



# Pure single-port laparoscopic proximal gastrectomy using a novel double-flap technique

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**Abstract:** We developed a novel double-flap technique as an anti-reflux procedure following single-port laparoscopic proximal gastrectomy. After performing laparoscopic proximal gastrectomy, an H-shaped seromuscular flap is created on the anterior wall of the gastric remnant and then reconstruction procedure is started. First, the posterior esophageal wall is fixed to the stomach at the cranial edge of the submucosal window. Second, the posterior wall of the esophagus and the gastric mucosa are sutured and layer-to-layer suturing is then performed between the anterior esophagus and stomach to complete the esophagogastronomy. Finally, the anastomotic site and distal esophagus are covered with the seromuscular flap. All steps were performed using continuous barbed sutures to facilitate anastomotic procedures. The above mentioned procedure is safe and feasible for the treatment of gastric cancer with acceptable short- and mid-term results. Thus, this procedure may be an attractive surgical option as a minimally invasive surgery.

**Keywords:** Single-port laparoscopic surgery; proximal gastrectomy; gastric cancer; single-incision laparoscopic gastrectomy; esophagogastronomy

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Current trends in the field of surgery are moving toward the use of less-invasive procedures for the treatment of early gastric cancer to provide a better quality of life for patients who have received a gastrectomy (e.g., function preserving and minimally invasive surgery) (1-4). Proximal gastrectomy is currently accepted by surgeons as the most favorable operative approach for the treatment of early gastric cancer located in the upper third of the stomach due to its advantages over total gastrectomy approaches with respect to preserving the reservoir function of the remnant stomach and for preventing the development of hormonal and nutritional deficiencies (5-7). Esophagogastronomy is a theoretically optimal reconstructive method following proximal gastrectomy because it is technically simple and preserves normal bowel integrity. However, the procedure can increase the risk for postoperative complications, such as reflux esophagitis, gastric stasis, and anastomotic

stenosis (8-10). Therefore, additional procedures, such as conventional fundoplication and reconstruction of the His angle, should be performed when conducting an esophagogastronomy to decrease reflux esophagitis rates and to treat reflux symptoms (11-13). However, these procedures do not provide satisfactory results in preventing such complications.

Kamikawa developed an original valvuloplastic esophagogastronomy procedure for preventing postoperative reflux esophagitis in 1998, whereby the distal esophagus and anastomotic site were implanted into the submucosal layer and covered with an H-shaped submuscular flap in open approaches (14). Using this reconstruction procedure, an ideal pseudo-fornix and shape can be formed for the esophagogastric junction that resembles original cardia, which may in turn facilitate the delivery of suitable anti-reflux functions.

Recently, conventional multi-port laparoscopic approaches have been applied to proximal gastrectomy with this reconstruction method for the treatment of early gastric cancer to reduce the invasiveness of surgical procedures (15-17). To maximize the advantages of laparoscopic surgery techniques, surgeons have attempted to use more minimally invasive surgical approaches. Since single-incision laparoscopic distal gastrectomy for gastric cancer, in which the procedure was performed via a single transumbilical incision to minimize abdominal trauma, was first reported in 2011 (18), several studies have reported the technical feasibility, improved cosmesis results, reduced levels of postoperative pain, shortened recovery times, and acceptable oncological outcomes compared to multi-port laparoscopic approaches (19-21). However, no reports have described a single-incision laparoscopic proximal gastrectomy method involving esophagogastronomy for anti-reflux procedures because the approach is technically demanding due to the reduced number of access ports, the limited scope view, and conflicts among laparoscopic devices.

We have devised a novel technique for esophagogastronomy after proximal gastrectomy in single-port laparoscopic approaches, in which all reconstructive procedures are performed through the use of continuous barbed sutures (V-Loc™90 Device, Medtronic, Minneapolis, MN). In the present report, we describe in detail this single-port laparoscopic proximal gastrectomy with a novel double-flap esophagogastronomy and evaluate the safety and feasibility of the procedure.

