Surgery Today (2019) 49:1080–1086
https://doi.org/10.1007/s00595-019-01836-3

HOW TO DO IT

Laparoscopic esophagogastrostomy using a knifeless linear stapler after proximal gastrectomy

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Received: 27 March 2019 / Accepted: 7 June 2019 / Published online: 20 June 2019

Abstract

Proximal gastrectomy should improve the late postoperative function in patients with gastric cancer located in the upper third of the stomach or esophagogastric junction. However, a standard method of esophagogastrostomy has not been established for improving the postoperative function. To prevent reflux and stenosis following proximal gastrectomy, we introduced a novel esophagogastrostomy method using a knifeless linear stapler. The stapler was inserted into holes created in both the esophagus and remnant stomach and fired proximally. A 1.5-cm incision was made from the edge of the entry hole between the staples. The entry hole was then closed with continuous sutures, and fundoplication was performed by wrapping the remnant stomach. We performed this technique in 12 consecutive patients without observing any anastomosis-related complications. The proportion of weight lost 1 year after surgery was 8.8%. Our surgical procedure might be feasible for treating gastric cancer located in the upper third of the stomach or esophagogastric junction.

Keywords Gastric cancer · Esophagogastrostomy · Proximal gastrectomy

Introduction

Although total gastrectomy has been widely performed as standard surgery for gastric cancer located in the upper third of the stomach or esophagogastric junction, proximal gastrectomy (PG) is expected to maintain the physiological function of the remaining stomach and improve the late postoperative function by reducing postoperative weight loss and decreasing the incidence of gastric symptoms and nutritional deficiencies [1, 2].

Recent studies on the distribution of lymph node metastases from gastric cancer located in the upper third of the stomach [3] and esophagogastric junction [4] have found that metastases to the #4d, #6, and #5 lymph nodes are extremely rare. Therefore, PG has been accepted for use in treating clinical T1 or T2 gastric cancer without lymph node metastasis in the upper third of the stomach when at least half of the remnant stomach can be preserved. Laparoscopic gastrectomy for gastric cancer has now become a widely accepted minimally invasive approach, particularly in Japan and Korea. Accordingly, laparoscopic PG for early gastric cancer located in the upper third of the stomach should also be able to replace laparoscopic total gastrectomy with regard to both oncological and nutritional considerations.

However, PG has been associated with some postoperative functional disorders, including reflux esophagitis and anastomotic stenosis, especially when esophagogastrostomy was performed [5]. Late postoperative functional problems after PG have led to a worsened nutritional status and a marked deterioration in patients' quality of life. Several recent esophagogastrostomy methods for preventing esophageal reflux have been reported [6–10], but the techniques are somewhat difficult to perform and complicated. Thus, a standard anastomotic procedure following PG has not been established.

We herein report our novel laparoscopic procedure that uses a knifeless endoscopic linear stapler for relatively

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00595-019-01836-3) contains supplementary material, which is available to authorized users.

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uncomplicated mechanical esophagogastrostomy, which might overcome the problems of postoperative reflux and anastomotic stenosis.

Methods

Patients

Starting in November 2015, laparoscopic proximal gastrectomy with esophagogastrostomy using a knifeless linear stapler was performed in 12 consecutive patients with gastric cancer at the Department of Gastrointestinal and Pediatric Surgery of Mie University Graduate School of Medicine. The diagnosis was based on preoperative examinations that included gastrointestinal endoscopy, an upper gastrointestinal series, and abdominal computed tomography. Tumor staging for each patient was based on the Japanese classification of gastric carcinoma (15th edition) [11].

In our institution, esophagogastrostomy following PG has been indicated for the following patients: clinical T1 or T2 gastric cancer of less than 4 cm in the upper third of the stomach without lymph node metastasis, and Siewert type III esophagogastric cancer or gastrointestinal stromal tumor that has invaded the esophagogastric junction, in which at least two-thirds of the remnant stomach can be preserved.

Proximal gastrectomy

Each patient was positioned with the legs open. The first port was placed through the umbilicus using an open method. The laparoscope was inserted via the umbilical port, and four operating ports and a Nathanson liver retractor were placed as indicated in Fig. 1. The surgeon stood on the right side of the patient and performed D1+ lymphadenectomy according to the Japanese gastric cancer treatment guidelines (version 4) [12]. The perigastric lymph nodes, including stations #1, #2, #3a, #4sa, #4sb, #7, #8a, #9, #11p were dissected via a laparotomy or laparoscopy. The right gastric artery, right gastroepiploic artery, branches of the left gastroepiploic arteries, and lymph nodes, including stations #3b, #5, #6, and #4d, were preserved to provide the vascular supply to the gastric wall through an arcade of peripheral vessels. The omentum was freed from the transverse colon and divided at the edge adherent to the colon to prevent injury to the connecting vessels. Consequently, a sufficient amount of omentum was fully preserved. The esophagus was then completely isolated and transected in the anterior–posterior direction at the level of the abdominal esophagus by a linear stapling device.

