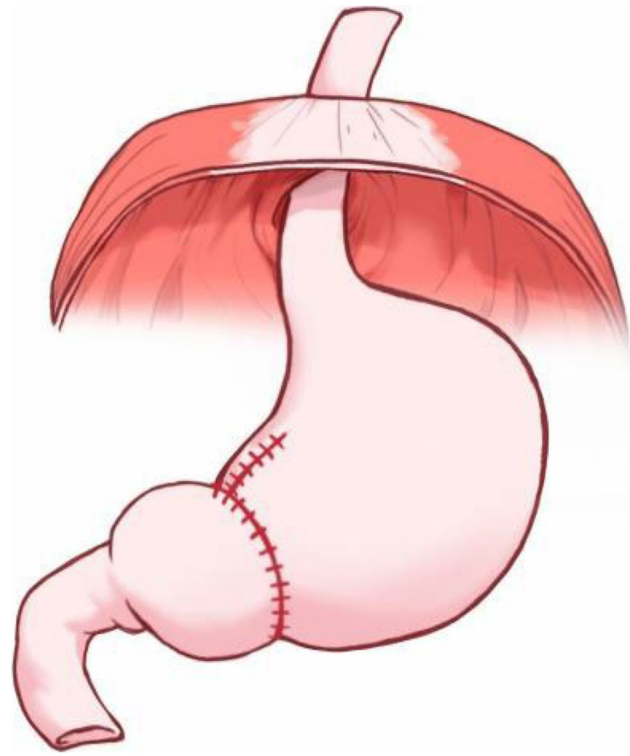

Fig. 9 Pylorus-preserving gastrectomy

Gastrojejunostomy reconstruction and clinical outcomes of PPG

The gastrointestinal reconstruction following PPG typically involves gastro-gastro anastomosis, which can be performed either extracorporeally or intracorporeally. Extracorporeal anastomosis reduces the likelihood of postoperative anastomotic stricture [35], while the use of linear cutting staplers during intracorporeal anastomosis effectively lowers the incidence of postoperative complications, making it recommended for total laparoscopic PPG [37].

Compared to distal gastrectomy, PPG demonstrates significant advantages in surgical outcomes and long-term nutritional status [38]. Postoperative dumping syndrome and bile reflux are less frequent, and nutritional outcomes are superior to those of distal gastrectomy, although the incidence of gastric emptying disorders is notably higher [39]. Additionally, the rate of postoperative gallstone formation is significantly lower after PPG, likely due to the preservation of the hepatic branch of the vagus nerve, which reduces postoperative stone formation [40].

A recent multicenter prospective study by Tanaka evaluated the postoperative quality of life (QOL) in patients undergoing distal gastrectomy (DG) and PPG, using the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire C30 (EORTC-QLQ-C30) and thePGSAS-37 [41]. The study found that DG achieved superior scores for nausea and vomiting (EORTCQLQ-C30) and dietary distress, dyspepsia, and dumping (PGSAS-37) in the first month postoperatively. There were no significant differences in long-term QOL between DG and PPG, and both groups experienced similar postoperative weight loss. This prospective observational study did not demonstrate that PPG was superior to DG in terms of postoperative weight change and QOL.

Morita conducted a follow-up study on 611 patients with early GC who underwent PPG, assessing short-term surgical outcomes and long-term survival [42]. The study found that 102 (16.7%) patients experienced complications, with 19 (3.1%) suffering major complications such as anastomotic leaks and abscesses. The most common complication was gastric emptying disorder, occurring in 49 (8.0%) patients, with a 5-year survival rate of 96.3%.

In a prospective multicenter trial by Shibata [43], the early and late outcomes of PPG were compared with those of DG combined with Billroth I anastomosis for early GC. The study showed that the incidence of early dumping syndrome was lower in PPG than in DG (8% vs. 33%), with no significant difference in gallstone formation between the two groups. These results indicate that PPG is as safe as DG and has an advantage in early dumping syndrome.

Saito followed up 26 patients (11 PPG, 15 DG) postoperatively for 5 years and found that the proportion of weight change in the PPG group was significantly lower than in the DG group, but the gastric emptying efficiency in the DG group was markedly superior to that in the PPG group [44]. There were no differences in clinical pathological characteristics, nutritional parameters, questionnaire responses, and endoscopic findings between the two groups. This suggests that PPG is superior to DG in maintaining body weight and preventing rapid gastric emptying in the long term.

Another multicenter randomized controlled study found no statistically significant difference in the incidence of dumping syndrome between PPG and DG at 1 year postoperatively (13.2% vs. 15.8%). The rate of gallstone formation was significantly lower after PPG than after DG (2.33% vs. 8.66%). Reflux esophagitis (17.8% vs. 6.3%) and gastric emptying disorders (16.3% vs. 3.9%) were more common in PPG [45]. Park found that the incidence of pyloric stenosis after PPG was significantly higher than after DG (7.3% vs. 1.6%) [46]. Therefore, maintaining pyloric blood supply, preserving vagal nerve branches, and ensuring an adequate length of the pyloric sleeve are crucial for preventing gastric emptying disorders after PPG.

PPG has certain advantages and limitations in the treatment of GC. While preserving the pylorus and antral regions contributes to improved postoperative quality of life, postoperative complications such as gastric emptying disorders cannot be overlooked. The choice of this surgical approach should be carefully considered based on individual patient circumstances.