## Methods

### *Patients and data collection*

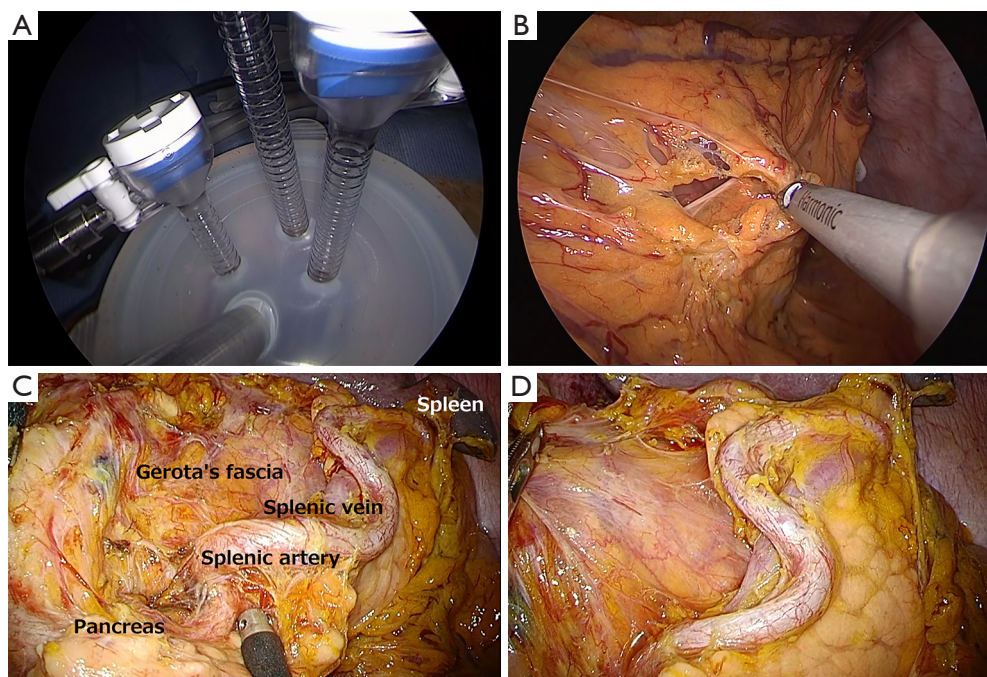
From August 2014 to February 2017, 44 patients consecutively underwent laparoscopic proximal gastrectomy for gastric carcinoma or esophagogastric junctional adenocarcinoma (32 patients underwent double-flap esophagogastronomy, 12 underwent double tract reconstruction, and 1 underwent a simple esophagogastronomy) at our institution according to a prospectively collected gastric cancer database and electronic medical records. Indications of single-port laparoscopic proximal gastrectomy include clinical T1N0 gastric cancer patients of whom the remnant stomach is more than two third and the length of the esophageal invasion of cancer is less than 1cm. TMN classifications were based on the Japanese Classification of Gastric Carcinoma—3<sup>rd</sup> English Edition (22). We retrospectively analyzed 4 patients (3 men and 1 woman)

who had consecutively undergone single-port laparoscopic proximal gastrectomy procedures based on the modified double-flap esophagogastronomy for the treatment of clinical stage I gastric carcinoma from May 2016 and December 2016. All procedures of this surgery were performed by a single surgeon (Dr. O) who had experienced over 400 single-port laparoscopic gastrectomies for the treatment of gastric cancers. In addition, he has performed over 30 esophagogastronomy with double flap technique in multiport laparoscopic proximal gastrectomy.

Data were prospectively collected and loaded into a computer database (age, gender, tumor location, pathological findings, reconstruction method used, operative outcomes, intraoperative and postoperative complications, and conversions and their causes). Postoperative parameters (time to flatus, time to oral intake, and postoperative hospital stay) were collected from medical records. Contrast radiography data were examined on the fourth postoperative day. Written informed consent was obtained from all the patients before surgery.

