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The crossover technique for intracorporeal esophagojejunostomy following laparoscopic total gastrectomy: a simple and safe technique using a linear stapler and two barbed sutures

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Abstract

Background Totally laparoscopic gastrectomy (LG) is preferred over open gastrectomy because it allows safe anastomosis, a small wound, and early bowel recovery. However, esophagojejunostomy (EJS) following laparoscopic total gastrectomy (LTG) remains technically challenging. To popularize LTG, a secure method of reconstruction must be developed. We present a simple and safe technique for intracorporeal EJS following LTG.

Methods Our modified technique for intracorporeal EJS as a part of Roux-en-Y reconstruction following LTG incorporates an isoperistaltic stapled EJS with closure of the entry hole using two unidirectional barbed sutures. First, a side-to-side isoperistaltic EJS is created between the dorsal and left side of the esophagus and the jejunal arm. Second, the opening for the stapler is closed with a two-layer continuous suture using two 15-cm 3-0 V-Loc suture devices. The full-thickness inner layer closure commences from the sides of the staple lines and progresses toward the center of the enterotomy. During suturing, the remaining thread is utilized to apply tension and lift the enterotomy. Once the full-thickness layer closure is complete at the center of the enterotomy, suturing of the second seromuscular layer is started in the forward direction toward each corner to give a crossover-shaped suturing line.

Results From February 2012 to October 2017, 27 patients with gastric cancer underwent LTG with intracorporeal stapled EJS as a part of Roux-en-Y reconstruction. All procedures were successfully performed without any intra- or postoperative anastomosis-related complications. No conversion to other procedures was required. The mean suturing time was 19.1 ± 9.5 min. The mean postoperative time to tolerating a liquid diet was 3.3 days, and the mean hospital stay was 12.1 days.

Conclusions We herein report our procedure for intracorporeal EJS using a linear stapler and barbed sutures. This technique is simple and feasible and has acceptable morbidity.

Keywords Gastric cancer · Laparoscopic surgery · Total gastrectomy · Roux-en-Y reconstruction · Esophagojejunostomy · Intracorporeal anastomosis · Barbed suture

Gastric cancer ranks as the fifth most prevalent form of cancer worldwide, and the third most common cause of cancer-related death [1]. Surgical resection combined with regional lymphadenectomy as a recommended part of radical gastrectomy is the sole curative treatment [2, 3]. In 1994, Kitano and colleagues first reported laparoscopy-assisted Billroth I gastrectomy. Since then, laparoscopic gastrectomy (LG) has been shown to be associated with earlier patient recovery compared with open surgery, and has gained increasing international acceptance. Improvements in instrumentation and laparoscopic techniques have led to widespread acceptance of LG, not only for various types of gastric resection, but also for total laparoscopic procedures [4–9].

Barbed sutures have been proposed to facilitate laparoscopic suturing. One of these novel sutures, the V-Loc 180 (Covidien, Mansfield, MA), consists of a barbed absorbable

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thread armed with a surgical needle at one end and a loop at the other end, which is used to secure the suture (Fig. 1). The barbs and the loop end make it possible to approximate the tissues without the need for tying surgical knots. In 2011, we commenced using this novel suture to close the entry hole for the linear stapler, and reported that the use of barbed sutures resulted in improved safety for intracorporeal anastomosis after LG [10–12]. Our method for intracorporeal anastomosis in any type of LG, even laparoscopic total gastrectomy (LTG), consists of either isoperistaltic or antiperistaltic side-to-side anastomosis using a linear stapler and closure of the stapler entry hole using the knotless, unidirectional barbed suture.

LTG is considered the most challenging surgical procedure among those used to treat gastric cancer, and is the reason why not only systematic lymph node dissection during LTG, but also intracorporeal esophagojejunostomy (EJS) after LTG, remains technically difficult. Here, we describe our procedure for intracorporeal isoperistaltic stapled EJS, which depends on the properties of the barbed suture, as part of Roux-en-Y reconstruction after LTG, in the hope that this will promote widespread acceptance of LTG for treatment of gastric cancer.