SG

SG refers to a circumferential gastric resection that preserves the pylorus and cardia. Unlike PPG, SG is defined as a partial gastric resection that retains the inferior pancreaticoduodenal artery and vein, as well as the right gastroepiploic artery and vein, and their respective territories. Some scholars delineate the distinction based on the distance of the distal gastric resection margin from the pylorus: approximately 3 cm for PPG and more than 4 cm for SG [47].

Indications for Surgery: SG is primarily indicated for early GCs located in the middle and upper stomach, characterized by tumor stage cT1N0 and a diameter of less than 4 cm. The resection margins should be at least 2 cm, with the lower margin being more than 4 cm from the pylorus and the upper margin exceeding 2 cm from the esophagogastric junction.

A growing body of comparative evidence suggests that SG is associated with a more favorable postoperative symptom profile compared to conventional LG or DG. One study demonstrated a significant reduction in the incidence of reflux symptoms and reflux esophagitis following SG relative to LG [48]. Similarly, Koichi reported that SG was associated with markedly lower rates of early postoperative dumping syndrome and reflux gastritis compared to DG. Importantly, during a mean follow-up period of 54.7 months, no recurrence was observed in the SG cohort, and all patients remained alive [49]. These findings are corroborated by Takeru, who also noted significantly fewer occurrences of reflux esophagitis and gastritis in SG patients relative to those undergoing DG. At a median follow-up of 32.8 months, neither recurrence nor mortality was documented in either group [50].More recently, a 2024 single-center retrospective analysis by Japanese investigators further reinforced the long-term oncologic safety of SG [51]. The 5- and 10-year overall survival rates in SG patients were 96.6% and 92.5%, respectively, significantly higher than those in the control group. Additionally, when guided by sentinel lymph node biopsy techniques, SG was associated with improved prognosis and reduced mortality from respiratory diseases compared to conventional surgical approaches. In conclusion, current evidence supports SG combined with sentinel lymph node navigation as a viable function-preserving surgical option for early-stage gastric cancer, offering favorable reflux-related outcomes, acceptable oncological efficacy, and potential long-term survival benefits.

At present, SG remains in the exploratory phase of clinical research, with no unified industry standards established for surgical techniques or efficacy evaluation. Further high-quality clinical data are needed to validate and refine these aspects. Regarding lymph node dissection, no clear and unified standards have been established. Different medical centers may adopt varying dissection strategies based on their own experiences and research findings, which could lead to differences in tumor eradication outcomes and patient prognosis. However, with the continuous development and maturation of sentinel lymph node navigation technology, this situation is expected to improve. This technology holds promise in ensuring tumor eradication while avoiding excessive trauma from over-dissection and reducing postoperative complications. It thus shows broad application potential in lymph node clearance during SG, with future clinical practice likely to further clarify its value and operational guidelines in SG.Given the current developmental stage of SG and clinical practice experiences, it is imperative to strictly adhere to the surgical indications. Only early GC patients meeting specific criteria, such as tumor size, location, and depth of invasion, should be considered for SG to ensure surgical safety and efficacy. Two special groups of early GC patients warrant cautious approach with SG: those with a family history of GC, as hereditary factors may increase the risk of tumor recurrence or progression, and those with poorly differentiated tumors, which often exhibit greater invasiveness and metastatic potential. Comprehensive and meticulous evaluation is necessary for these patients to balance the benefits and risks of SG surgery. Additionally, in clinical practice, it is crucial to fully respect the patient's and family's right to informed consent. Detailed explanations should be provided regarding the patient's condition, the specifics of SG surgery, potential risks, expected outcomes, and alternative treatment options, ensuring that the family makes an informed choice based on full understanding.

LG

LG refers to the non-circumferential resection of the stomach, primarily applicable to patients with early-stage GC who have not developed lymph node metastasis. For patients at risk of lymph node metastasis, targeted regional lymph node dissection can be performed to achieve curative tumor removal.

Laparoscopic and endoscopic cooperative surgery (LECS) is a minimally invasive technique that integrates laparoscopic gastrectomy with endoscopic submucosal dissection (ESD) to achieve local resection of gastric tumors with precise and minimal margins. Numerous studies have established that classical LECS is a safe and feasible approach for resecting gastric submucosal tumors, including those located at the challenging esophagogastric junction. However, this method involves opening the gastric wall and exposing the lumen, which elevates the risk of abdominal infection, intra-abdominal tumor cell dissemination, and peritoneal implantation. To address these limitations, several modified techniques have been developed. These include combined laparoscopic and endoscopic approach for neoplasia with a non-exposure technique(CLEAN-NET), laparoscopy-assisted endoscopic full-thickness resection (LAEFR), non-exposed endoscopic wall-inversion surgery (NEWS), and closed LECS. These innovations effectively mitigate the risks associated with gastric cavity exposure and have expanded the indications for LECS to include selected cases of gastric epithelial tumors [52].LECS enables localized gastric resection while preserving gastric function—though it does not allow for lymph node dissection. The laparoscopic component contributes to reduced rates of postoperative perforation. As early as 2012, Nunobe emphasized that LECS allows for precise margin determination via detailed endoscopic assessment and ESD techniques, making it suitable for early gastric cancers that meet endoscopic resection criteria yet are technically challenging for ESD alone [53].In recent years, the incorporation of sentinel lymph node (SLN) navigation technology has further refined the application of LECS in early gastric cancer. Combining LECS with SLN mapping allows for minimally invasive resection with simultaneous assessment of nodal status, promoting a function-preserving yet oncologically sound approach [54]– [55]. The Korean SENORITA study enrolled 527 early-stage patients who underwent laparoscopic sentinel lymph node navigation-guided local gastric resection (LSNNS) and laparoscopic standard gastrectomy (LSG). Short-term results indicated that compared to the LSG group, the LSNNS group experienced fewer discomfort symptoms such as pain, dietary restrictions, anxiety, and taste disturbances, while maintaining better nutritional parameters [56]. Long-term outcomes revealed that although the 3-year disease-free survival rate in the LSNNS group was lower than that in the LSG group (91.8% vs. 95.5%), the disease-specific and overall survival rates in the LSNNS group were comparable to those in the LSG group after salvage surgery for postoperative recurrence [57]. These findings suggest that under rigorous follow-up, LG is safe and reliable, offering patients a superior long-term quality of life and nutritional status. Although LECS for early-stage GC has not yet been widely implemented clinically, and its oncological safety requires further validation through high-quality evidence, it holds significant potential as a valuable treatment modality for early GC in the future. More clinical studies are anticipated to explore the safety of LECS for local full-thickness resection in treating early-stage GC.