### **Surgical procedures**

We previously reported our surgical approach for single-incision laparoscopic gastrectomy for D1 and D2 lymph node dissection (23,24). In brief, the patient is placed in the supine position with his or her legs spread open. The surgeon is positioned between the patient's legs, and an assistant stand on each side of the patient. A transumbilical laparotomy is created through a 2.5 to 3.0 cm vertical umbilical incision, and a wound-sealing device is applied. Single-incision laparoscopic surgery is performed using a commercially available access-port (EZ access; Hakko, Nagano, Japan) (*Figure 1A*). During the procedure, a pneumoperitoneum is established with carbon dioxide insufflations at a pressure level of approximately 8 to 12 mmHg according to body type. A 10 mm flexible high-definition scope (Endoeye flexible HD camera system; Olympus Medical Systems Corp) is used to visualize the surgical fields. We mainly use a conventional straight grasper and ultrasonic coagulation cutting device (Harmonic scalpel, Ethicon Endosurgery, Cincinnati, OH, USA) to perform gastric mobilization and lymph node dissection. The greater omentum is dissected approximately 4 cm from the gastroepiploic artery (*Figure 1B*). The left gastroepiploic vessels are transected after clipping for the dissection of station no. 4sb lymph nodes. The gastrosplenic ligament is transected using laparoscopic coagulating shears for the dissection of station

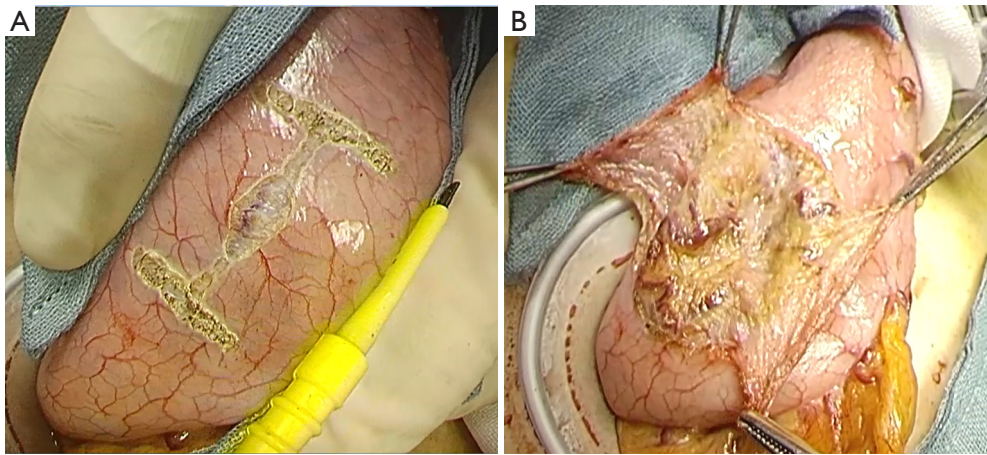


**Figure 1** Representative photo of the single-port laparoscopic proximal gastrectomy. (A) Trocar placement on an access port; (B) dissection of the greater omentum; (C) suprapancreatic lymphadenectomy. The left gastric artery was cut after the completion of No. 7, 8a, 9, and 11p LN. d Completion of No. 11d LN.