Methods

From February 2012 to October 2017, 27 patients (15 men and 12 women) with gastric cancer underwent LTG with intracorporeal Roux-en-Y reconstruction at our institute. Of these patients, 24 were diagnosed with gastric cancer in the upper third of the stomach and three with cancer of the gastroesophageal junction. Indications for LG at our institute include the majority of tumors with the exception of disease with a poor prognosis, such as bulky tumors, tumors invading the adjacent organs, and type 4 disease. The type of gastric resection is determined based on Japanese treatment guidelines [13, 14] according to the location and size of the tumor, the depth of invasion, and the nodal status of the tumor. The principle of any resection is to achieve en-bloc resection of the gastric segment and surrounding lymph nodes to achieve adequate oncological clearance. Distal gastrectomy (DG) is generally indicated for cancers in the distal and middle thirds of the stomach for which there are proximal tumor margins of at least 2 cm for early and 3–5 cm for advanced lesions. Some patients with very early disease can receive limited resections such as pylorus-preserving gastrectomy [7]. A proximal gastrectomy procedure is indicated for patients with early gastric cancers in the upper third of the stomach with no evidence of lymph node metastasis. Total gastrectomy is indicated for locally advanced proximal tumors, or for multiple lesions in which the distal stomach cannot be preserved. When an advanced proximal tumor is located at the greater curvature, LTG with combined resection of the spleen is performed with curative intent [15].

The V-Loc 180 closure device is a unidirectional barbed variant of the absorbable copolymer polyglyconate (Maxon, Covidien). It has the same material and degradation properties as a Maxon monofilament polyglyconate suture; tissue closure strength is approximately 50% at 30 days with complete absorption in 180 days. While etching the barbs reduces the core diameter of these sutures, they have been sized according to their postetching diameter, and the 3-0 V-Loc suture has the same tensile strength as 3-0 Maxon. A loop at the end of the suture can be used for knotless suturing, and the first 2 cm of the suture are without barbs to allow throws to be readjusted before the barbs are engaged (Fig. 1).

Total gastrectomy with adequate regional lymph node dissection (D1 and stations nos. 8a, 9, 11p, 11d, and 12a)

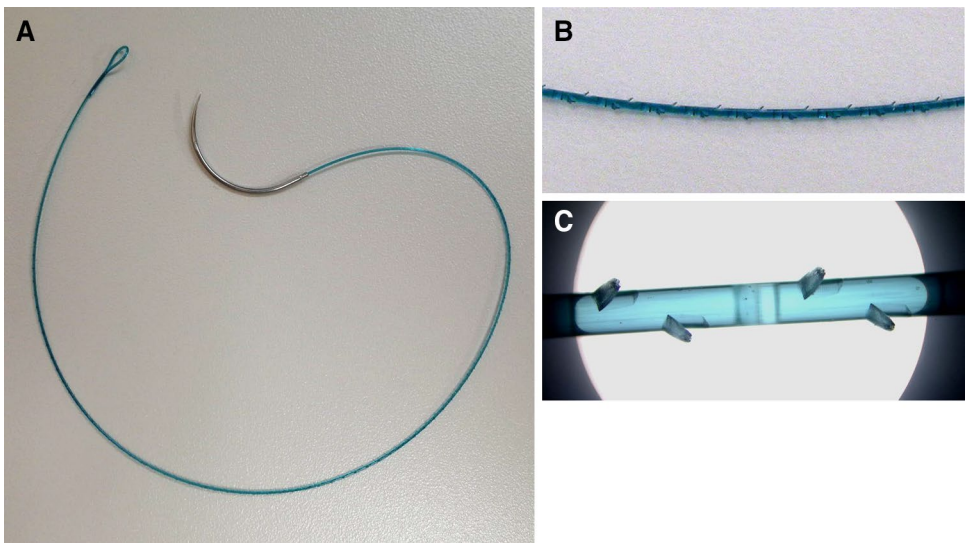


Fig. 1 Fifteen-centimeter 3-0 V-Loc 180 suture on a V-20 needle (26 mm tapered): **A** no barbs within the first 2 cm of the suture, allowing for readjustment of the throw without adverse effects, and a loop at the other end for passing the needle to secure the suture; **B** a close-up of the unidirectional barbed suture; **C** micrograph of the laser-etched barbs

