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# A Novel Esophagogastrostomy Technique for Laparoscopic Proximal Gastrectomy: Conical Remnant Gastroesophageal Side-overlap Fundoplication

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**Abstract.** *Background: There is currently no universally-accepted, ideal method of esophagogastric reconstruction to address reflux esophagitis and anastomotic complications of esophagogastrostomy after proximal gastrectomy. Case Report: In June 2022, two patients with Siewert type II carcinoma of esophagogastric junction underwent laparoscopic proximal gastrectomies, using a novel esophagogastrostomy technique of Conical remnant GastroEsophageal side-Overlap fundoplication (CGEO). On postoperative day 4, upper gastrointestinal fluoroscopy was performed, with patients in downward and left oblique positions, allowing gastrografin to accumulate within fundic reconstructions. No reflux into the esophagus was subsequently observed, and both patients were discharged (postoperative days 9 and 11). Six months after surgery, endoscopic view showed that the reconstructed cardia returned to its normal state, in the absence of any reflux symptoms. As of April 2023, we have operated on four patients using CGEO, and all of them recovered without obvious reflux symptoms. Conclusion: CGEO is a feasible and safe reconstructive esophagogastrostomy procedure following laparoscopic proximal gastrectomy for Siewert type II esophagogastric junction carcinoma.*

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Over the past four decades, the incidence of adenocarcinoma at the esophagogastric junction has increased significantly (1, 2). In instances of upper gastric cancer or partial esophagogastric junction cancer, total gastrectomy is the standard surgical intervention (3). This enables radical removal of any distal gastric nodal metastases (4). It also helps avoid the development of severe reflux esophagitis after proximal gastrectomy (5). However, various nutritional metabolic derangements may unavoidably result from total gastrectomy. Efforts to preserve gastric function have thus gradually gained momentum in recent years (6).

Although proximal gastrectomy allows for retention of distal stomach function, the anatomy of the esophagogastric junction is destroyed, and the capacity to prevent reflux is lost. Consequently, there is an inherent propensity for severe reflux esophagitis and anastomotic stenosis after surgery. Various anti-reflux methods of gastrointestinal reconstruction have continued to emerge in this setting (7-9), but a standard proximal gastric reconstruction procedure has not been embraced (10-12).

This study is focused on a new Conical remnant GastroEsophageal side-Overlap fundoplication (CGEO) technique for esophagogastrostomy after laparoscopic proximal gastrectomy. The CGEO procedure has advantages for gastric tube reconstruction and side-to-side overlap anastomosis of the esophagus to gastric remnant and is suitable for radical resection of type II esophagogastric junction carcinoma or proximal gastric cancer.

## Case Report

This work conforms with the SCARE criteria. The Ethics Committee of the Chinese National Cancer Center Shenzhen