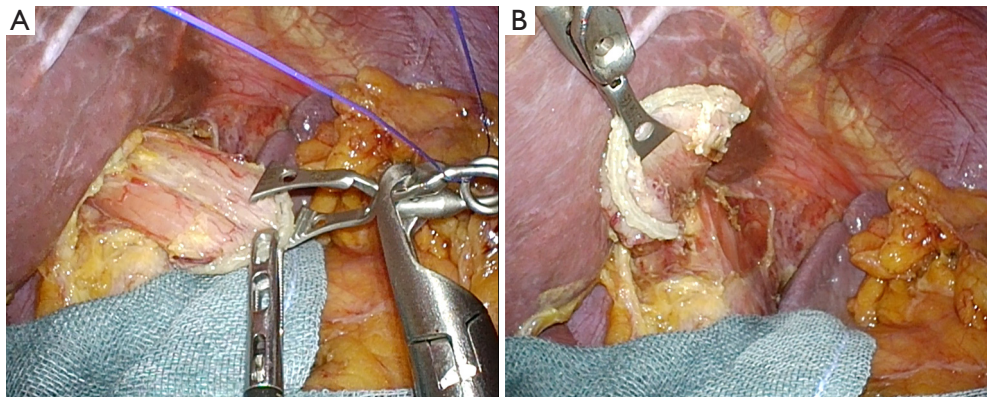
no. 4sa lymph nodes. During a station no. 8a dissection, the common hepatic artery and bifurcations of the proper hepatic and gastroduodenal arteries are exposed along the plane of the periarterial plexus for lymph node dissection. The left gastric artery is divided after double clipping, and station no. 7 and 9 lymph nodes are consecutively dissected from the periarterial plexus (*Figure 1C*). During a station no. 11p dissection, lymph nodes are dissected in the dorsal plane where the splenic vein or pancreas can be identified. No. 11d lymph nodes are dissected along the distal pancreatic artery toward the splenic hilum when necessary (*Figure 1D*). After achieving gastric mobilization and adequate lymphadenectomy, the esophagus and stomach are staple-transected using a linear stapling device (ECHELON FLEX Powered ENDOPATH Stapler, Ethicon Endosurgery, Cincinnati, OH, USA). Then, the resected specimen is extracted through a small incision.

The reconstruction procedure is described as follows. An H-shaped seromuscular flap (2.5×3.5 cm) located 5 cm from the top is created on the anterior wall of the gastric remnant extracorporeally (*Figure 2*). The stomach is opened approximately 5 mm from the lower edge of the mucosal ‘casement’ to perform an esophagogastrostomy, and stay

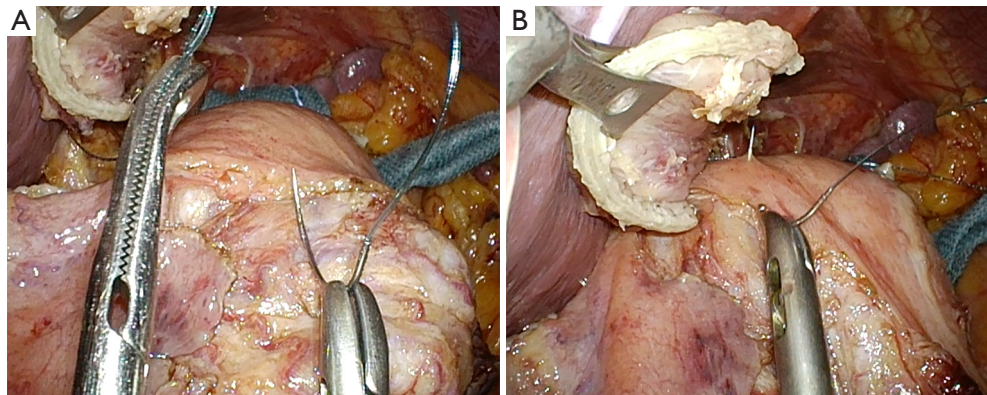
sutures are created along both edges of the opening window to make markings if necessary. The stomach is inserted into the peritoneal cavity, and the pneumoperitoneum is re-established to perform an intracorporeal anastomosis. All reconstruction tasks are completed using barbed sutures to perform the procedures simply (even during the single-incision laparoscopic approaches). First, the posterior esophageal wall is fixed to the stomach at the cranial edge of the submucosal window via continuous suturing using barbed sutures (V-Loc™90 Device, Medtronic, Minneapolis, MN, USA) (*Figures 3,4*). This step is the most cumbersome and difficult of the reconstruction method, as the procedure is often performed in narrow areas of the uppermost abdominals or lower mediastinum. The use of continuous and locked barbed sutures make this difficult step easier to perform. Second, the esophagus is opened proximal to the staple line of the stump, and the posterior wall of the esophagus and the gastric mucosa are then sutured by continuous barbed sutures. Layer-to-layer suturing via continuous V-Loc sutures is performed between the anterior esophagus and stomach along the lower edges of the flap to complete the esophagogastrostomy (*Figure 5*). Finally, the anastomosis and distal esophagus are covered



