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Linear-stapled side-to-side esophagojejunostomy with hand-sewn closure of the common enterotomy after prophylactic and therapeutic total gastrectomy

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Abstract

After total gastrectomy, anastomosis-related complications such as leak or stricture can be highly morbid. Between July 2005 and December 2015, a linear-stapled side-to-side esophagojejunostomy with hand-sewn closure of the common enterotomy (modified Orringer technique) was used for Roux-en-Y reconstruction after prophylactic total gastrectomy in 22 germline *CDHI* mutation carriers and after therapeutic total gastrectomy in 18 patients diagnosed with gastric adenocarcinoma. All operations were performed by the same surgeon. No patient in either cohort developed a clinically evident anastomotic leak, one patient (2.5%) developed a contained radiographic leak that healed without intervention, and one patient (2.5%) developed an anastomotic stricture treated by endoscopic dilatation 7 months after operation. These rates were lower than radiographic leak and stricture rates in a comparison group of 32 patients who received a completely hand-sewn esophagojejunostomy (6.3% and 3.1%, respectively). Here we describe how to perform the linear-stapled esophagojejunostomy anastomosis.

Keywords

Gastric adenocarcinoma; hereditary diffuse gastric cancer; *CDHI* mutation; total gastrectomy; esophagojejunostomy; anastomotic leak; anastomotic stricture

Introduction

Gastric cancer is the fifth leading cause of cancer worldwide and accounts for over 700,000 cancer-related deaths every year.[1] Early gastric cancer has an excellent prognosis when treated with endoscopic resection or gastrectomy with regional lymphadenectomy.[2-5]

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Patients with locally advanced gastric cancer often receive multimodality treatment with surgery, chemotherapy, and/or chemoradiation.[6, 7] A small percentage of gastric adenocarcinomas (Lauren diffuse type) arise in individuals with germline mutation of the *CDHI* gene, which encodes the E-cadherin cell adhesion protein.[8-10] For germline *CDHI* mutation carriers, the cumulative risk of developing diffuse gastric adenocarcinoma by 80 years of age is up to 80%, and the average age of diagnosis is 38 years old.[11, 12] Prophylactic total gastrectomy is recommended in healthy individuals with germline *CDHI* mutation.[13]

The creation of the esophagojejunal anastomosis after total gastrectomy can be technically demanding, and reconstruction-related complications such as anastomotic leak and stricture account for a significant proportion of post-operative morbidity.[14-17] A recent retrospective review examined the adverse events within 90 days of operation for 238 patients who received total gastrectomy for gastric cancer.[18] Esophagojejunal anastomotic leak requiring invasive intervention was the most common major adverse event (11%). Even among the usually younger and healthier individuals that receive prophylactic total gastrectomy, esophageal anastomotic leak rates between 8-26% have been reported.[19-23] Anastomotic stricture rates of up to 21% have been reported following esophagojejunostomy with the highest rates occurring with circular staplers.[24-28]

In 2000, Orringer *et al.* described a technique for cervical esophagogastric anastomosis following transhiatal esophagectomy using a linear stapler to create a side-to-side anastomosis between the posterior wall of the esophagus and the gastric conduit, followed by closing the common enterotomy with two layers of running suture.[29] Prior to the use of this anastomosis, hand-sewn esophagogastric or esophagocolic anastomoses were performed in over 1000 patients with leak rates between 10-15%.[30] After employing the stapled anastomosis technique, clinically significant leaks were observed in only 3 of 114 patients (2.7%).

In this article, we report a single surgeon's experience with a modified version of the Orringer anastomosis in 22 *CDHI* mutation carriers who underwent prophylactic total gastrectomy and 18 patients diagnosed with gastric adenocarcinoma who underwent therapeutic total gastrectomy. The technique for the linear-stapled side-to-side esophagojejunal anastomosis is highlighted and described. Clinicopathologic factors and treatment outcomes are compared between patients who received the stapled esophagojejunostomy and a group of 32 patients who received a completely hand-sewn esophagojejunostomy.

Methods

A retrospective review of patients who underwent prophylactic or therapeutic total gastrectomy by a single surgeon (S.S.Y.) was performed for the time period between July 2005 and December 2015. Institutional Review Board approvals were obtained from both institutions at which the surgeon performed the operations (Massachusetts General Hospital, Boston, MA; Memorial Sloan Kettering Cancer Center, New York, NY). Patient

demographics, clinical history, operative details, and postoperative outcomes were collected and recorded in prospectively maintained databases.

Operative Technique

The peritoneal cavity is entered via a vertical midline incision from xiphoid to umbilicus. A Bookwalter retractor is used to gain adequate exposure of the foregut structures. During gastric and nodal dissection, wide exposure of the distal esophagus is obtained to allow adequate visualization and performance of the esophagojejunal anastomosis (Fig. 1a). The left lateral segment of the liver is completely mobilized by dividing the left triangular ligament and is retracted to the right of the esophageal hiatus. The phrenoesophageal ligament is completely divided, and the abdominal esophagus and lower thoracic esophagus are mobilized to a length of approximately 6-8 cm above the gastroesophageal junction (GEJ). The anterior and posterior vagal trunks are divided. In obese patients or for tumors encroaching the esophagus, the esophageal hiatus can be opened anteriorly to improve exposure of the distal thoracic esophagus. After this dissection, the orogastric tube is removed.