Sentinel lymph node navigation surgery

Sentinel Lymph Node Navigation represents an innovative approach, serving as an auxiliary tool for lymph node localization during early-stage GC surgeries. It aids in assessing lymph node metastasis, delineating the extent of lymphadenectomy, and assisting surgeons in formulating individualized lymph node dissection plans, thereby conferring survival benefits to patients [58]. The application of Sentinel Lymph Node Navigation in the treatment of early-stage GC has progressively matured, particularly in guiding lymph node dissection during additional surgeries [59]. However, clinical outcomes reveal that while high detection and accuracy rates are achieved through Sentinel Lymph Node Navigation in early-stage GC patients, similar results are not observed in advanced GC cases [60].

Despite its numerous advantages, only a limited number of centers directly employ Sentinel Lymph Node Navigation biopsy to determine the extent of lymph node resection.A multicenter retrospective study revealed that, in 132 patients with early GC undergoing sentinel lymph node navigation surgery, the detection rate of sentinel lymph nodes was 98.5%, with lymph node metastasis identified in 9 cases (6.8%). Among these, 8 cases had metastatic lymph nodes within the sentinel lymph node basin, and 1 case had non-sentinel lymph node metastasis within the sentinel lymph node basin [61]. Aoyama's research indicated that over 50% of early GC patients require sentinel lymph node navigation surgery, particularly those with tumors in the upper third of the stomach, who are candidates for sentinel lymph node basin-preserving functional surgery [62]. Takahashi's study demonstrated that the use of indocyanine green (ICG) and infrared laparoscopic systems (IRLS) in early GC patients achieved a 100% detection rate of sentinel lymph nodes and 100% accuracy in identifying metastatic lymph nodes, indicating that infrared ICG imaging can precisely detect sentinel lymph nodes and occult metastatic sentinel lymph nodes [63]. Eom assessed the QOL and nutritional outcomes between 194 patients undergoing LSNNS and 257 patients undergoing LSG using the EORTCQLQ-C30 and the Stomach Module Score (STO22) [64]. The study identified factors associated with poor QOL in patients undergoing gastric functional preservation surgery. It found that the LSNNS group had better QOL scores in physical functioning, dyspnea, loss of appetite, dysphagia, dietary restrictions, anxiety, taste alteration, and body image at three months postoperatively. At one year postoperatively, the LSNNS group showed significantly higher body mass index, hemoglobin, albumin, and protein levels compared to the LSG group. Multivariate analysis indicated that LSNNS was significantly associated with overall health status, reflux, and dietary restrictions at three months postoperatively, while LSG was significantly associated with the risk of diarrhea and dietary restrictions at three years postoperatively. These findings suggest that LSNNS offers superior long-term QOL and nutritional outcomes compared to LSG. In a retrospective cohort study by Kinami that enrolled 662 patients (239 SNNSs and 423 controls), the incidence of pathological lymph node metastasis was comparable between the two groups (10.5% vs. 10.4%) [65]. Sentinel lymph node biopsy demonstrated a sensitivity of 84% and an accuracy of 98.6%. In the SNNS group, 81.6% of patients underwent modified function-preserving gastrectomies with tailored lymphadenectomy, wherein the extent of nodal dissection was further reduced than recommended by standard guidelines. The 5-year OS rate was significantly higher in the SNNS group than in the control group (96.8% vs. 91.3%; $P < 0.05$), although recurrence-free survival did not differ significantly between groups. After propensity score matching (231 patients per group), the 5-year cumulative recurrence rates were similar (1.30% in both groups), with no statistically significant difference.In a multicenter prospective trial conducted by Kitagawa [66], the SN concept was evaluated using a dual-tracer method involving blue dye and radioisotopes. Among 397 enrolled patients, the SN detection rate was 97.5% (387/397). Of the 57 patients with lymph node metastases confirmed by conventional hematoxylin and eosin staining, 93% (53/57) had positive SNs. The overall accuracy of metastatic evaluation via SN biopsy was 99% (383/387). These findings support the feasibility of SNNS as a potential alternative to standard gastrectomy in early gastric cancer. With continued refinement in SN biopsy techniques and treatment strategies, the application of SN navigation is expected to expand, facilitating more individualized and minimally invasive surgical approaches.The aforementioned studies imply that sentinel lymph node navigation surgery can serve as an alternative to standard gastrectomy. With the advancement of sentinel lymph node biopsy procedures and treatment modalities, the application of sentinel lymph node biopsy will expand, enabling personalized minimally invasive surgery and aiding in the decision-making process for the treatment of early GC patients.