for advanced gastric cancer was performed according to the following procedures (Fig. 2). The patient is positioned with his or her hips extended and abducted. The primary surgeon stands on the patient's right side, with the assistant on the patient's left, and the endoscopist standing between the patient's legs. A pneumoperitoneum (12 mmHg) is established through an umbilical trocar, and the umbilical optical port serves as a reference point for the insertion of ports on either side of the patient's abdomen. The left lobe of the liver is retracted using a Nathanson liver retractor (Fig. 3) to create the surgical field. Greater curvature mobilization is performed by dividing the gastrocolic ligament at least 3 cm away from the gastroepiploic arcade. The left gastroepiploic vessels are divided, and the dissection is continued in the same plane, in the process proximally dividing the gastrosplenic ligament and controlling the short gastric vessels. This is continued until the superior pole of the spleen is completely free from the fundus. Distal mobilization up to the duodenum and the right gastroepiploic vessels is then performed. After duodenal transection, the right and left gastric vessels are divided, and medial-to lateral mobilization of the upper part of the stomach from the retroperitoneum is performed before esophageal transection. Lymph node dissection is performed during vascular mobilization according to the guidelines, removing the lymph nodes en-bloc on the side of the resection. Vessels are ligated at their roots in most instances. The specimen is retrieved from the abdominal cavity and reconstruction is commenced.

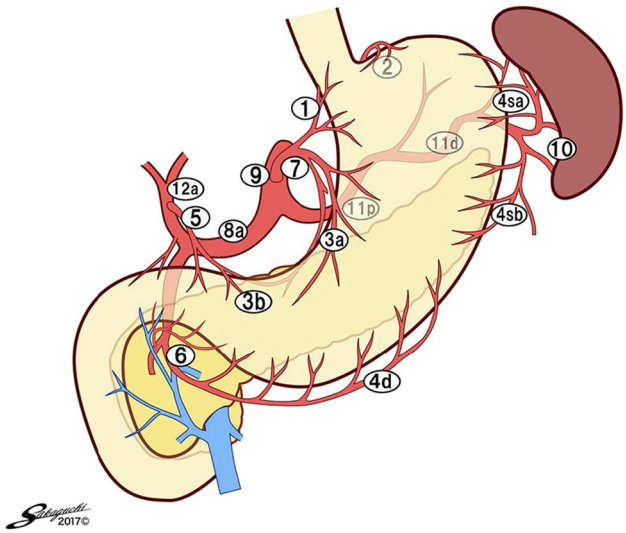
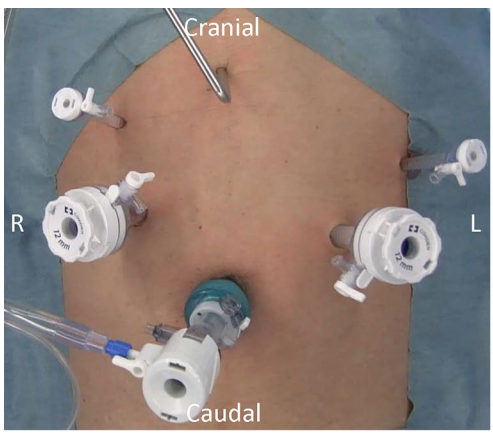


Fig. 2 Dissected lymph nodes for D2 during total gastrectomy

Surgical technique for intracorporeal esophagojejunostomy using a linear stapler and two barbed sutures (Figs. 4, 5, 6, 7, 8, 9, 10)

The procedure for intracorporeal Roux-en-Y anastomosis after LTG is as follows: First, 20 cm of jejunum is measured from the ligament of Treitz and transected using a linear stapler. An arm of the jejunum is mobilized by cutting into the mesentery towards its root, and then the tension between it and the esophagus is assessed to allow safe EJS. Intracorporeal EJS consists of an isoperistaltic side-to-side anastomosis using a linear stapler and two absorbable barbed sutures. A small enterotomy is made in the bowel 5 cm distal to the end of the jejunal arm. Next, another hole is made in the left tip of the esophageal stump along the staple line. A nasal tube is pulled out of the stump to identify the true lumen of the esophagus. Then, a stay suture is placed to avoid a gap between the esophageal mucosa and wall.