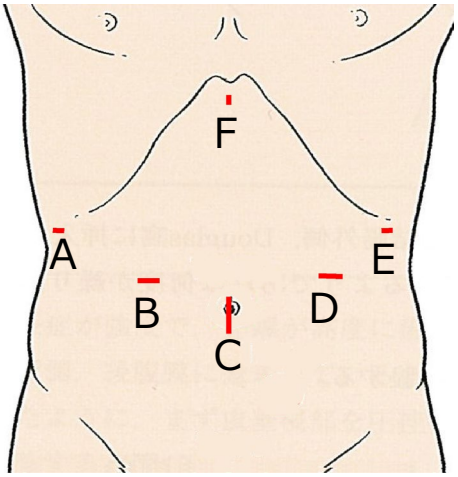

Fig. 1 Port sites for laparoscopic proximal gastrectomy. A: 5-mm port, B: 12-mm port, C: laparoscope through the umbilicus, D: 12-mm port, E: 5-mm port, F: Nathanson liver retractor

Esophagogastrostomy performed by a knifeless linear stapler (Online Video 1)

After proximal gastrectomy was performed, the specimen was retrieved through the 3-cm opening of the umbilical wound, the remnant stomach was sewn at the two points of the left and right crus diaphragm that separated the isolation line of the remnant stomach before esophagogastrostomy. Two small entry holes were made: one at the posterior edge of the transected esophagus and the other at the center of the anterior wall of the stomach, 5 cm from the proximal edge. A knifeless linear stapler (ENDOPATH ETS 45 mm No Knife; Ethicon Endo-Surgery, Cincinnati, OH, USA) was inserted through the left lower port, and using a nasogastric tube as a guide, a jaw was inserted into each of the created holes. Each jaw was closed and fired in the proximal direction from both holes (Fig. 2a). A 1.5-cm-long incision from the edge of the entry holes between the staplers was then made using scissors (Fig. 2b), and the common stab hole was closed by continuous hand suturing with absorbable barbed sutures (3-0 Stratafix; Ethicon Endo-Surgery) (Fig. 2c). Finally, a posterior 180° fundoplication was created by wrapping the remnant stomach around the esophagus (Fig. 2d).

Results

Patients' characteristics and surgical outcomes

Patients' characteristics and surgical outcomes are shown in Table 1. The patients included ten men and two women with a mean age of 64 (range 53–79) years. The mean body

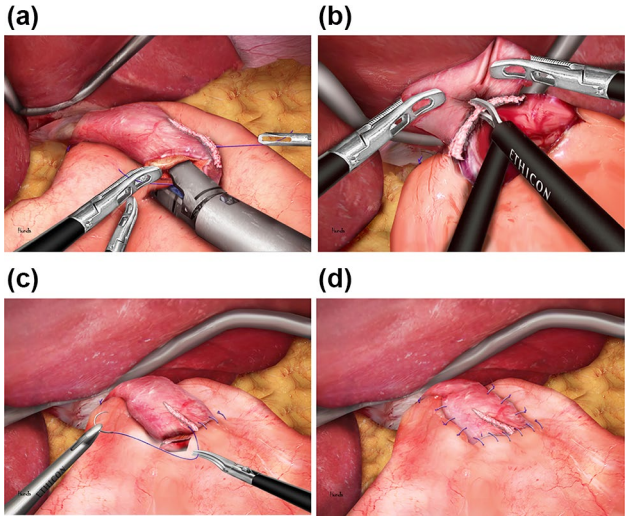

Fig. 2 A knifeless linear stapler (ENDOPATH ETS 45 mm no knife; Ethicon Endo-Surgery) was inserted through the left lower port, and using a nasogastric tube as a guide, a jaw was inserted into each of the created holes. Each jaw was closed and fired in the proximal direction from both holes (**a**). A 1.5-cm-long incision from the edge of the entry hole between the staplers was then made by scissors (**b**), and the common stab hole was closed with continuous hand suturing using absorbable barbed suture (3-0 Stratafix; Ethicon Endo-Surgery) (**c**). A posterior 180° fundoplication was created by wrapping the remnant stomach around the esophagus (**d**)

mass index was 23.4 (range 18.1–38.3). Six patients were diagnosed with clinical T1 or T2 gastric cancer in the upper third of the stomach, without lymph node involvement; four patients were diagnosed with esophagogastric junction cancer (Siewert type III); and two patients were diagnosed with a gastrointestinal stromal tumor. The mean duration of surgery was 281 (range 172–415) min, and the mean duration of esophagogastrostomy was 61 (range 38–75) min. A mean number of 31 (range 15–42) lymph nodes were harvested.