Additionally, some scholars argue that the high false-negative rate of sentinel lymph node navigation biopsy may be related to the biopsy method and the occurrence of skip metastasis in lymph nodes [67]. Kim suggests that using paraffin pathological section examination can increase the sensitivity and specificity of sentinel lymph nodes to 93% and 99%, respectively, but the challenge lies in how to rapidly complete paraffin section examination during surgery [68]. Moreover, there is ongoing debate regarding the choice of tracers and injection sites [69].

Application of dual-modality endoscopy in early-stage patients

Currently, endoscopic therapy represents the predominant approach for the treatment of early-stage GC, with a lymph node metastasis rate ranging from 4.1% to 35.8% [70]. However, while endoscopic surgical treatment is performed, regional lymph node dissection cannot be concurrently conducted. Conversely, standalone laparoscopic surgery carries the risk of excessive resection. Consequently, the advent of laparoscopic-endoscopic combined surgery has emerged. Hiki first proposed LECS in 2006 and successfully implemented it in over 200 patients, ensuring safety [71]. This method maximizes the preservation of normal gastric tissue and gastric function while guaranteeing tumor safety and lymph node dissection. The integration of dual-modality endoscopy with sentinel lymph node navigation aids in determining the minimal extent of gastric resection, avoiding excessive lymph node dissection, and ensuring early postoperative recovery and improved quality of life for patients.

A prospective study, encompassing 258 cases of sentinel lymph node navigation surgery and 269 cases of standard gastric resection, revealed that sentinel lymph node navigation surgery outperformed standard gastric resection in terms of 3-year disease-free survival, postoperative complications, and quality of life [57]. Research indicates that sentinel lymph node navigation surgery enhances lymph node detection rates while reducing surgical time, intraoperative blood loss, and postoperative complications [72]. Hur compared the 5-year survival outcomes of standard gastric resection and sentinel lymph node navigation surgery in early-stage GC patients, finding no significant differences in disease-free survival and overall survival rates between the two groups [73]. Nonetheless, given the superior control of intraoperative bleeding and postoperative complications in sentinel lymph node navigation surgery, it remains the preferred option. Another prospective study demonstrated that postoperative outcomes of local gastric resection with dual-modality endoscopy were superior to those of laparoscopic distal gastric resection in terms of esophageal reflux and residual gastritis, as well as in nutritional status and weight control [74]. Chen retrospectively analyzed the outcomes of 15 early-stage GC patients treated with dual-modality endoscopy [75]. Findings revealed that, during follow-up periods of 6–26 months, none of the patients experienced tumor recurrence or metastasis. Three patients received B-grade nutritional scores 3–6 months postoperatively due to positive vertical margins, necessitating additional standard distal gastric resection and D2 lymph node dissection. Four patients developed gastric emptying disorders postoperatively, all of whom recovered well following symptomatic treatment. No cases of postoperative bleeding, abdominal infection, or incision infection were reported. Hashimoto's follow-up of 201 patients found that one patient developed an anastomotic fistula postoperatively, and another experienced gastric emptying disorder. No cases of anastomotic stricture or dumping syndrome were reported. One patient experienced recurrence 18 months postoperatively and succumbed to the primary disease 86 months postoperatively. Another patient exhibited reduced oral intake and weight loss, shedding 10 kg in the first three months and 14 kg by the 14th month postoperatively, followed by gradual recovery. Multiple endoscopic examinations revealed no abnormalities, potentially attributable to psychological factors [76]. These research outcomes collectively affirm the safety and feasibility of dual-modality endoscopy treatment, warranting further exploration.

The aforementioned studies, though focused on early-stage GC patients, are equally applicable to those undergoing non-curative resections. The author posits that with the continuous refinement and improvement of lymph node navigation technology and the establishment of more precise staging criteria, the next phase of research may involve multicenter prospective clinical trials. These trials would compare the efficacy of function-preserving gastrectomy with that of dual-modality combined therapy, focusing on long-term survival rates and postoperative quality of life.

Future prospects

In the surgical treatment of GC, ensuring tumor eradication while enhancing patient quality of life is paramount. Function-preserving surgery for GC not only addresses the urgent need for high-quality living among patients but also aligns with the inevitable trend of the future's precision medicine concept. The key research focus for future surgical approaches will be how to further minimize surgical scope while maximally preserving gastric function. Sentinel lymph node navigation, metastatic lymph node tracing technologies, and dual-modality combined treatments represent the future direction of development. Simultaneously, the establishment of more precise and individualized GC treatments will be a future trend. Currently, most function-preserving surgical techniques for GC remain in the exploratory stage, requiring more high-level evidence-based medical data to validate their superiority and to refine operational methods and procedures.

Acknowledgements
Not applicable.

Authors' contributions

SQZ conducted research and drafted the initial manuscript; LYH and ZF optimized the illustrations and revised the draft; HZP formulated the research direction and guided the logic of article writing. All authors approved the final version of the manuscript.