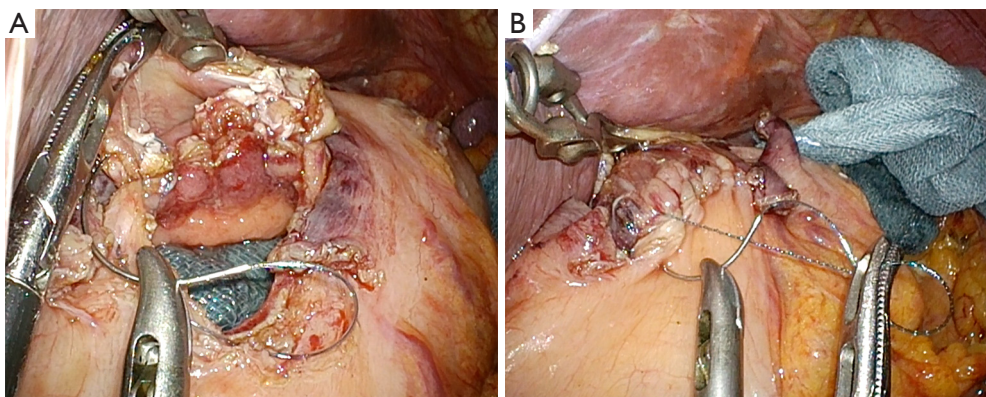
**Figure 2** An H-shaped marking (25 mm × 35 mm) facilitated the creation of a seromuscular double-flap.



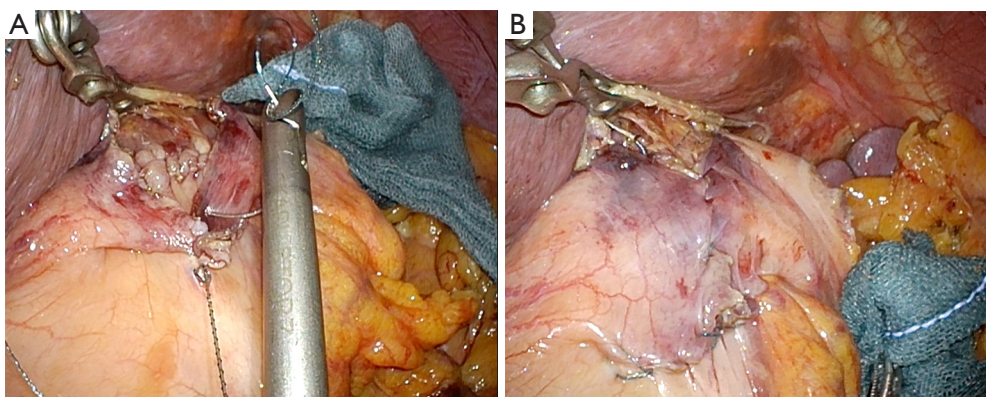
**Figure 3** Set-up of fixation between the esophagus and stomach. (A,B) Lifting of the esophagus using an Organ retractor™ with thread.



**Figure 4** ‘Ogami’ approach applied to needle suturing to anchor the posterior esophagus and the cranial edge of the submucosal window of the stomach. The needle is held in line with the needle holder, and then the instrument is rotated and pushed to suture the tissue.



**Figure 5** Esophagogastrostomy. Anastomosis between the posterior and anterior esophageal walls and the stomach. All steps were performed using continuous barbed sutures.



**Figure 6** Closure of the seromuscular double-flap. The anastomotic site and distal esophagus were covered with a flap by using two or three barbed sutures to complete the modified double-flap reconstruction procedure.

with the seromuscular flap via 3-barbed suturing (*Figure 6*). We typically use the original ‘Ogami’ technique whereby the needle is grasped by the needle holder parallel to the instrument axis (as when placing one’s palms together in prayer) and is rotated and pushed to suture (*Figure 4*).