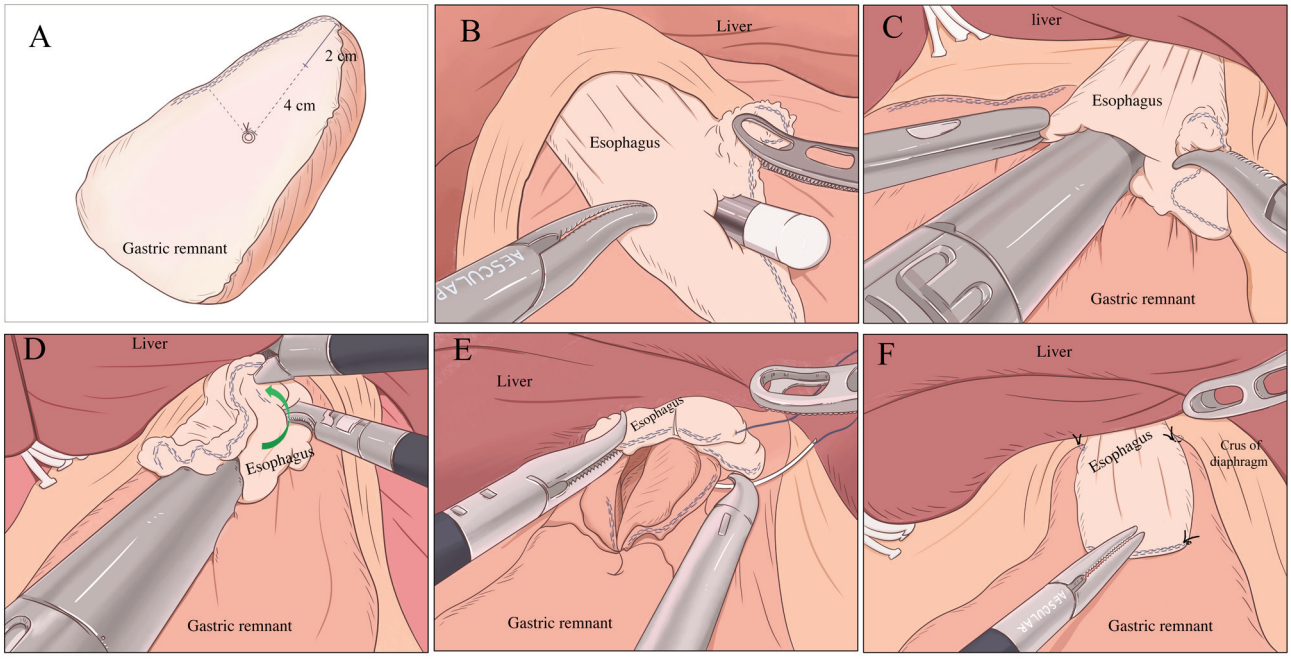


Figure 1. *Schematic illustration of CGEO: (A) Opening (~1 cm) made in the anterior gastric wall at the center of the tapered base (6 cm caudally), placing one support suture at the orifice to prevent linear stapling into submucosa; (B) Full-thickness esophageal excision (1 cm) on the right side of the esophageal stump, nasogastric tube remaining within abdomen as guide during anastomosis; (C) Linear stapler inclined to the anterior wall of the residual stomach, metal anvil plate inserted into esophagus along the ventral side of nasogastric tube; (D) Rotation of esophageal stump 90° counterclockwise, bringing its right aspect in contact with the anterior of the gastric remnant to achieve esophagogastrostomy (at ~4 cm); (E) Closure of the entry hole using barbed running sutures; and (F) Left/right edges of remnant gastric stump sutured to the crus of the diaphragm (with esophageal stump), the left lower parietal peritoneal angle of esophagus attached to the gastric wall by single stitch (to flatten esophageal stump), and the valvuloplasty of the esophageal stump completed.*

Hospital approved the study, and all study participants provided their informed consent.

Patient 1 was a 71-year-old man diagnosed with cancer (Siewert type II) of the esophagogastric junction, staged preoperatively as T3N0M0. Laparoscopic proximal gastrectomy with CGEO reconstruction was undertaken on June 1, 2022.

Patient 2 was an 82-year-old man diagnosed with cancer (Siewert type II) of the esophagogastric junction. Imaging details indicated stage T4N2M0. After four cycles of neoadjuvant chemotherapy and two cycles of immunotherapy, the tumor had regressed significantly, downgrading preoperative staging to T2N0M0. Laparoscopic proximal gastrectomy and CGEO reconstruction were performed on June 15, 2022.

*Surgical procedures*. Laparoscopic proximal gastrectomy. Patients assumed reverse Trendelenburg positions, with legs open and the surgeon situated to their right. Laparoscopic ultrasound coagulation scissors (Harmonic; Ethicon Endo-surgery Inc, Cincinnati, OH, USA) were primarily used for purposes of nodal dissection and gastric mobilization. D2 lymphadenectomy was conducted according to Japanese Gastric Cancer Association treatment guidelines. We preserved the right gastric and right gastroepiploic arteries, supplying blood to the gastric remnant. After dissecting No. 4sb and No. 3 lymph nodes, the lesser curvature of the stomach was partially severed *via* the first linear stapler just for 30-mm to ensure the tumor resection margin at the distance from the esophageal cardia. We then dissected the stomach at an acute angle to large curvature, leaving a conically shaped gastric remnant (Ethicon ECHELON FLEX Powered ENDOPATH; 60-mm blue cartridges; Johnson & Johnson, New Brunswick, NJ, USA).