Funding

This work was supported by National Natural Science Foundation of China (No. 82460559), Gansu Provincial Joint Scientific Research Fund Major Project(No. 25JRRA1264),Gansu Province Health Industry Science and Technology Innovation Major Projects (No. GSWSKY2024-06),the Cuiying Scientific and Technological Innovation Program of the Second Hospital of Lanzhou University (CY2022-YB-A04, CY2023-MS-B17, CY2024-MS-B18).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The formal ethical review was waived by our institutional review board.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]The Second Hospital & Clinical Medical School, Lanzhou University, Lanzhou, China
[2]Key Laboratory of the Environmental Oncology of Gansu Province, The Second Hospital & Clinical Medical School, Lanzhou University, Lanzhou, China
[3]Department of Surgical Oncology, The Second Hospital & Clinical Medical School, Lanzhou University, Lanzhou 730000, China

Received: 27 July 2025 / Accepted: 19 September 2025
Published online: 13 October 2025

References

1. Bray F, Laversanne M, Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229–63. https://doi.org/10.3322/caac.21834.
2. Gastroenterology Group of the Surgery Branch of the Chinese Medical Association, Oncology Surgery Branch of the Chinese Medical Association, Gastroenterology Group of the Surgeons Branch of the Chinese Medical Association. Consensus of experts in the surgery branch of the Chinese medical association (2021 Edition). Chin J Gastroenterol Surg. 2021;24(05):377–82. https://doi.org/10.3760/cma.j.issn.441530-20210305-00102.
3. Hiramatsu Y, Kikuchi H, Takeuchi H. Function-preserving gastrectomy for early gastric cancer. Cancers. 2021;13(24):6223. https://doi.org/10.3390/cancers13246223.
4. Han F, Xie Y. Development and current status of resection and reconstruction methods for proximal gastric cancer surgery. Chin J Gen Surg. 2024;33(04):531–8. https://doi.org/10.7659/j.issn.1005-6947.2024.04.002.
5. Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2021 (6th edition). Gastric Cancer. 2023;26(1):1–25. https://doi.org/10.1007/s10120-022-01331-8.
6. Chen Y, Zhao L, Hu S et al. Clinical outcomes of proximal gastrectomy versus total gastrectomy for locally advanced proximal gastric cancer: a propensity score matching analysis - ScienceDirect.Annals of Oncology, 30[2024-10-18]. https://doi.org/10.1093/annonc/mdz422.025
7. Zhibin Bi Y, Li M, Han, et al. Feasibility and preliminary efficacy analysis of modified Dual-Channel anastomosis in Gastrointestinal reconstruction after proximal gastrectomy. Chin J Gen Surg. 2024;33(04):624–33. https://doi.org/10.7659/j.issn.1005-6947.2024.04.012.
8. Ying K, Bai W, Yan G, et al. The comparison of long-term oncological outcomes and complications after proximal gastrectomy with double tract reconstruction versus total gastrectomy for proximal gastric cancer. World J Surg Oncol. 2023;21(1):101. https://doi.org/10.1186/s12957-023-02985-z.
9. Li Y, Wu J, Han M, et al. Modified Double-Tract reconstruction in Gastrointestinal reconstruction after proximal gastrectomy. J Coll Physicians Surgeons–Pakistan: JCPSP. 2024;34(11):1632–5. https://doi.org/10.29271/jcpsp.2024.11.1632.
10. Lu S, Ma F, Zhang Z, et al. Various kinds of functional digestive tract reconstruction methods after proximal gastrectomy. Front Oncol. 2021;11:685717. https://doi.org/10.3389/fonc.2021.685717.
11. Li L, Liu Z, Cai X, et al. Cardia function-preserving surgery and anti-reflux anastomotic method after proximal gastrectomy for gastric cancer: current status and future perspectives. Front Oncol. 2022;12:1000719. https://doi.org/10.3389/fonc.2022.1000719.
12. Aizawa M, Yabusaki H, Nakada K, et al. Simple modifications of conventional esophagogastrostomy after proximal gastrectomy adequately reduces the postoperative reflux esophagitis: a retrospective analysis of posterolateral fundoplication. Langenbecks Arch Surg. 2022;407(7):3153–60. https://doi.org/10.1007/s00423-022-02628-z.
13. Ojima T, Nakamori M, Nakamura M, et al. Fundoplication with 180-degree wrap during esophagogastrostomy after robotic proximal gastrectomy for early gastric cancer. J Gastrointest Surg. 2018;22(8):1–2. https://doi.org/10.1007/s11605-018-3765-2.
14. Shiraishi N, Hirose R, Morimoto A, et al. Gastric tube reconstruction prevented esophageal reflux after proximal gastrectomy. Gastric Cancer. 1998;1:78–9. https://doi.org/10.1007/s101209800023.
15. Fu J, Li Y, Liu X, et al. Clinical outcomes of proximal gastrectomy with gastric tubular reconstruction and total gastrectomy for proximal gastric cancer: a matched cohort study. Front Surg. 2023;9:1052643. https://doi.org/10.3389/fsurg.2022.1052643.
16. Cheng XD, Xu ZY, Du YA, et al. Preliminary efficacy analysis of cheng's giraffe reconstruction after proximal gastrectomy in adenocarcinoma of esophagogastric junction. Chin J Gastrointest Surg. 2020;23(2):158–62. https://doi.org/10.3760/cma.j.issn.1671-0274.2020.02.011.
17. Zhang YQ, Xu ZY, Du YA, et al. Functional outcomes of 100 patients with adenocarcinoma of the esophagogastric junction undergoing cheng's GIRAFFE (®) reconstruction after proximal gastrectomy. Chin J Gastrointest Surg. 2022;25(5):447–53. https://doi.org/10.3760/cma.j.cn441530-20220414-00146.
18. Li L, Cai X, Liu Z, et al. Digestive tract reconstruction after laparoscopic proximal gastrectomy for gastric cancer: a systematic review. J Cancer. 2023;14(16):3139. https://doi.org/10.7150/jca.87315.
19. Kuroda S, Nishizaki M, Kikuchi S, et al. Double-flap technique as an antireflux procedure in esophagogastrostomy after proximal gastrectomy. J Am Coll Surg. 2016;223(2):e7–13. https://doi.org/10.1016/j.jamcollsurg.2016.04.041.
20. Kuroda S, Choda Y, Otsuka S, et al. Multicenter retrospective study to evaluate the efficacy and safety of the double-flap technique as antireflux esophagogastrostomy after proximal gastrectomy (rD-FLAP study). Ann Gastroenterol Surg. 2018;3(1):96–103. https://doi.org/10.1002/ags3.12216.
21. Shoji Y, Nunobe S, Ida S, et al. Surgical outcomes and risk assessment for anastomotic complications after laparoscopic proximal gastrectomy with double-flap technique for upper-third gastric cancer. Gastric Cancer. 2019;22(5):1036–43. https://doi.org/10.1007/s10120-019-00940-0.
22. Wang Y, Li Z, Ji J. Key points and challenges in the arch-style reconstruction of laparoscopic-assisted proximal gastrectomy. Chin J Pract Surg. 2022;42(10):1194–6. https://doi.org/10.19538/j.cjps.issn1005-2208.2022.10.25.
23. Yamashita Y, Yamamoto A, Tamamori Y, et al. Side overlap esophagogastrostomy to prevent reflux after proximal gastrectomy. Gastric Cancer. 2017;20:728–35. https://doi.org/10.1007/s10120-016-0674-5.
24. Yamashita Y, Tatsubayashi T, Okumura K, et al. Modified side overlap esophagogastrostomy after laparoscopic proximal gastrectomy. Ann Gastroenterol Surg. 2022;6(4):594–9. https://doi.org/10.1002/ags3.12549.
25. Kameyama JI, Ishida H, Yasaku Y, et al. Proximal gastrectomy reconstructed by interposition of a jejunal pouch. Surg Technique Eur J Surg. 1993;159(9):491–3.
26. Ahn SH, Jung DH, Son SY, et al. Laparoscopic double-tract proximal gastrectomy for proximal early gastric cancer. Gastric Cancer. 2014;17:562–70. https://doi.org/10.1007/s10120-013-0303-5.
27. Sato R, Kinoshita T, Akimoto E, et al. Feasibility and quality of life assessment of laparoscopic proximal gastrectomy using double-tract reconstruction. Langenbecks Arch Surg. 2021;406:479–89. https://doi.org/10.1007/s00423-020-02076-7.