The pathological types included adenocarcinoma in all cases of gastric cancer and esophagogastric junction cancer. The pathological depth of tumor invasion in gastric cancer included pT1a (one patient, 16.7%), pT1b (three patients, 50%), pT2 (one patient, 16.7%), and pT3 (one patient, 16.7%), and the depth of tumor invasion in esophagogastric junction cancer included T3 (three patients, 75%) and T4a (one patient, 25%). Both patients with gastric cancer and the four patients with esophagogastric junction cancer were pathologically found to have lymph node metastases.

Intraoperative complications and cases of conversion to open surgery did not occur. One patient developed a superficial infection at the surgical site, but other postoperative complications, including anastomotic leakage and intra-abdominal abscess, did not occur in any of the patients. The patients started drinking water on postoperative day 1 and started eating meals on postoperative day 4. The mean observation period was 506 days. All patients were asymptomatic without the need for proton pump inhibitors or H2 blockers. Only one patient reported occurrence of mild dysphagia 3 months after surgery. We performed an endoscopic examination, which showed mild stenosis of the anastomosis. However, endoscopic dilatation was unnecessary. The mean proportions of weight lost by each patient at 6 months and 1 year after surgery were 9.8% and 8.8%, respectively.

Postoperative examinations

Figure 3 shows a contrast-enhanced radiographic image with Gastrografin made 4 days after surgery. The passage of Gastrografin from the esophagus to the remnant stomach was very good, with no apparent reflux of contrast agent into the esophagus, even with the patient in the head-down tilt position (Fig. 3a). Endoscopic examinations performed 6–12 months after surgery in 10 of the 12 patients showed that the lumen of the abdominal esophagus was closed and almost completely flat because of pressure by the remnant stomach on the dorsal side (Fig. 3b), but the lumen was easily expanded by air. The anastomosis was only visible on the lower side of the esophageal wall, and the gastroscope was smoothly inserted through the anastomosis (Fig. 3c). Endoscopy revealed that both an angle of His and pseudofornix had formed (Fig. 3d). Evidence of reflux esophagitis or an anastomotic ulcer was absent in 9 of 10 patients, and the only patient with mild stenosis at the site of anastomosis also had no findings of reflux esophagitis.

Discussion

Several operative procedures for reconstruction following PG have been proposed, including esophagogastric anastomosis and esophagojejunal anastomosis, which includes the double-tract method [13] or the jejunal interposition method [14]. The double-tract method and jejunal interposition method use 8–15 cm of interposed jejunum for reconstruction between the esophagus and remnant stomach to prevent reflux esophagitis. In addition, the remnant stomach must be observed through the interposed jejunum to perform timely monitoring for recurrent and de novo neoplastic tumors. Although the double-tract or jejunal interposition method is favored by some surgeons for controlling postoperative gastroesophageal regurgitation, the procedures are technically demanding and require lengthy operative times [15]. Furthermore, late complications, such as stasis, jejunitis, small bowel obstruction, and difficulty in performing endoscopic surveillance of the remnant stomach, have been reported [16].

Several esophagogastrostomy techniques for preventing esophageal reflux have been described. Uyama et al.

Table 1 Patients' and surgical characteristics ($n = 12$)