The abdominal esophagus was fully mobilized, transecting its lower end by linear stapler, and sampling the area for rapid frozen sections. Sufficient tissue (5-cm segment) at the esophageal excision line was removed, relying on more proximal esophagus for safe reconstruction.

*Conical remnant gastroesophageal side-overlap fundoplication (CGEO)*. Determining the anastomotic site of the residual stomach and esophagus. The proximal apex of the greater gastric curvature was tapered, creating an opening (~1 cm) in the anterior gastric wall at the center of the tapered base (6 cm

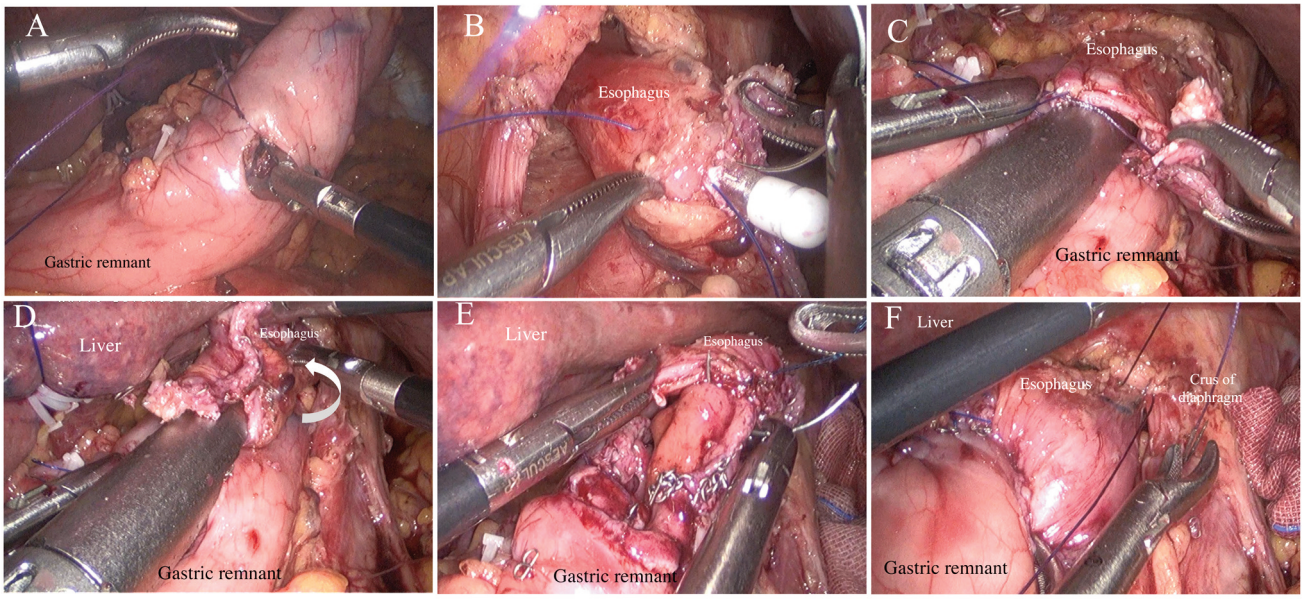


Figure 2. *Intraoperative views of CGEO: (A) Opening (~1 cm) made in the anterior gastric wall at the center of the tapered base (6 cm caudally), placing one support suture at the orifice to prevent linear stapling into submucosa; (B) Full-thickness esophageal excision (1 cm) on the right side of the esophageal stump, nasogastric tube remaining within abdomen as guide during anastomosis; (C) Linear stapler inclined to the anterior wall of the residual stomach, metal anvil plate inserted into esophagus along the ventral side of nasogastric tube; (D) Rotation of esophageal stump 90˚ counterclockwise, bringing its right aspect in contact with the anterior of the gastric remnant to achieve esophagogastrostomy (at ~4 cm); (E) Closure of the entry hole using barbed running sutures; and (F) Left/right edges of remnant gastric stump sutured to the crus of the diaphragm (with esophageal stump), the left lower parietal peritoneal angle of esophagus attached to the gastric wall by single stitch (to flatten esophageal stump), and the valvuloplasty of the esophageal stump completed.*

caudally). A single support suture was placed at the orifice to prevent linear stapling into submucosal layer (Figure 1A and Figure 2A). We excised ~1 cm of esophageal wall (full thickness) along the stapler line on the right aspect of esophageal stump. The full wall was then affixed using two running sutures as a support measure. The anesthesiologist made the required adjustments of nasogastric tube, which remained within the abdomen as a guide during anastomosis (Figure 1B and Figure 2B).