28. Wang L, Xia Y, Jiang T, et al. Short-term surgical outcomes of laparoscopic proximal gastrectomy with Double-Tract reconstruction versus laparoscopic total gastrectomy for adenocarcinoma of esophagogastric junction: a Matched-Cohort study. J Surg Res. 2020;246:292–9. https://doi.org/10.1016/j.jss.2019.09.022.
29. Tian P, Liu Y, Bian S, et al. Laparoscopic proximal gastrectomy versus laparoscopic total gastrectomy for proximal gastric cancer: a systematic review and meta-analysis. Front Oncol. 2021;10:607922. https://doi.org/10.3389/fonc.2020.607922.
30. Aburatani T, Kojima K, Otsuki S, et al. Double-tract reconstruction after laparoscopic proximal gastrectomy using detachable ENDO-PSD. Surg Endosc. 2017;31(11):4848–56. https://doi.org/10.1007/s00464-017-5539-4.
31. Kim DJ, Kim W. Laparoscopy-assisted proximal gastrectomy with double tract anastomosis is beneficial for vitamin B12 and iron absorption. Anticancer Res. 2016;36(9):4753–8. https://doi.org/10.21873/anticanres.11031.
32. Nomura E, Kayano H, Lee SW, et al. Functional evaluations comparing the double-tract method and the jejunal interposition method following laparoscopic proximal gastrectomy for gastric cancer: an investigation including laparoscopic total gastrectomy. Surg Today. 2019;49(1):38–48. https://doi.org/10.1007/s00595-018-1699-7.
33. Cao H, Li ZY, Zhao G, et al. Expert consensus and operating guidelines on gastric resection with preservation of the pylorus (2019 Edition). Chin J Practical Surg. 2019;39(05):412–8. https://doi.org/10.19538/j.cjps.issn1005-2208.2019.05.02.
34. Oh SY, Lee HJ, Yang HK. Pylorus-preserving gastrectomy for gastric cancer. J Gastric Cancer. 2016;16(2):63–71. https://doi.org/10.5230/jgc.2016.16.2.63.
35. Sun KK, Wu YY. Pylorus-preserving gastrectomy for early gastric cancer. World J Gastrointest Oncol. 2024;16(3):653–8. https://doi.org/10.4251/wjgo.v16.i3.653.
36. Kosuga T, Tsujiura M, Nakashima S, et al. Current status of function-preserving gastrectomy for gastric cancer. Ann Gastroenterol Surg. 2021;5(3):278–86. https://doi.org/10.1002/ags3.12430.
37. Ohashi M, Hiki N, Ida S, et al. A novel method of intracorporeal end-to-end gastrogastrostomy in laparoscopic pylorus-preserving gastrectomy for early gastric cancer, including a unique anastomotic technique: piercing the stomach with a linear stapler. Surg Endosc. 2018;32(10):4337–43. https://doi.org/10.1007/s00464-018-6237-6.
38. Jeong SH, Park M, Seo KW, et al. A comparative study of postoperative complications associated with distal gastrectomy and pylorus-preserving gastrectomy among gastric cancer patients based on nationwide survey data and propensity score weighting. Cancers (Basel). 2024;16(12):2203. https://doi.org/10.3390/cancers16122203.
39. Mao X, Xu X, Zhu H, et al. A comparison between pylorus-preserving and distal gastrectomy in surgical safety and functional benefit with gastric cancer: a systematic review and meta-analysis. World J Surg Oncol. 2020;18(1):160. https://doi.org/10.1186/s12957-020-01910-y.
40. Wang CJ, Kong SH, Park JH, et al. Preservation of hepatic branch of the vagus nerve reduces the risk of gallstone formation after gastrectomy. Gastric Cancer. 2021;24(1):232–44. https://doi.org/10.1007/s10120-020-01106-z.
41. Tanaka C, Kanda M, Misawa K, et al. The long-term quality of life after distal and pylorus-preserving gastrectomy for stage I gastric cancer: a prospective multi-institutional study (CCOG1601). Surg Today. 2025;55(2):162–71. https://doi.org/10.1007/s00595-024-02881-3.
42. Morita S, Katai H, Saka M, Fukagawa T, Sano T, Sasako M. Outcome of pylorus-preserving gastrectomy for early gastric cancer. Br J Surg. 2008;95(9):1131–5. https://doi.org/10.1002/bjs.6295.
43. Shibata C, Shiiba KI, Funayama Y, et al. Outcomes after pylorus-preserving gastrectomy for early gastric cancer: a prospective multicenter trial. World J Surg. 2004;28(9):857–61. https://doi.org/10.1007/s00268-004-7369-5.
44. Saito Y, Takahashi T, Nishida T, et al. Long-term outcomes of pylorus-preserving gastrectomy for early gastric cancer. Am Surg. 2024;90(3):386–92. https://doi.org/10.1177/00031348231200671.
45. Lee HJ, Kim YW, Park DJ, et al. Laparoscopic pylorus-preserving gastrectomy versus distal gastrectomy for early gastric cancer: a multicenter randomized controlled trial (KLASS-04). Ann Surg. 2025;281(4):573–81. https://doi.org/10.1097/SLA.0000000000006503.
46. Park DJ, Kim YW, Yang HK, et al. Short-term outcomes of a multicentre randomized clinical trial comparing laparoscopic pylorus-preserving gastrectomy with laparoscopic distal gastrectomy for gastric cancer (the KLASS-04 trial). Br J Surg. 2021;108(9):1043–9. https://doi.org/10.1093/bjs/znab295.