The anvil fork of the 45-mm-long linear stapler is inserted into the jejunum through a 12-mm port on the right, and the stapler is partially closed and shifted towards the esophagus, bringing the jejunum in by an antecolic route. Under the guidance of the nasal tube, the cartridge fork of the stapler is inserted into the esophagus and the stapler is closed with the left dorsal wall of the esophagus and jejunum between its jaws, and then fired to create the side-to-side anastomosis (Fig. 4). After checking for any bleeding in the V-shaped



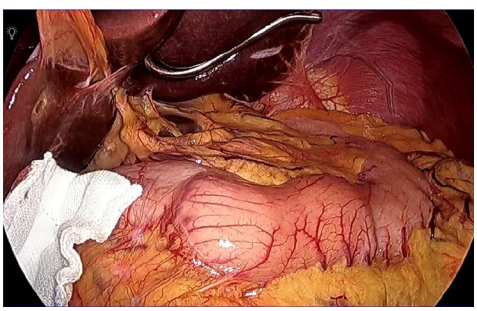


Fig. 3 Port placement and the Nathanson liver retractor in position in the abdominal cavity

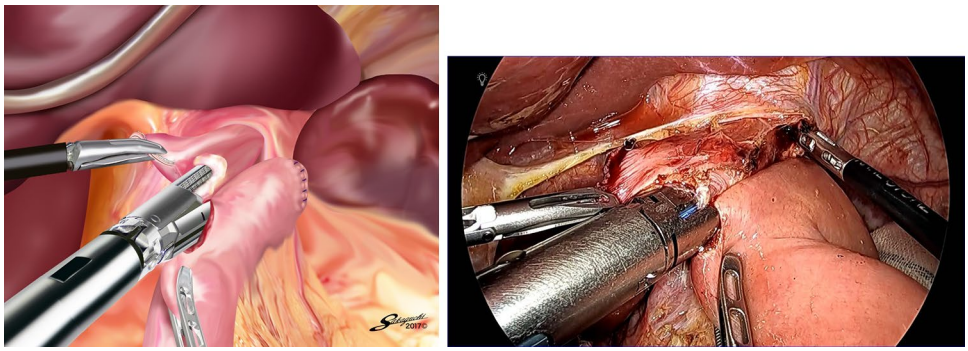


Fig. 4 The 45-mm-long stapler is closed with the left dorsal wall of the esophagus and jejunum between its jaws to create the side-to-side anastomosis

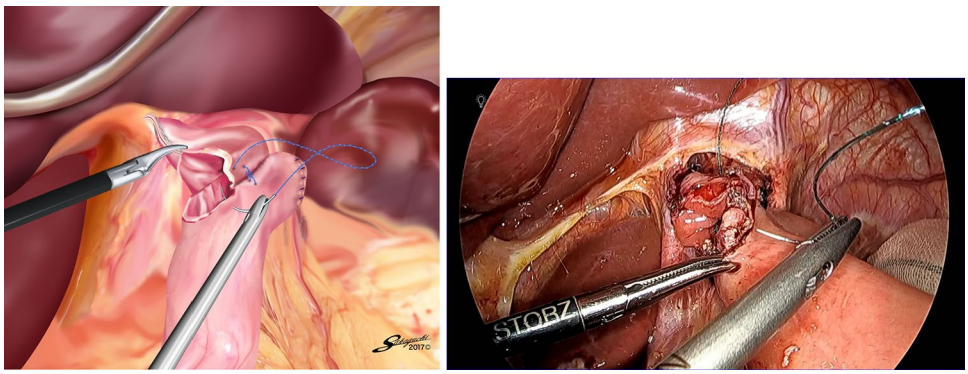


Fig. 5 Step 1 of the intracorporeal suture closure of the common enterotomy hole for the stapler, showing the full-thickness inner layer closure using a knotless unidirectional barbed suture (blue), starting from the left corner of the staple line between the esophagus and jejunum