## Results

All proximal gastrectomies with the double-flap esophagogastrostomy were performed using the single-port laparoscopic approach in the R0 status with no open conversions or transfusions (*Table 1*). The median operative time was 275 minutes (range, 267–326 minutes). The median blood loss was 12.5 mL (range, 0–50 mL). Liquid and soft diets were resumed over 2 and 3 postoperative days, respectively. The median first flatus and defecation times were 3 and 4 postoperative days, respectively (*Table 2*).

The contrast radiography results from the third and fourth postoperative days reveal that in all four cases, contrast medium was not regurgitated into the esophagus when the head was tilted 30 degrees downward. Concerning postoperative morbidities, no complications, such as anastomotic leakage/stenosis or pancreatitis/pancreatic fistula, were observed. The postoperative course was excellent, and the postoperative hospital stay was 8 days for all patients. None of the patients experienced postoperative gastroesophageal reflux symptoms during the 6-month follow-up period. This reconstruction method created the pseudo-fornix and an ideal shape for the esophagogastric junction that resembled the original cardia, demonstrated by the upper gastrointestinal endoscopic examination at 3 to 6 months after operation (*Figure 7*). The upper gastrointestinal endoscopic examination showed no anastomotic stenosis and esophagitis. Although, one patient,

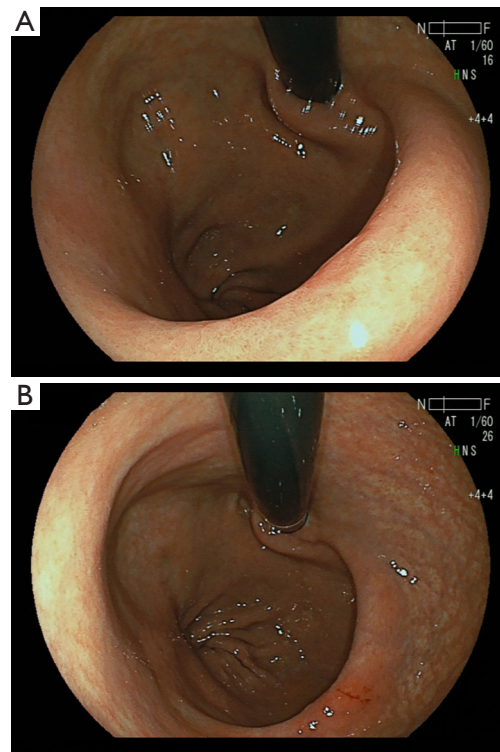
**Table 1** Patient characteristics (n=4)

Characteristics	Value
Median age [range]; years	73.5 [71–80]
Gender: male/female	3/1
ASA, 1/2/3	0/2/2
Median BMI (range); kg/m <sup>2</sup>	22.2 (14.7–23.8)
Main lesion	
Upper	4
Extent of lymph node dissection	
D1+/D2	4/0
Clinical TMN classification	
cT1bN0M0	4
Pathological TMN classification	
pT1bN0M0	3
pT2N0M0	1
Curability	
R0/R1	4/0
Completion rate	4/4 (100%)

BMI, body mass index; ASA, American Society of Anesthesiologists; TNM staging was based on the Japanese Classification of Gastric Carcinoma (3rd English Edition) (15).

**Table 2** Operative outcomes (n=4)

Operative outcomes	Value
Operative time, Median [range], minutes	275 [267–326]
Estimated blood loss, Median [range], mL	12.5 [0–50]
Conversion to multiport LPG/ open procedure	0/0
Time to first flatus, days, median [range]	3 [1–4]
Time to oral intake, liquids, days	2
Time to oral intake, solid diet, days	4
Postoperative hospital stay, days	8
Postoperative complications	0
Anastomotic leakage/stenosis	0
Pancreatitis/pancreatic fistula	0
Abdominal abscess	0
Gastroesophageal reflux symptoms	0
Reflux esophagitis	0



**Figure 7** Representative photo of upper gastrointestinal endoscopic finding at 6 months after operation.

who suffered no reflux esophagitis, has administered antacid agent such as proton pump inhibitors for the treatment of the NSAIDS-induced gastric ulcer, other patients could be free from antacid agent administration at about 3 months postoperative day. The average ratio of body weight loss at 1, 3, 6 months postoperative (relative to preoperative body weight) was 4.8%, 8.2%, and 7.7%, respectively. There was no mortality or recurrence in this series.