47. Kim J, Kim S, Min YD. Consideration of cardia preserving proximal gastrectomy in early gastric cancer of upper body for prevention of gastroesophageal reflux disease and stenosis of anastomosis site. J Gastric Cancer. 2012;12(3):187–93. https://doi.org/10.5230/jgc.2012.12.3.187.
48. Shinohara T, Ohyama S, Muto T, Kato Y, Yanaga K, Yamaguchi T. Clinical outcome of high segmental gastrectomy for early gastric cancer in the upper third of the stomach. Br J Surg. 2006;93(8):975–80. https://doi.org/10.1002/bjs.5388.
49. Ishikawa K, Arita T, Ninomiya S, Bandoh T, Shiraishi N, Kitano S. Outcome of segmental gastrectomy versus distal gastrectomy for early gastric cancer. World J Surg. 2007;31(11):2204–7. https://doi.org/10.1007/s00268-007-9192-2.
50. Matsuda T, Kaneda K, Takamatsu M, et al. Segmental gastrectomy with radical lymph node dissection for early gastric cancer. World J Gastroenterol. 2010;16(41):5247–51. https://doi.org/10.3748/wjg.v16.i41.5247.
51. Kinami S, Kaida D, Okamoto K, et al. Long–term survival prognosis of function–preserving curative gastrectomy for early gastric cancer. Oncol Lett. 2024;27(3):115. https://doi.org/10.3892/ol.2024.14248.
52. Hiki N, Nunobe S. Laparoscopic endoscopic cooperative surgery (LECS) for the gastrointestinal tract: updated indications. Ann Gastroenterol Surg. 2019;3(3):239–46. https://doi.org/10.1002/ags3.12238.
53. Nunobe S, Hiki N, Gotoda T, et al. Successful application of laparoscopic and endoscopic cooperative surgery (LECS) for a lateral-spreading mucosal gastric cancer. Gastric Cancer. 2012;15(3):338–42. https://doi.org/10.1007/s10120-012-0146-5.
54. Vanella S, Godas M, Pereira JC, Pereira A, Apicella I, Crafa F. Laparoscopic and endoscopic cooperative surgery for full-thickness resection and sentinel node dissection for early gastric cancer. World J Gastrointest Endosc. 2022;14(8):508–11. https://doi.org/10.4253/wjge.v14.i8.508.
55. Aisu Y, Yasukawa D, Kimura Y, Hori T. Laparoscopic and endoscopic cooperative surgery for gastric tumors: perspective for actual practice and oncological benefits. World J Gastrointest Oncol. 2018;10(11):381–97. https://doi.org/10.4251/wjgo.v10.i11.381.
56. An JY, Min JS, Hur H, et al. Laparoscopic sentinel node navigation surgery versus laparoscopic gastrectomy with lymph node dissection for early gastric cancer: short-term outcomes of a multicentre randomized controlled trial (SENORITA). Br J Surg. 2020;107(11):1429–39. https://doi.org/10.1002/bjs.11655.
57. Kim YW, Min JS, Yoon HM, et al. Laparoscopic sentinel node navigation surgery for stomach preservation in patients with early gastric cancer: a randomized clinical trial. J Clin Oncol. 2022;40(21):2342–51. https://doi.org/10.1200/JCO.21.02242.
58. Oh SE, An JY, Min JS, et al. Determining the precise extent of Sentinel basins during laparoscopic gastrectomy for early gastric cancer. World J Surg Oncol. 2023;21(1):60. https://doi.org/10.1186/s12957-023-02953-7.
59. Booka E, Takeuchi H. Recent advances in sentinel node navigation surgery for early gastric cancer. J Gastric Cancer. 2023;23(1):159. https://doi.org/10.5230/jgc.2023.23.e4.
60. Huang Y, Pan M, Deng Z, et al. How useful is sentinel lymph node biopsy for the status of lymph node metastasis in cT1N0M0 gastric cancer? A systematic review and meta-analysis. Update Surg. 2021;73:1275–84. https://doi.org/10.1007/s13304-021-01026-2.
61. Mayanagi S, Takahashi N, Mitsumori N, et al. Sentinel node mapping for post-endoscopic resection gastric cancer: multicenter retrospective cohort study in Japan. Gastric Cancer. 2020;23(4):716–24. https://doi.org/10.1007/s10120-019-01038-3.
62. Aoyama J, Kawakubo H, Goto O, et al. Potential for local resection with sentinel node basin dissection for early gastric cancer based on the distribution of primary sites. Gastric Cancer. 2019;22(2):386–91. https://doi.org/10.1007/s10120-018-0865-3.
63. Takahashi N, Nimura H, Fujita T, et al. Laparoscopic sentinel node navigation surgery for early gastric cancer: a prospective multicenter trial. Langenbecks Arch Surg. 2017;402(1):27–32. https://doi.org/10.1007/s00423-016-1540-y.
64. Eom BW, Yoon HM, Kim YW, et al. Quality of life and nutritional outcomes of stomach-preserving surgery for early gastric cancer: a secondary analysis of the SENORITA randomized clinical trial. JAMA Surg. 2024;159(8):900–8. https://doi.org/10.1001/jamasurg.2024.1210.
65. Kinami S, Nakamura N, Miyashita T, et al. Life prognosis of Sentinel node navigation surgery for early-stage gastric cancer: outcome of lymphatic basin dissection. World J Gastroenterol. 2021;27(46):8010–30. https://doi.org/10.3748/wjg.v27.i46.8010.
66. Kitagawa Y, Takeuchi H, Takagi Y, et al. Sentinel node mapping for gastric cancer: a prospective multicenter trial in Japan. J Clin Oncol. 2013;31(29):3704–10. https://doi.org/10.1200/JCO.2013.50.3789.