*Side-to-side anastomosis of the right esophageal wall to anterior of conical gastric remnant*. The liner stapler (60-mm blue cartridge) was applied to the anterior wall of the residual stomach, inserting its metal anvil plate into the esophagus along the ventral side of the nasogastric tube (Figure 1C and Figure 2C). Our assistant rotated the esophageal stump 90˚ counterclockwise, bringing its right aspect in contact with the anterior wall of gastric remnant (Figure 1D and Figure 2D). Prior to anastomosis, it is best to confirm that the anterior stomach wall is relatively uniform from left to right; and to prevent ischemia, stapling at adequate distance from the lesser gastric curvature is advised. Esophagogastrostomy was achieved at ~4 cm from the anterior gastric wall open hole. The entry hole was then closed using barbed running sutures (V-Loc 90 Device; Medtronic, Minneapolis, MN, USA) (Figure 1E and Figure 2E) for ensuring that the final diameter of esophagogastric anastomosis is above 3.5 cm.

*Valvuloplasty of the esophageal stump*. The edges of the remnant gastric stump were sutured to the crus of the diaphragm, along with the esophageal stump. The left lower parietal peritoneal angle of the esophagus was also sutured to the gastric wall, ensuring that the esophageal stump remained flat (Figure 1F and Figure 2F). We reinforced the left side of esophagus (cephalad to caudad) with barbed suture to be certain that the esophagus and the anterior gastric remnant were completely attached. Barbed suture was continued along the anastomotic entry hole to further buttress the seromuscular layer (Figure 3A).

Average operation time was 310 min, including 90 min for reconstructive esophagogastrostomy. In both patients, upper gastrointestinal fluoroscopy studies performed 4 days after respective proximal gastrectomies proved similar, showing very smooth esophageal flow of gastrografin into the residual