The esophagus is transected approximately 2 cm proximal to the GEJ for prophylactic cases and 4-5 cm proximal to gross tumor in therapeutic cases using the Endo GIA™ Ultra Universal Short stapler with a 60 mm articulating medium/thick (purple) reload with Tri-Staple™ technology (Covidien, North Haven, CT). The cartridge is maximally articulated to transect the esophagus in a transverse fashion. A Satinsky clamp can be placed across the esophagus 6-8 cm proximal to the GEJ to prevent the esophagus from retracting cephalad. In preparation for reconstruction, at least 5 cm of the remaining esophagus must be completely mobilized, paying particular attention to mobilization of the posterior wall.

Reconstruction is performed with a Roux-en-Y esophagojejunostomy in retrocolic fashion. The jejunum is divided approximately 20 cm distal to the ligament of Treitz with an Endo GIA™ stapler with a 60 mm medium/thick (purple) reload. The intervening mesentery is divided as much as necessary to allow a 60 cm Roux limb to reach the esophagus without tension through a window in the transverse mesocolon.

The esophagojejunal anastomosis is created using a modification of a technique described by Orringer *et al.*, thus termed the modified Orringer technique.[29] Two anastomotic stay sutures of 3-0 silk are placed 15-20 mm apart just proximal to the midportion of the esophageal staple line (Fig. 1b). Placing these sutures just proximal to the staple line helps prevent tearing of the esophageal wall when tension is placed on these sutures. A 10 mm esophagotomy is created in the midportion of the staple line by cutting out the three rows of staples between the stay sutures. The lumen of the esophagus should be identified between the two smooth whitish layers of mucosa (Fig. 1c). All layers of the anterior wall, including mucosa and muscularis, are sewn together by a 3-0 silk interrupted suture, and all layers of the posterior wall are sewn together in similar fashion (Fig. 1d). This step is performed to prevent false passage of the stapler anvil. A large Kelly clamp can be used to investigate the esophageal lumen to determine the appropriate angle for insertion of the stapler anvil and to determine if tension-free passage up to 5 cm is possible.

An enterotomy is created on the antimesenteric border of the jejunal Roux limb approximately 6 cm distal to the transection staple line. The large jaw of the Endo GIA™ stapler with a 45 mm medium/thick (purple) reload is placed into the jejunum (Fig. 2a), and the antimesenteric portion of the Roux limb is brought posterior to the esophagus. The small jaw is placed into the esophageal lumen (Fig. 2b). Prior to firing the stapler, the esophagotomy and the Roux limb enterotomy must be exactly aligned at the proximal end of the stapler anvil. The esophagus tends to retract cephalad, and the Roux limb tends to slide caudad. If these two orifices are misaligned, a greater length of the jejunum is incorporated in the staple line, resulting in a common enterotomy that is larger than necessary. Once the orifices are aligned without any intervening tissue between the esophagus and the Roux limb, the stapler is slowly fired, creating three rows of staples on each side of the staple line.

The common enterotomy is closed with hand-sewn, interrupted 3-0 silk sutures in a single-layer fashion. The corner sutures are placed first, and the untied ends are kept together with a Halsted clamp. The esophageal bites of the corner stitches occur just posterior to the staple line of the original esophageal transection on the posterior wall of the esophagus (Fig. 2c). The remaining sutures are then placed from anatomical left to right, and the untied ends for each suture are kept together with a Halsted clamp. The esophageal bites of these subsequent stitches are placed anterior to the staple line of the original esophageal transection on the anterior wall of the esophagus. A long, fine needle driver is typically used for suturing in this narrow space. It is important to avoid excessive torque on the needle, as the esophageal wall lacks serosa and can tear relatively easily. Thus, forceps are used to grasp the tip of the needle as it exits the esophageal wall and pull the remainder of the needle through the tissue to minimize torque. Once all sutures have been placed, they are tied from anatomical left to right, and the ends are cut (Fig. 2d). Figure 3 shows line drawings which demonstrate the key steps in the creation of this esophagojejunoanastomosis.

In the postoperative period, patients are kept *nil per os* (NPO) until day 3-5, and an upper gastrointestinal series with contrast is obtained to rule out a subclinical anastomotic leak or stenosis. If no abnormality is identified, patients are advanced from sips to a mechanical soft diet in the ensuing three days. The patient is subsequently discharged on a mechanical soft diet for 2-3 weeks.