67. Deng Jingyu R. Clinical controversies and research considerations regarding lymph node dissection in gastric cancer. Chin J Gastrointest Surg. 2022;25(4):361–6. https://doi.org/10.3760/cma.j.cn441530-20220120-00027.
68. Kim SG, Eom BW, Yoon HM, et al. Recent updates and current issues of sentinel node navigation surgery for early gastric cancer. Chin J Cancer Res. 2021;33(2):142–9. https://doi.org/10.21147/j.issn.1000-9604.2021.02.02.
69. Zhang Y, Uehara T, Toyota T, et al. Stannous colloid mixed with indocyanine green as a tracer for sentinel lymph node navigation surgery. Sci Rep. 2022;12(1):17056. https://doi.org/10.1038/s41598-022-21420-z.
70. ZeLong Y, ZhenYu C, JianHai L, et al. Influence of tumor location on lymph node metastasis and survival for early gastric cancer: a population-based study. J Gastrointest Surg. 2020;24(9):1978–86. https://doi.org/10.1007/s11605-019-04367-x.
71. Hiki N, Yamamoto Y, Fukunaga T, et al. Laparoscopic and endoscopic cooperative surgery for gastrointestinal stromal tumor dissection. Surg Endosc. 2008;22(7):1729–35. https://doi.org/10.1007/s00464-007-9696-8.
72. Zhang Z, Deng C, Guo Z, et al. Safety and efficacy of indocyanine green near-infrared fluorescent imaging-guided lymph node dissection during robotic gastrectomy for gastric cancer: a systematic review and meta-analysis. Minim Invasive Ther Allied Technol. 2023;32(5):240–8. https://doi.org/10.1080/13645706.2023.2165415.
73. Hur H, Lee YJ, Kim YW, et al. Clinical efficacy of laparoscopic sentinel node navigation surgery for stomach preservation in patients with early gastric cancer: 5-year results of the SENORITA trial. Ann Surg. 2024. https://doi.org/10.1097/SLA.0000000000006219.
74. Okubo K, Arigami T, Matsushita D, et al. Evaluation of postoperative quality of life by PGSAS-45 following local gastrectomy based on the Sentinel lymph node concept in early gastric cancer. Gastric Cancer. 2020;23:746–53. https://doi.org/10.1007/s10120-020-01047-7.
75. Chen C, Li D, Zhang Z, et al. Exploration of the clinical application of combined laparoscopy and endoscopy surgery in early gastric cancer: A report of 15 cases. Chin J Gastrointest Surg. 2023;26(08):757–62. https://doi.org/10.3760/cma.j.cn441530-20230504-00143.
76. Hashimoto Y, Abe N, Nunobe S, et al. Outcomes of laparoscopic and endoscopic cooperative surgery for gastric submucosal tumors: a retrospective multicenter study at 21 Japanese institutions. Ann Gastroenterol Surg. 2024;8(5):778–86. https://doi.org/10.1002/ags3.12787.

Publisher's Note