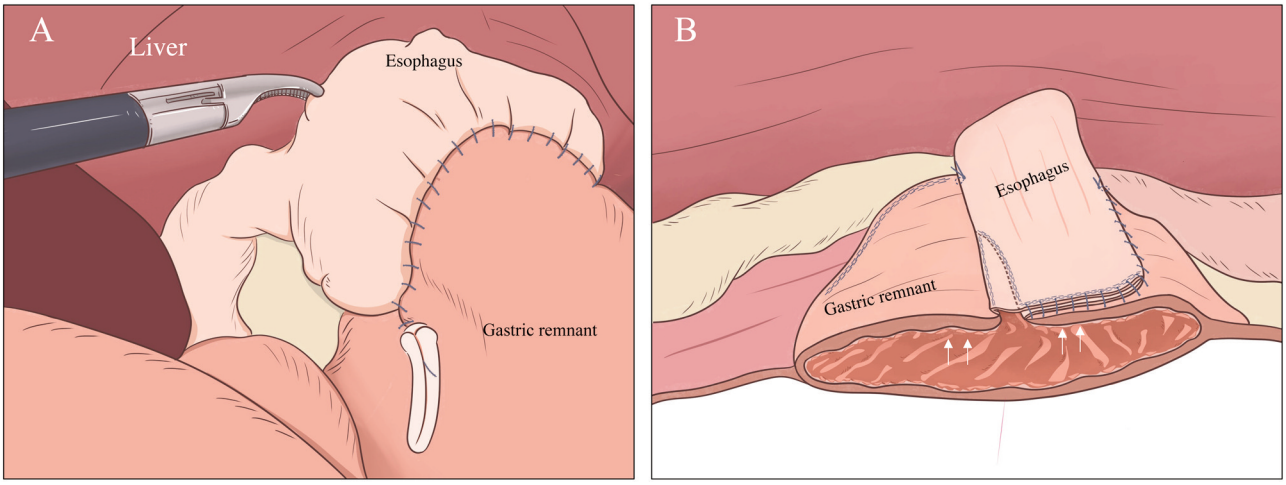


Figure 3. *Reinforcement of the anastomotic entry hole and anti-reflux mechanisms of CGEO: (A) Barbed suturing of the left esophagus (cephalad to caudad), continued along anastomotic entry hole to further buttress seromuscular layer; and (B) Anti-reflux mechanisms of CGEO (fundic reconstruction for anti-reflux; lower esophageal anastomosis to the anterior gastric wall through 90˚ rotation, keeping lower esophagus closed; and closure of the lower esophagus under high gastric pressure, front wall of the stomach forcing posterior and anterior esophageal walls together).*

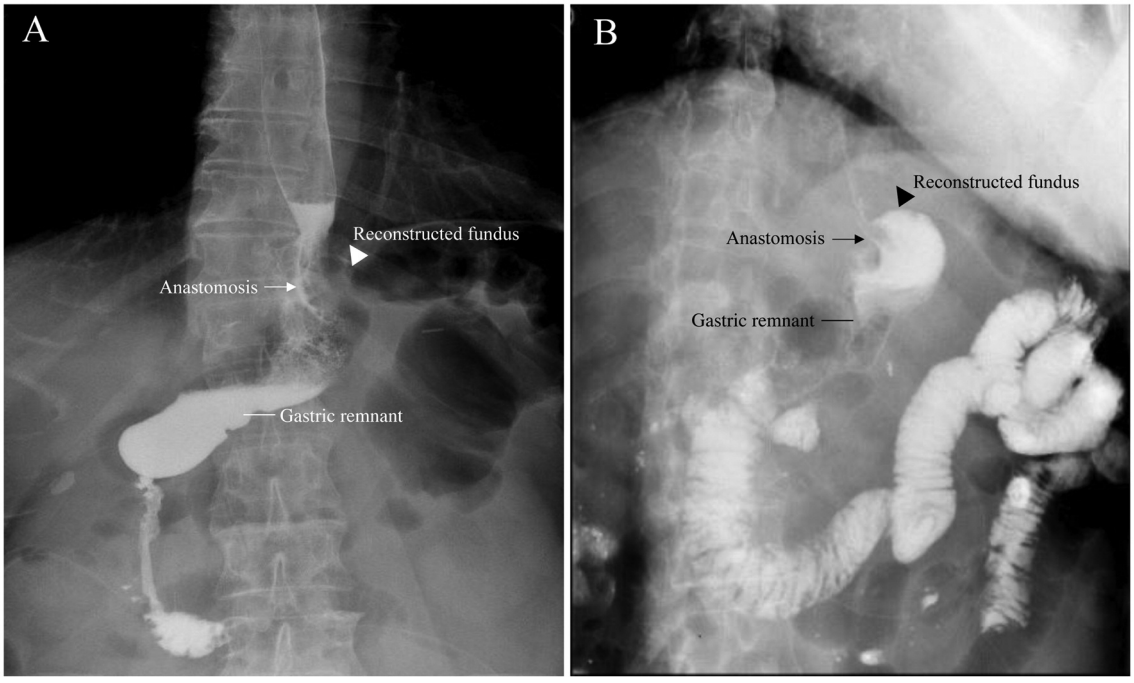


Figure 4. *Upper gastrointestinal fluoroscopy 4 days after proximal gastrectomy and CGEO: (A) Very smooth flow of gastrografin from esophagus into the residual stomach (white arrow at anastomosis; white arrowhead at the reconstructed gastric fundus); and (B) Accumulation of gastrografin in reconstructed fundus (no reflux into esophagus), with patient in downward and left oblique position (black arrow at anastomosis; black arrowhead at reconstructed gastric fundus).*

stomachs (Figure 4A). When placed in downward and left oblique positions, gastrografin accumulated in fundic reconstructions, with no evidence of esophageal reflux (Figure 4B). Both patients were promptly discharged (postoperative days 9 and 11). Postoperative pathologic staging was T0N0M0, confirming a pathologic complete response for patient 2. There was no need for adjuvant chemotherapy.