Results

Thirty-two patients who underwent prophylactic total gastrectomy for germline *CDHI* mutation were identified from the examined time period. Table 1 summarizes the clinicopathologic and treatment characteristics of this group. Median age at time of operation was 42 years (range, 16-58 years), and 22 patients were female (69%). A small proportion of patients presented with accompanying gastrointestinal symptoms, and abdominal pain or discomfort was the most common symptom (13%). All patients had a documented family history of gastric cancer. Twelve patients had at least one family member with history of breast cancer (38%). A hand-sewn end-to-side esophagojejunal anastomosis was performed in the first ten consecutive patients, as previously described.[31] Thereafter, a linear-stapled side-to-side esophagojejunoanastomosis with hand-sewn closure of the common enterotomy (i.e., modified Orringer anastomosis) was employed, as described above.[29]

For patients who received prophylactic total gastrectomy with an entirely hand-sewn anastomosis ($n=10$), no patient experienced an esophagojejunal anastomotic leak as documented by esophagram (performed in all 10 patients) or clinical symptoms. One patient (10%) developed anastomotic stricture requiring endoscopic dilatation at 6 months after the operation. Within 30 post-operative days, one patient developed pulmonary embolism which was treated with low molecular weight heparin bridge to warfarin.

In the patient cohort receiving prophylactic total gastrectomy with the modified Orringer anastomosis ($n = 22$), no patient experienced an anastomotic leak as documented by esophagram (performed in 21 of 22 patients) or clinical symptoms. No patients developed anastomotic stricture that required endoscopic dilatation. Within 30 postoperative days, one patient developed a superficial surgical site infection which was treated with a course of oral antibiotics, and one patient developed mild pancreatitis requiring re-admission on post-operative day 16 for supportive care.

Among all patients who received prophylactic total gastrectomy, the 30-day mortality rate was 0%, and the median nadir weight loss was 16% (range <1-43%) from baseline weight. At least one focus of intramucosal and/or early invasive carcinoma was present in 30 resected specimens (94%). Formal lymph node dissections were not performed, but perigastric lymph nodes were generally incorporated in the prophylactic total gastrectomy specimen. The median number of nodes resected was 13 (range, 1-40 nodes).

During the study period, 40 patients diagnosed with clinically apparent gastric adenocarcinoma underwent therapeutic total gastrectomy by the same surgeon. The first 22 consecutive patients had a hand-sewn esophagojejunostomy anastomosis while the subsequent 18 had a modified Orringer anastomosis. Table 2 summarizes the clinicopathologic and treatment characteristics of this group. Median age at time of operation was 67 years (range, 40-92 years), and 18 patients (45%) were female. Nineteen patients (48%) had diffuse-or mixed-type gastric cancer; Lauren histologic type was unspecified in nine patients. Formal D1+ or D2 lymphadenectomy was performed in all cases, and the median number of lymph nodes resected was 39 (range, 9-94 nodes). Twenty patients (50%) received neoadjuvant chemotherapy or chemoradiation.

Thirteen patients (33%) developed complications within 30 days of therapeutic total gastrectomy. Complications included superficial surgical site infection ($n = 2$), aspiration pneumonia ($n = 1$), infectious colitis ($n = 2$), adhesive bowel obstruction requiring laparotomy ($n = 1$), deep venous thrombus managed with oral anticoagulation ($n = 2$), and perihepatic abscess requiring drainage ($n = 1$). Among patients who received hand-sewn anastomoses after therapeutic total gastrectomy ($n = 22$), two patients developed subclinical radiographic anastomotic leak documented on esophagram. These radiographic leaks healed without intervention. There were no strictures requiring dilation. For patients who received the modified Orringer anastomosis after therapeutic total gastrectomy ($n = 18$), one patient developed a subclinical radiographic leak which healed without intervention, and one patient developed an esophagojejunal anastomotic stricture requiring endoscopic dilatation 7 months after the operation. No patient developed a clinically evident esophagojejunal

anastomotic leak that required image-guided drainage. Among all patients, no post-operative deaths occurred within 30 days of operation.

When examining all 72 patients who underwent prophylactic or therapeutic total gastrectomy, patients who received a hand-sewn anastomosis ($n = 32$) had a subclinical radiological anastomotic leak rate of 6.3% and an anastomotic stricture rate of 3.1% (Table 3). Following adoption of the modified Orringer anastomosis ($n = 40$), subclinical radiological anastomotic leak and stricture rates were 2.5% and 2.5%, respectively.

Discussion

In this article, we describe a single surgeon's experience with a linear-stapled side-to-side esophagojejunostomy reconstruction in 22 consecutive patients who underwent prophylactic total gastrectomy for *CDH1* mutation and 18 consecutive patients who underwent therapeutic total gastrectomy for gastric adenocarcinoma. Using this anastomosis, there were no clinically evident anastomotic leaks. Routine post-operative upper gastrointestinal contrast studies identified a subclinical leak in one patient (2.5%), which healed without intervention. Only one patient (2.5%) developed a symptomatic stricture that required endoscopic dilatation. Thus, this modified Orringer technique may be a safe and reliable means of performing the esophagojejunal anastomosis following total gastrectomy.