Variables	Number (%)	Mean (range)
Gender		
Male	10 (83%)	
Female	2 (17%)	
Age (years)		64 (53–79)
Body mass index (kg/m^2)		23.4 (18.1–38.3)
Tumor size (mm)		31 (12–40)
Disease and pathological type		
Gastric cancer		
Differentiated ad	5 (83%)	
Undifferentiated ad	1 (17%)	
Esophagogastric cancer		
Differentiated ad	3 (75%)	
Undifferentiated ad	1 (25%)	
SCC	0 (0%)	
Gastrointestinal stromal tumor	2	
Pathological depth of tumor invasion		
Gastric cancer		
T1	4 (68%)	
T2	1 (17%)	
T3	1 (17%)	
T4	0 (0%)	
Esophagogastric cancer		
T1	0 (0%)	
T2	0 (0%)	
T3	3 (75%)	
T4	1 (25%)	
Pathological lymph node metastasis		
Gastric cancer		
Positive	2 (33%)	
Negative	4 (67%)	
Esophagogastric cancer		
Positive	4 (100%)	
Negative	0 (0%)	
Duration of operation (min)		281 (172–415)
Duration of anastomosis (min)		61 (38–75)
Estimated blood loss (g)		186 (24–410)
Complications		
Anastomotic leak	0 (0%)	
Intra-abdominal abscess	0 (0%)	
Surgical site infection	1 (8.3%)	
Remote infection	0 (0%)	
Stenosis	1 (8.3%)	
Delayed gastric emptying	0 (0%)	
Postoperative hospital stay (days)		18 (10–35)
Post-gastrectomy syndrome		
Dysphagia	1 (8.3%)	
Nausea	0 (0%)	
Diarrhea	0 (0%)	
Dumping	0 (0%)	
Proportion of weight lost at 6 months after surgery (%)		9.8 (1.8–17.5)
Proportion of weight lost at 1 year after surgery (%)		8.8 (0.6–18.4)

Table 1 (continued) *ad.* Adenocarcinoma, *SCC* squamous cell carcinoma

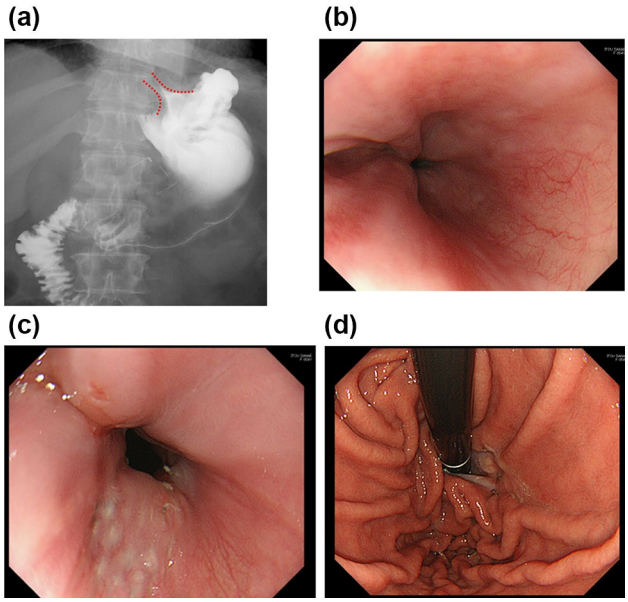

Fig. 3 A contrast-enhanced radiographic image with Gastrografin made 4 days after surgery. The passage of Gastrografin from the esophagus to the remnant stomach was very good, with no apparent reflux of contrast agent into the esophagus even with the patient in the head-down tilt position (**a**). Endoscopic examinations performed 6–12 months after surgery in 10 of the 12 patients showed that the lumen of the abdominal esophagus was closed and almost flat because of pressure by the remnant stomach on the dorsal side (**b**), but the lumen was easily expanded by air. The anastomosis was only visible on the lower side of the esophageal wall, and the gastroscope was smoothly inserted through the anastomosis (**c**). Endoscopy revealed that both an angle of His and pseudo-fornix had formed (**d**)

reported a case of laparoscopic side-to-side esophagogastrostomy performed by a linear stapler [7], which anastomoses the esophagus to the anterior wall in the center of the stomach. This procedure is simple and can be performed rapidly. However, it destroys the high-pressure zone in the lower end of the esophagus, because the dorsal side of the lower esophagus is cut, resulting in a decrease in the pressure required for preventing reflux esophagitis. Yamashita et al. anastomosed the left esophageal wall to the anterior gastric wall and the right esophageal wall to the gastric wall in such a manner that the dorsal esophageal wall was pressed flat into a valvular shape by pressure from the artificial fundus, resulting in formation of a reflux prevention mechanism [8]. This method is also an uncomplicated procedure, but concerns of possible reflux remain, based on the patient's position. Okabe et al. previously reported a procedure that is similar to our own. However, several points differ between their procedure and ours, such as a knifeless stapler being used first only for the fixation of the esophagus onto the anterior wall of the stomach and then end-to-side anastomosis is performed by hand suturing after cutting all transection lines of the esophageal stump. In contrast, in our procedure, we perform side overlap anastomosis for fixation using a knifeless stapler [9]. Intracorporal anastomosis by hand suturing requires technical skill to perform and is likely the cause of anastomotic stenosis.