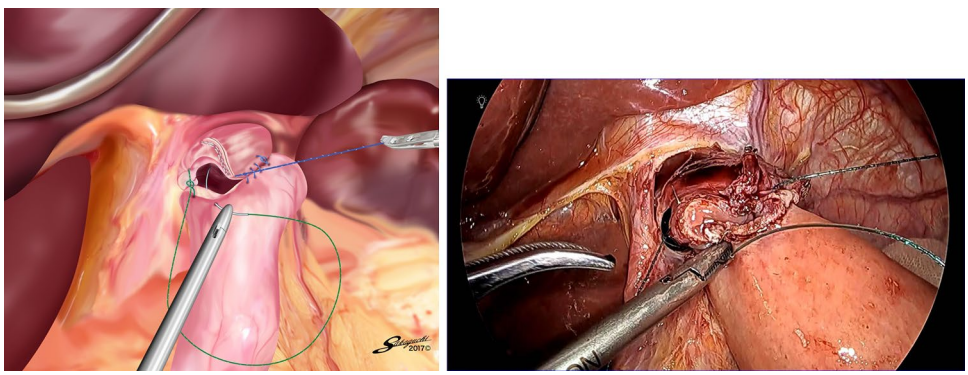


Fig. 6 Step 2 of the intracorporeal suture closure of the common enterotomy hole for the stapler showing the full-thickness inner layer closure using the other barbed suture (green), starting from the right corner of the staple line, while the first thread (blue) is retracted in a 2 o'clock direction to expose the deeper suturing field and facilitate the procedure

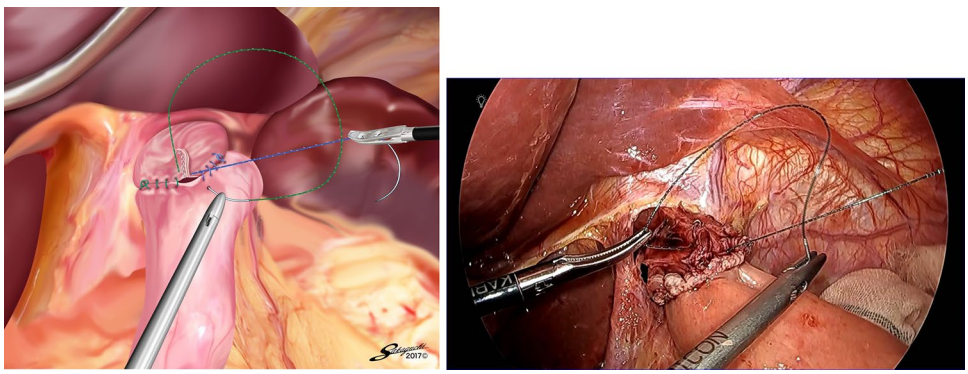


Fig. 7 The full-thickness inner layer closure is complete, adjacent to the center of the opening for the stapler

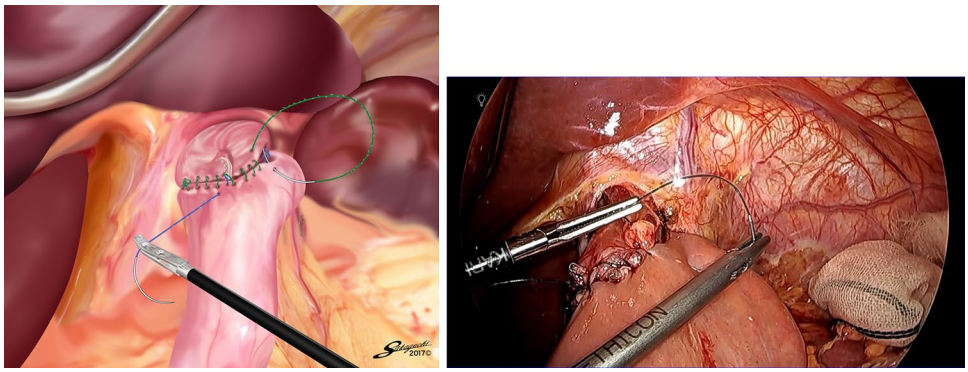


Fig. 8 Step 3 of the intracorporeal suture closure of the common enterotomy hole for the stapler showing the second seromuscular layer closure using the second suture (green) in the forward direction, towards the left corner of the side-to-side anastomosis, while the first thread (blue) is retracted in a 7–8 o'clock direction to apply traction