Historically, reconstruction-related complications after total gastrectomy were associated with cause-specific mortality rates between 13-30%. [17, 32-34] The improved post-operative outcomes from more recent published series has been partially attributed to the decrease in esophagojejunal anastomotic leak rates, reported as low as <5% from large East Asian studies. [35-37] However, anastomotic leaks continue to prolong hospital stays and increase healthcare costs, and studies have suggested that anastomotic complications not only worsen post-operative outcomes but can also adversely affect long-term disease-specific survival. [17]

Large randomized control studies from East Asia and Europe have previously demonstrated no difference in anastomotic leak or stricture rates between hand-sewn and stapled anastomoses in total gastrectomy. [35, 38, 39] Nonetheless, the widespread use and availability of mechanical stapling devices and the growing expertise of minimally invasive approaches has largely shifted the method of esophagojejunal anastomosis construction to stapled anastomosis. Small case series utilizing novel techniques have been reported, but no single consensus method has been widely adopted or definitively shown to be superior in outcomes. [28, 40-42] Table 4 summarizes the esophagojejunal anastomosis-related complication rates after total gastrectomy from the most recent surgical case series of comparable size to this study cohort.

Many centers, particularly in East Asian countries, perform circular stapled anastomoses. However, circular staplers carry their own set of challenges, including technical difficulty in the properly positioning the stapler anvil. Systems of transoral delivery of the anvil have been developed, but they carry the potential risks of injuring the esophageal mucosa and potential bacterial seeding of the abdominal cavity. [43] The modified Orringer technique

described here may have a flatter learning curve based on the pervasive use and familiarity of the Endo GIA™ linear stapler among general surgery practices and academic centers.

While similar anastomosis-related outcomes were achieved in patients who received therapeutic total gastrectomy, it is important to note that *CDHI* mutation carriers represent a unique population. For a number of reasons, the operative morbidity is likely significantly lower in the prophylactic total gastrectomy population compared to total gastrectomy performed for diagnosed invasive gastric cancer. Indeed, in our study cohort, patients who received therapeutic total gastrectomy were advanced in age, and many received neoadjuvant therapy or adjacent organ resection – all of which could contribute to post-operative morbidity. A formal radical lymphadenectomy, which can contribute to complications, is also not routinely performed in prophylactic total gastrectomy.

The post-operative quality of life for the patient is critically important, particularly for patients with germline *CDHI* mutation as they often receive prophylactic total gastrectomy before any appreciable gastrointestinal symptoms arise. Long-term follow-up for patients who received prophylactic total gastrectomy was difficult, as they were typically discharged from the surgical clinic after 12 months. In that period, all patients were provided nutritional consultation and were prescribed a daily multivitamin with ferrous sulfate and monthly vitamin B₁₂ injections. No statistically significant differences in post-gastrectomy dumping syndrome, persistent reflux symptoms, or weight loss were identified when comparing patients who received modified Orringer anastomosis to patients who received a completely hand-sewn anastomosis. However, a more robust, large-scale trial examining the functional status of varying reconstructive techniques will be necessary to overcome the limitations of the present study.

In summary, a linear-stapled side-to-side esophagojejunostomy with hand-sewn closure of the common enterotomy for Roux-en-Y reconstruction after total gastrectomy can be performed safely with anastomotic leak and stricture rates less than 5%. This manuscript describes one of the largest Western experiences in the operative management of *CDHI* mutation carriers.

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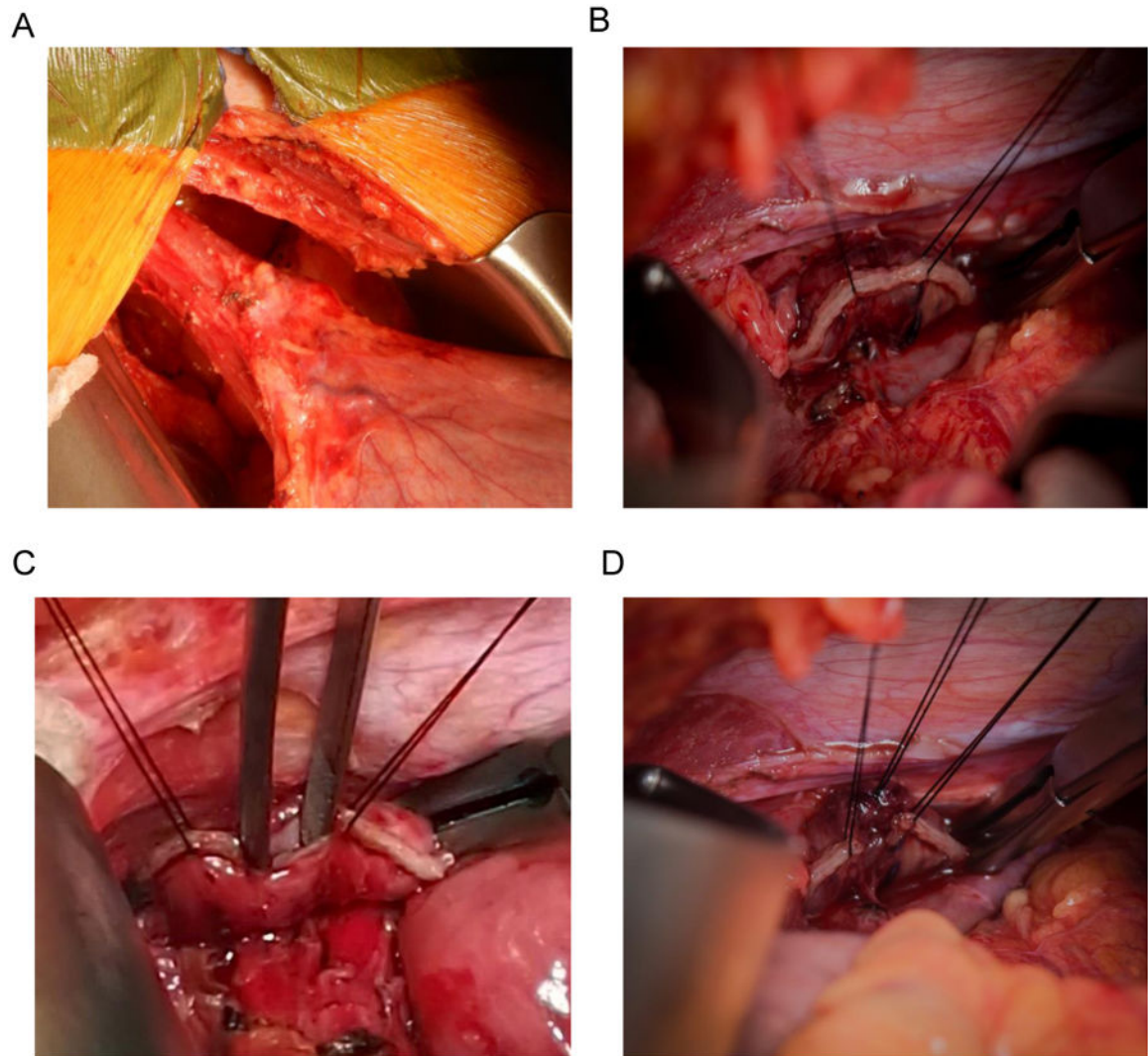