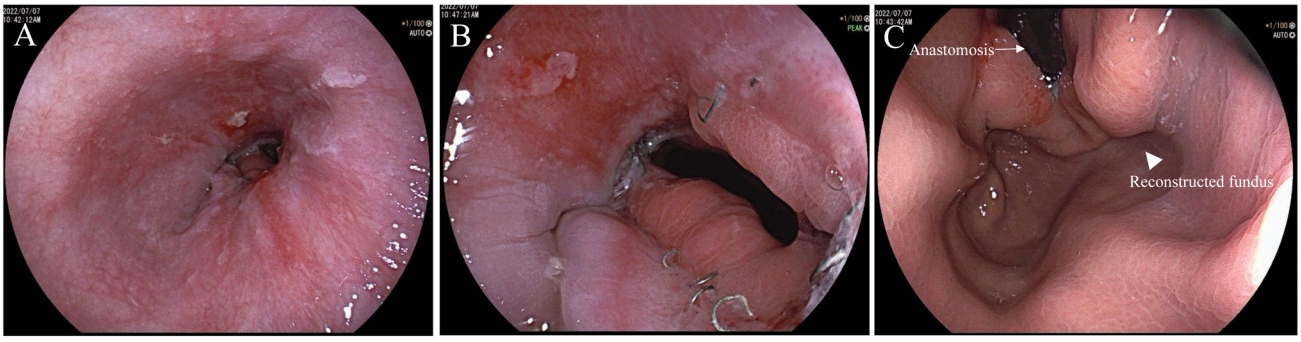


Figure 5. *Endoscopic view 1 month after proximal gastrectomy and CGEO: (A) Gastroesophageal lumen flattened by pressure on the dorsum of residual stomach (reconstructed cardia closed in natural state); (B) Anastomosis of esophageal wall (right posterior side), devoid of stenosis and easily expandable upon endoscopic ventilation; and (C) Discernible angle of His by gastroscopy, with no hiatal hernia of reconstructed cardia.*

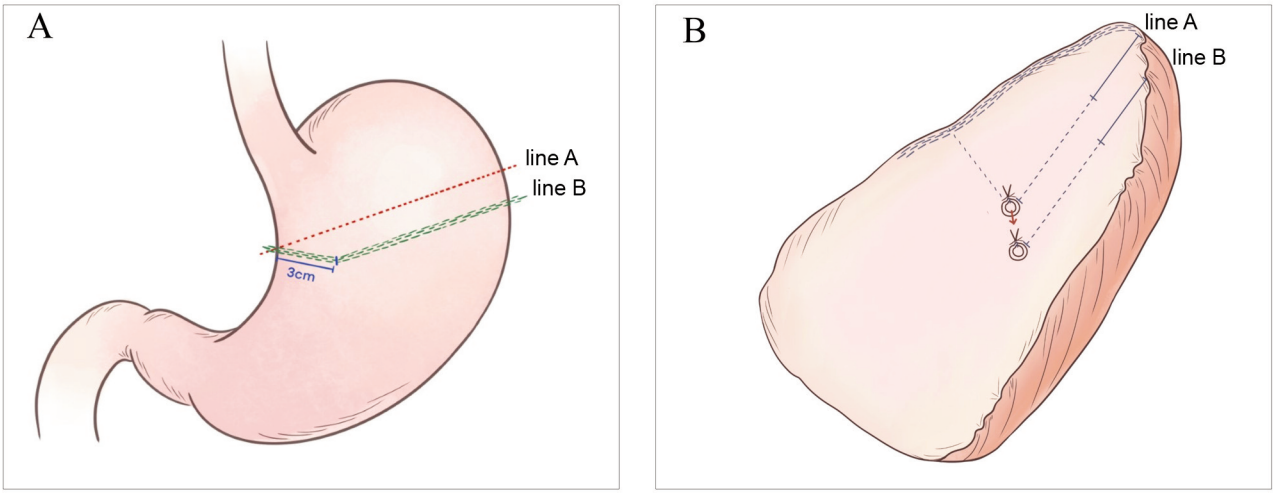


Figure 6. *Design of the conical gastric remnant: (A) Design of the conical gastric remnant along the line B to ensure the tumor resection margin at the distance from the esophageal cardia. (B) Anastomosis line can be properly closer to the greater gastric curvature for cases with small gastric remnant (along line B).*