## Discussion

The esophagogastrostomy is theoretically a desirable reconstruction method after proximal gastrectomy for the treatment of early gastric cancer located in the upper portion of the stomach because the method preserves intestinal integrity and the physiological function of the gastric remnant, which yields better postoperative nutritional outcomes. However, the rates of late postoperative adverse events (e.g., reflux esophagitis and anastomotic stricture) are relatively high, even when fundoplication procedures are applied to the anastomotic site. Kamikawa's valvuloplastic esophagogastrostomy approach, which involves supporting strong anti-

reflux function by implanting the esophagus into the submuscular tunnel of the stomach, seems to be a promising reconstruction procedure for proximal gastrectomy (14). Double-flap valvuloplastic esophagogastronomy should be performed with hand-sewn sutures (without stapling devices) to achieve a flexible anastomosis to create a one-way check valve (15). Thus, while the anastomosis of the posterior wall is performed by continuous suturing, the anastomosis of the anterior wall is performed by creating interrupted sutures to maintain the flexible anastomosis of the original technique. This reconstruction method is extremely complicated and time-consuming to perform even when using multi-port laparoscopic approaches because it involves applying multi-step, skilled laparoscopic hand-sewn sutures and ligation techniques to perform numerous interrupted sutures, leading to prolonged operative times (15-17,25).

We have devised a simple approach for valvuloplastic esophagogastronomy that involves using barbed sutures and knotless, self-anchoring surgical sutures. We used continuous barbed sutures during every phase to more easily perform the reconstruction procedures and shorten the reconstruction period. This novel technique facilitates proximal gastrectomy with valvuloplastic esophagogastronomy even in single-port laparoscopic approaches. In addition, the 'Ogami' holding approach to intracorporeal suturing is exceedingly useful when performing the reconstruction procedures based on single-port laparoscopic approaches whereby the axis of the needle holder is positioned parallel to the direction of suturing. In our study, the median operative time was 275 min when using a single-incision laparoscopic approach (including 50 min for reconstruction procedures), which was similar to that in multi-port laparoscopic approaches (data not shown). In addition, our data is far shorter than operative times reported previously in multi-port laparoscopic proximal gastrectomy with conventional double flap technique (342–387 minutes, medians) (15,16,22). There was one case report on single-port proximal gastrectomy with double tract reconstruction for early gastric cancer (26). Double tract reconstruction procedures necessitate three anastomoses including esophagojejunostomy, gastrojejunostomy, and jejunojunostomy, each of which are technically complicated and time consuming in single-port laparoscopic approaches (350 minutes). The resulting short- and mid-term surgical outcomes were excellent (no anastomotic leakages, strictures, reflux esophagitis, or gastroesophageal reflux symptoms). Furthermore, the ratio of body weight loss at 1, 3, 6 months postoperative (relative to preoperative body weight), which was 4.8%, 8.2%, and

7.7%, respectively, may be minimal compared to other reconstruction procedures. Thus, single-port laparoscopic proximal gastrectomy procedures based on modified double-flap techniques are safe and feasible with acceptable short- and mid-term results.

However, our study included limited number of cases (n=4) and relatively short-terms follow up; therefore, further research is warranted to confirm the safety and feasibility of single-port laparoscopic proximal gastrectomy with the modified continuous suturing technique compared to multi-port laparoscopic proximal gastrectomy.

In summary, double-flap single-port laparoscopic proximal gastrectomy procedures are technically feasible and safe when applying our modified technique. By the use of above mentioned procedures, the expert laparoscopic surgeons could achieve a safe operation, and the approach constitutes an attractive surgical approach to proximal gastrectomy for the treatment of early gastric cancer. Prospective randomized trials that compare single-port laparoscopic gastrectomy approaches to conventional laparoscopic gastrectomy techniques are still required to further establish this innovative and minimally invasive surgical approach.

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## Footnote

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*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures

performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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