Figure 1.

(a) The distal esophagus is mobilized to a length of 6 to 8 cm above the gastroesophageal junction.

(b) Two stay sutures of 3-0 silk are placed 15-20 mm apart in the midportion of the esophageal staple line. In preparation for the anastomosis, a 10 mm esophagotomy will be created in between the stay sutures by cutting out the three rows of staples.

(c) The lumen of the esophagus with whitish mucosa is demonstrated.

(d) To prevent false passage of the stapler anvil, the layers of the esophageal wall are sutured together. The two anastomotic stay sutures and the suture through the anterior wall layers are visible.

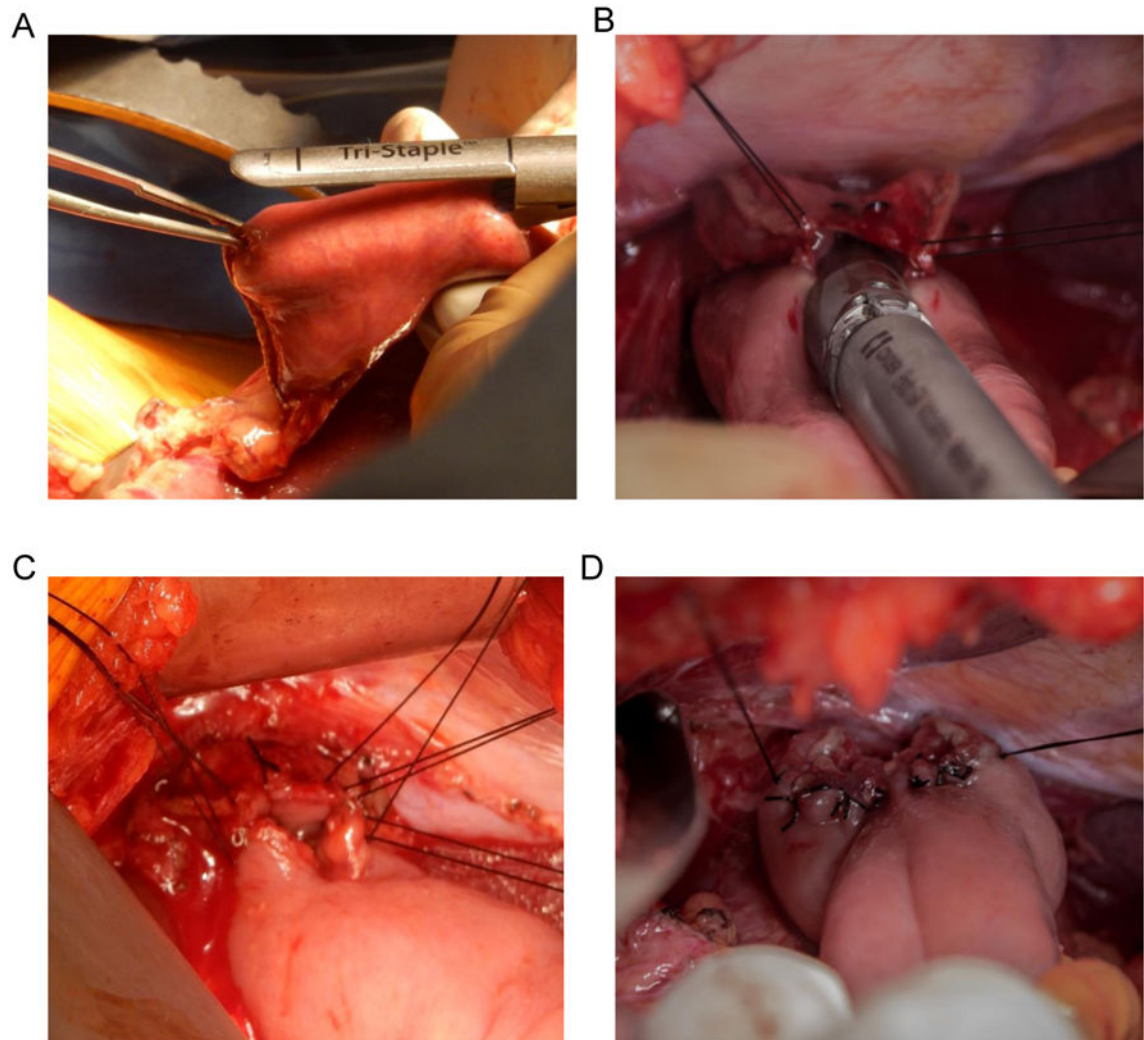


Figure 2.