One month after surgery, the fundic reconstructions appeared in better conditions gastroscopically. Owing to dorsal-sided pressure on the remnant stomachs, gastroesophageal lumens were flattened. Reconstructed cardias also remained closed in their natural states, displaying only mild signs of reflux esophagitis (Figure 5A). The esophageal anastomoses (of the right posterior walls) expanded easily upon endoscopic ventilation and were devoid of stenosis (Figure 5B). Gastroscopic examinations confirmed the reconstructed angles of His at the reconstructed cardias, and hiatal hernias were absent (Figure 5C). Neither patient had clinical symptoms of reflux. At postoperative month 3, weight loss relative to preoperative baseline was 2-5 kg, and testing indicated nutritional states was undiminished. As of April 2023, we have operated on four cases using CGEO, and all the patients recovered without obvious reflux symptoms.

## Discussion

Surgeons have been experimenting with new esophagogastrostomy techniques for several decades. Given the high incidence of reflux esophagitis, the traditional approach to esophagogastric anastomosis has been slowly abandoned (10). Although the double tract method is highly protective of reflux esophagitis, it calls for three anastomoses, and food diversion to the residual stomach may not be precise (10, 13). More recently, the double flap method has shown good anti-reflux efficacy, although the esophagus must be joined longitudinally to a cross-section of the residual stomach, and flap suturing within a confined inferior mediastinum is extremely difficult (14). In 2016, the side overlap with fundoplication (SOFY) developed by Dr. Yamashita greatly facilitated the reconstructive process and improved anti-

reflux effect. Unfortunately, SOFY is limited for type II cancer reconstruction in the inferior mediastinum (8). Tubular stomachs may be amenable to lower mediastinal reconstruction, considering the lesser space required and simplicity of length adjustments. However, they lack well-defined anti-reflux mechanisms, and procedures involving staplers are costly (5, 15).

During mediastinal reconstruction, the central diaphragmatic tendon is duly opened until the outer pericardium is visible, and the cru of the diaphragm is incised as needed for better field of vision. Thus, CGEO procedures offer advantages for both gastric tube reconstruction and side-to-side anastomotic overlap of the esophagus to the remnant stomach, promising to reduce dependence on the inferior mediastinal space and ease the technical demands of surgery.

The anti-reflux mechanisms of CGEO technique are as follows: 1) Fundic reconstruction for anti-reflux; 2) Anastomosis of the lower esophagus (to the anterior gastric wall) through 90˚ rotation, so it is always closed; and 3) Closure of the lower esophagus under high gastric pressure, the anterior gastric wall forcing the posterior and anterior esophageal walls together (Figure 3B). These anti-reflux principles have been demonstrated through postoperative contrast studies and during gastroscopy, even in elderly patients. Because of these anti-reflux mechanisms, CGEO might be used not only for Siewert type II, but also for Siewert type III esophagogastric junction carcinoma.

The lesser curvature of the stomach was partially severed *via* the first linear stapler just for 30-mm to ensure the tumor resection margin at the distance from the esophageal cardia along the line B not line A, which is also one of the technical points of CGEO (Figure 6A). How to ensure the blood flow between the anastomotic staple is the technical difficulty of CGEO. When designing the anastomotic location of CGEO, 2 cm away from the top of the conical gastric remnant should be retained, which effectively preserves the blood supply anterior of conical gastric remnant. In addition, for cases with small gastric remnant, anastomosis line can be properly selected to be closer to the greater gastric curvature to prevent ischemia between the staple line of conical gastric remnant (Figure 6B). However, there are only four examples of CGEO to date. Extensive long-term clinical corroboration is clearly needed.

## Conclusion

CGEO is a feasible and safe esophagogastrostomy reconstruction procedure after laparoscopic proximal gastrectomy for Siewert type II esophagogastric junction carcinoma.

## Conflicts of Interest

The Authors declare that they have no competing interests in relation to this study.

## Authors' Contributions

LMW drafted the manuscript and provided the original pictures. HYM, PDR, HJC, YYW, and YGC reviewed the manuscript. All Authors read and approved the final manuscript.

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