Recently, Hayami et al. described a new esophagogastrostomy procedure consisting of a double-flap technique that wraps the remnant stomach around the entire circumference of the esophagus and embeds the lower edge of the esophagus within the submucosal layer of the stomach [10]. Although the short- and long-term outcomes following this procedure have been reported to be sufficiently satisfactory, this technique is extremely complicated, particularly when performed via laparoscopy. It might require a longer operative time than other reconstruction methods.

In contrast to these previously proposed techniques, our novel esophagogastrostomy procedure is characterized by side overlap anastomosis between the dorsal esophagus and anterior stomach wall for fixation using a knifeless linear stapler. Since this anastomosis is only located on the lower esophageal wall, the high-pressure zone of the lower esophageal wall is maintained. In addition, fundoplication with 180° wrapping is performed, which involves sewing the remnant stomach around the lower esophagus but above the site of anastomosis (Fig. 4a). The abdominal esophagus is then pulled sufficiently to the caudal side, and then the remnant stomach firmly presses against the abdominal esophagus from the back side and thereby flattens it, which plays an important role in reflux prevention (Fig. 4b).

Valvuloplasty and fundoplication are important procedures for preventing reflux esophagitis. Our method can be applied because it is uncomplicated and easy to perform and results in a decreased operative time, even by laparoscopic standards. Furthermore, we believe that our procedure, which uses a knifeless linear stapler for anastomosis, should result in decreased rates of anastomotic stenosis. However, if anastomotic stenosis occurs, it can be easily resolved by cutting between stapler lines. In addition, esophagogastric anastomosis is technically difficult when the anastomotic region is located at a high position, such as with esophagogastric tumors. In principle, the highest suturing point possible with our procedure is at the bottom of the esophageal using this anastomotic method. However, we experienced two cases in which the length of the lower esophagus was too short to obtain a secure margin and in such a case, intramediastinal anastomosis is required. The endoscopic findings of these two cases showed that both the angle of His and a pseudo-fornix had been formed. Although this procedure was able to

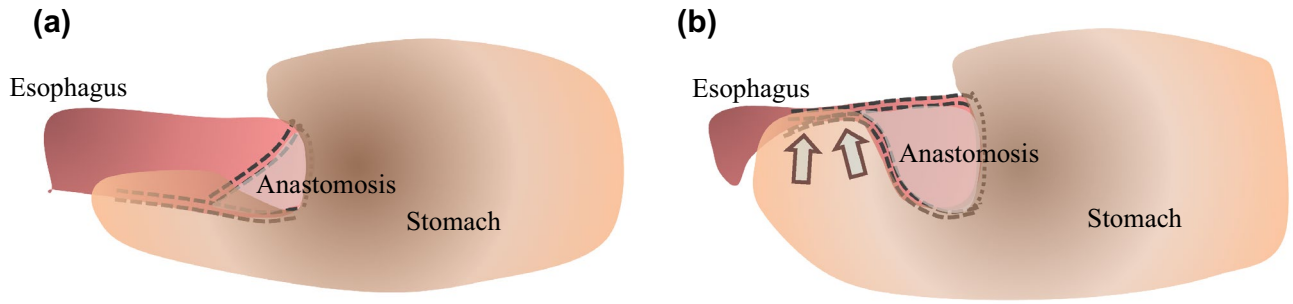

Fig. 4 Illustration of the anastomotic region seen from the side. Fundoplication with 180° wrapping was performed, which involved sewing the remnant stomach around the lower esophagus, but above the site of anastomosis (**a**). The abdominal esophagus was sufficiently pulled to the caudal side, and the remnant stomach was firmly pressed against the abdominal esophagus and flattened it from the back side, which plays an important role in reflux prevention (**b**)

be performed in both of these cases, we need to accumulate further data supporting the indications for our procedure to treat tumors located in higher regions.

We noted no major complications during this study. However, a study limitation should be mentioned: we only performed this novel operative method of reconstruction following PG in a small number of cases without sufficient follow-up. Therefore, additional detailed clinical studies, including randomized control trials, are needed to confirm the efficacy of this procedure regarding the nutritional, functional, and oncological outcomes.

In conclusion, our laparoscopic procedure using an endoscopic knifeless linear stapler consists of a relatively simple mechanical esophagogastrostomy leading to a shortened operative time. We propose that this novel operation may be a feasible surgical procedure for treating gastric cancer located in the upper third of the stomach or esophagogastric junction.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest and received no financial support for this study.

Ethical statement All procedures and subsequent analyses were performed with the approval of the Institutional Review Board of Mie University Hospital in Japan (no. 2017-3203). The study was conducted in accordance with the guidelines of the 1975 Declaration of Helsinki. Written informed consent was obtained from all study participants.

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