(a) The large jaw of the Endo GIA™ stapler with a 45 mm medium/thick (purple) reload is placed into the enterotomy created on the antimesenteric border of the jejunal Roux limb approximately 6 cm distal to the transection staple line.

(b) The small jaw of the stapler is placed into the esophageal lumen.

(c) The common enterotomy is closed with hand-sewn, interrupted 3-0 silk sutures in a single-layer fashion.

(d) The completed esophagojejunal anastomosis with hand-sewn closure of the common enterotomy.

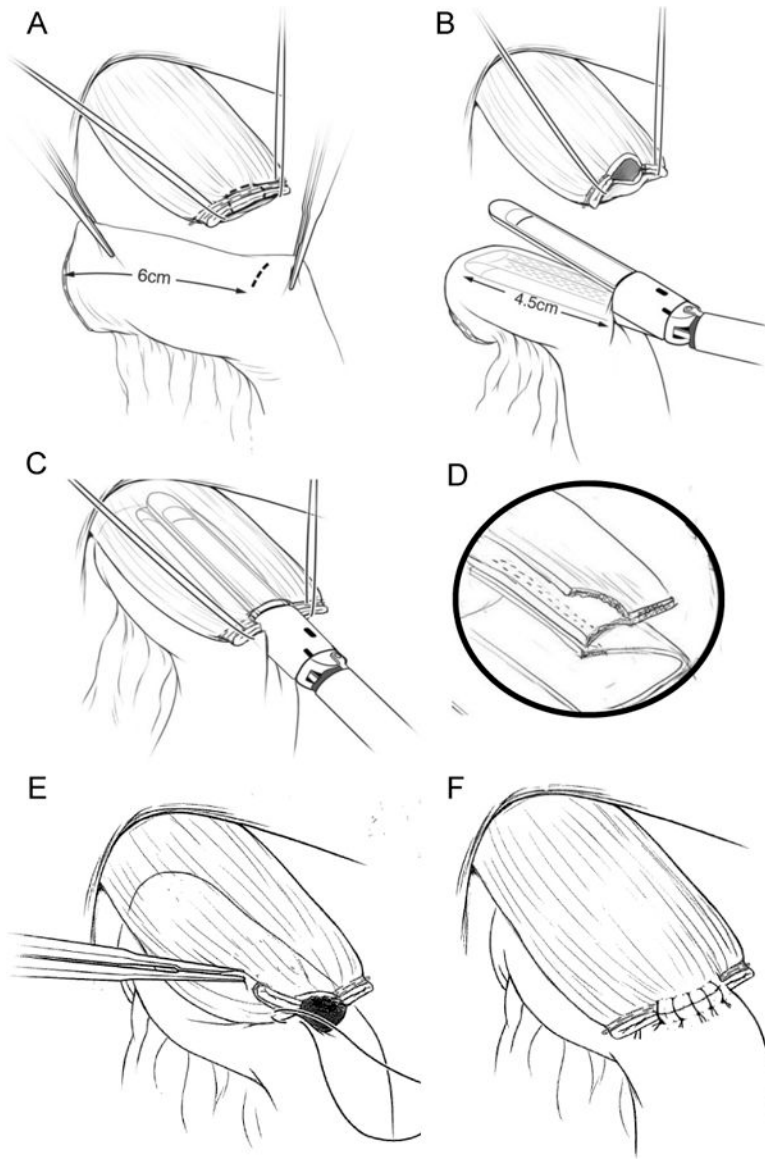


Figure 3. (a)-(f) Line drawings demonstrating performance of the esophagojejunostomy anastomosis

Table 1
Clinicopathologic and treatment characteristics in patients with germline *CDHI* mutation who underwent prophylactic total gastrectomy

Prophylactic Total Gastrectomy	All patients (n=32) n or median (% or range)	Hand-sewn anastomosis (n=10) n or median (% or range)	Modified Orringer anastomosis (n=22) n or median (% or range)
Age (years)	42 (16-58)	42 (26-50)	42 (16-58)
Gender			
Male	10 (31.3)	6 (60.0)	4 (18.2)
Female	22 (68.7)	4 (40.0)	18 (81.8)
Body mass index	25.6 (18.0-41.8)	25.6 (22.1-41.8)	25.8 (18.0-36.3)
Gastrointestinal symptoms at presentation ^a			
Abdominal pain or discomfort	4 (12.5)	3 (30.0)	1 (4.5)
Nausea or vomiting	2 (6.2)	1 (10.0)	1 (4.5)
Dyspepsia or heartburn	2 (6.2)	1 (10.0)	1 (4.5)
Dysphagia	1 (3.1)	0 (0.0)	1 (4.5)
Diarrhea	2 (6.2)	1 (10.0)	1 (4.5)
None	23 (71.9)	5 (50.0)	18 (81.8)
Family history			
Gastric cancer	32 (100.0)	10 (100.0)	22 (100.0)
Family members with <i>CDHI</i> mutation	29 (90.7)	9 (90.0)	20 (90.9)
Breast cancer	12 (37.5)	4 (40.0)	8 (36.4)
Operative time (minutes)	190 (124-308)	229 (187-308)	167 (124-267)
Estimated intraoperative blood loss (milliliters)	100 (50-1000)	300 (100-800)	100 (50-1000)
Length of stay (days)	8 (7-12)	7 (7-8)	8 (7-12)
Anastomotic leak	0 (0.0)	0 (0.0)	0 (0.0)
Anastomotic stricture	1 (3.1)	1 (10.0)	0 (0.0)
30-day morbidity	3 (9.4)	1 (10.0)	2 (9.1)

Prophylactic Total Gastrectomy	All patients (n=32) n or median (% or range)	Hand-sewn anastomosis (n=10) n or median (% or range)	Modified Orringer anastomosis (n=22) n or median (% or range)
30-day mortality	0 (0.0)	0 (0.0)	0 (0.0)
Weight loss (nadir: % from baseline)	15.8 (0.6-43.2)	15.7 (8.9-43.2)	16.0 (0.7-28.8)
Presence of microscopic foci of carcinoma			
Noninvasive (intramucosal or <i>in situ</i>)	9 (28.2)	7 (70.0)	2 (9.1)
Invasive (T1a)	19 (59.4)	1 (10.0)	18 (81.8)
Noninvasive and Invasive	2 (6.2)	1 (10.0)	1 (4.5)
None	2 (6.2)	1 (10.0)	1 (4.5)
Lymph nodes resected (n)	13 (1-40)	13 (6-18)	13 (1-40)

^aSymptoms not mutually exclusive

Table 2
Clinicopathologic and treatment characteristics in patients who underwent therapeutic total gastrectomy for gastric cancer

Therapeutic Total Gastrectomy	All patients (n=40) n or median (% or range)	Hand-sewn anastomosis (n=22) n or median (% or range)	Modified Orringer anastomosis (n=18) n or median (% or range)
Age (years)	67 (40-92)	67 (40-82)	68 (42-92)
Gender			
Male	22 (55.0)	10 (45.5)	12 (66.7)
Female	18 (45.0)	12 (54.5)	6 (33.3)
Body mass index	25.8 (17.3-42.1)	25.5 (17.3-42.1)	27.1 (20.8-34.0)
Gastrointestinal symptoms at presentation ^a			
Abdominal pain or discomfort	20 (50.0)	11 (50.0)	9 (50.0)
Nausea or vomiting	18 (45.0)	11 (50.0)	7 (38.9)
Dyspepsia or heartburn	5 (12.5)	4 (18.2)	1 (5.6)
Dysphagia	4 (10.0)	2 (9.1)	2 (11.1)
Gastrointestinal bleed / Microcytic anemia	9 (22.5)	5 (22.7)	4 (22.2)
None	1 (2.5)	1 (4.5)	0 (0.0)
Family history			
Gastric cancer	5 (12.5)	4 (18.2)	1 (5.6)
Breast cancer	9 (22.5)	5 (22.7)	4 (22.2)
Neoadjuvant treatment			
Chemotherapy	17 (42.5)	11 (50.0)	6 (33.3)
Chemoradiation therapy	3 (7.5)	1 (4.5)	2 (11.1)
Adjuvant treatment			
Chemotherapy	13 (32.5)	8 (36.4)	5 (27.8)
Chemoradiation therapy	8 (20.0)	6 (27.3)	2 (11.1)
Operative time (minutes)	266 (187-485)	301 (224-485)	242 (187-451)
Estimated intraoperative blood loss (milliliters)	400 (100-1300)	400 (250-1300)	300 (100-1000)

Therapeutic Total Gastrectomy	All patients (n=40) n or median (% or range)	Hand-sewn anastomosis (n=22) n or median (% or range)	Modified Orringer anastomosis (n=18) n or median (% or range)
Adjacent organ resection ^a			
Distal pancreatectomy	3 (7.5)	2 (9.1)	1 (5.6)
Splenectomy	12 (30.0)	11 (50.0)	3 (16.7)
Length of stay (days)	9 (5-24)	9.5 (5-24)	8 (5-14)
Anastomotic leak			
Radiographic	3 (7.5)	2 (9.1)	1 (5.6)
Clinical	0 (0.0)	0 (0.0)	0 (0.0)
Anastomotic stricture	1 (2.5)	0 (0.0)	1 (5.6)
30-day morbidity	13 (32.5)	9 (40.9)	4 (22.2)
30-day mortality	0 (0.0)	0 (0.0)	0 (0.0)
Weight loss (nadir % from baseline)	17.3 (3.5-32.6)	15.8 (6.3-29.6)	18.6 (3.5-32.6)
Lauren histologic type			
Intestinal	12 (30.0)	2 (9.1)	10 (55.6)
Diffuse	16 (40.0)	13 (59.1)	3 (16.7)
Mixed	3 (7.5)	0 (0.0)	3 (16.7)
Unspecified	9 (22.5)	7 (31.8)	2 (11.1)
Pathologic TNM stage ^b			
Stage 0	3 (7.5)	2 (9.1)	1 (5.6)
Stage I	10 (25.0)	4 (18.2)	6 (33.3)
Stage II	10 (25.0)	7 (31.8)	3 (16.7)
Stage III	17 (42.5)	9 (40.9)	8 (44.4)
Lymph nodes resected (n)	39 (9-94)	37 (9-83)	39 (15-94)

^aCategories not mutually exclusive^bAmerican Joint Committee on Cancer, 7th edition

Table 3

Anastomosis-related complications after total gastrectomy

Total gastrectomy	All patients (n=72) n (%)	Hand-sewn anastomosis (n=32) n (%)	Modified Orringer anastomosis (n=40) n (%)
Anastomotic leak			
Radiographic	3 (4.2)	2 (6.3)	1 (2.5)
Clinical	0 (0.0)	0 (0.0)	0 (0.0)
Anastomotic stricture	2 (2.8)	1 (3.1)	1 (2.5)

Table 4
Surgical case series of anastomotic complications after total gastrectomy (Publication date 1990-2016, study n = 70)

First Author	Study period	Approach ^a	Anastomosis Method ^b	n	EJ Leak (%)	EJ Stenosis (%)
Fujimoto S[38]	1983-1989	O	Hand	180	2.2	0.6
		O	Circular	199	3.5	3.0
Seuffert RM[39]	1987-1988	O	Hand	40	0	2.5
		O	Circular	40	2.5	0
Kim CB[44]	1987-1992	O	Circular	100	2.0	2.0
Yoo CH[45]	1990-2000	O	Circular	185	4.9	8.1
Kawamura Y[46]	1997-2012	LA	Linear	259	5.0	NR
Jeong GA[47]	1998-2005	LA	Circular	131	2.3	0
Sierzega M[17]	1999-2004	O	Circular	690	5.9	NR
Hyodo M[35]	2001-NR	O	Circular	390	0.5	1.0
Son MW[48]	2001-2008	O	Circular	106	1.9	2.8
Ito H[49]	2001-2012	O	Circular	166	4.2	3.0
		LA	Circular	46	0	4.3
		TL	Circular	117	1.7	1.7
Wada N[50]	2001-2012	LA	Circular	100	4.0	0
Nagai E[51]	2002-2010	LA	Linear	94	2.1	0
Lee JH[52]	2003-2010	O + LA	Circular	753	1.5	3
Lee MS[53]	2003-2010	O	Circular	228	2.2	1.8
Jeong O[54]	2003-2011	O	Circular	122	2.5	1.6
		LA	Circular	122	7.4	1.6
	2004-2013	LA	Circular	203	4.4	NR

First Author	Study period	Approach ^a	Anastomosis Method ^b	n	EJ Leak (%)	EJ Stenosis (%)
Kim DJ[55]	2004-2014	LA	Circular	94	5.3	3.2
Usui S[56]	2004-2014	LA	Circular	78	0	0
Morimoto M[41]	2005-2013	LA	Linear	77	0	1.3
Lee SR[57]	2006-2009	O	Circular	50	6.0	0
		LA	Circular	34	5.9	5.9
Tsunoda S[58]	2006-2012	TL	Linear	112	1.8	0
Chen K[42, 59]	2006-2014	TL	Hand	42	0	0
			Linear	32	0	6.3
			Circular	18	5.6	5.6
Ichikawa D[60]	2007-2013	LA	Circular	88	0	3.4
Kanaji S[36]	2008-2011	O	Circular	185	4.9	NR
Kim HS[61]	2009-2010	TL	Linear	124	1.6	1.6
Yoon HM[26]	2009-2011	LA	Circular	65	4.6	4.6
		RA	Circular	36	0	2.8
Shim JH[62]	2009-2011	O	Hand	35	2.9	0
		LA	Linear + Circular	35	8.6	22.9
Song JH[63]	2009-2013	O	Circular	134	0	NR
		LA	Circular	74	0	NR
Zhang G[64]	2010-2011	LA	Circular	73	0	0
Kim HS[27, 65]	2011	O	Linear	207	1.4	0.5
		TL	Linear	139	0.7	0
Li P[66]	2012	LA	Circular	108	0.9	NR

^aO = open; LA = laparoscopy-assisted; TL = totally laparoscopic; RA = robot-assisted

^bHand = manually hand-sewn; Linear = linear stapler; Circular = circular stapler (including transoral delivery of anvil) n = number of patients; EJ = esophagojejunal anastomosis; NR = not recorded