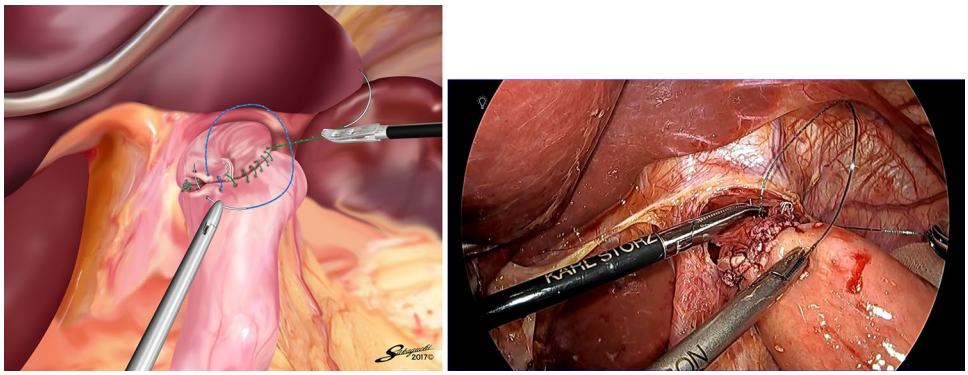


Fig. 9 Step 4 of the intracorporeal suture closure of the common enterotomy hole for the stapler showing the second seromuscular layer closure using the first suture (blue) in the forward direction, towards the right corner of the anastomosis, while the second thread (green) is utilized for applying tension and lifting the suturing field upwards

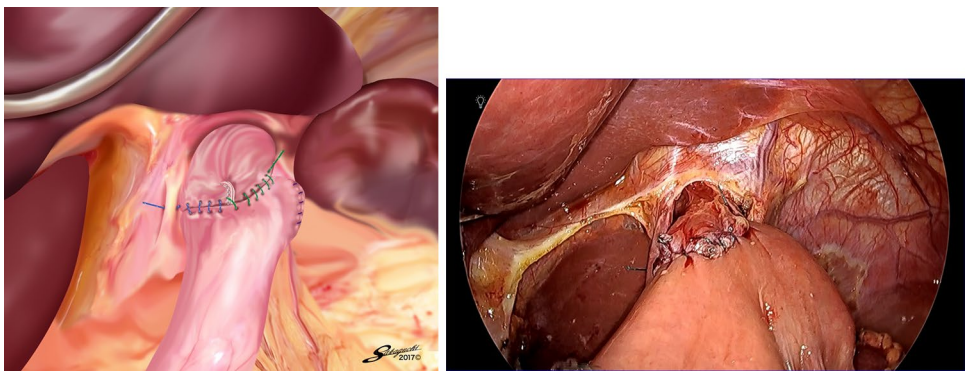


Fig. 10 Completed linear-stapled esophagojejunostomy, resembling a crossover suturing shape

anastomotic line, the opening hole for the linear stapler is closed with an Albert–Lembert two-layer continuous suture using two 15-cm 3-0 V-Loc suture devices. The full-thickness inner layer closure is initiated from the left corner of the staple line between the esophagus and jejunum toward the center of the enterotomy, using the first thread (Fig. 5).

Once the full-thickness suturing is complete from the left side of the anastomotic line to the center of the enterotomy, the other closure is performed starting from the opposite (right side) corner of the enterotomy upwards towards the first thread (Fig. 6). During the suturing using the second thread, the first thread is grasped and retracted in a 2 o'clock direction to expose a deeper suturing field and facilitate the procedure (Fig. 7). Once the full-thickness layer closure is complete at around the center of the stapler hole, suturing of the seromuscular layer is continued in the forward direction towards the left corner of the stapler line using the second suture. During this procedure, the first thread is again utilized to apply tension to the suturing field (Fig. 8). As the final step, the other seromuscular suture line is commenced in the forward direction towards the right corner using the first thread (Fig. 9), resulting in a crossover-shaped suturing line. The assistant on the left side grasps the second thread in a 2–3 o'clock direction to apply traction, which helps to visualize the deep surgical field and facilitate the usually cumbersome suturing. After the last stitch is used to anchor the right crus of the diaphragm, both sutures are

simply cut without any knots (Fig. 10). This completes the intraabdominal esophagojejunal anastomosis.

Next, we move on to the intracorporeal jejunojejunal anastomosis. An enterotomy is made 40 cm distal to the EJS, and another just proximal to the jejunal stump on the Treitz ligament side. A side-to-side jejunojejunostomy is created using a linear stapler. The remaining enterotomy is closed by continuous single-layer suturing using a 15-cm 3-0 V-Loc suture device. Finally, the Petersen's defect is closed as much as possible using nonabsorbable thread, completing the intracorporeal R-Y reconstruction.

Results

Table 1 shows the patient demographics and postoperative outcomes. Between February 2012 and October 2017, 27 patients (15 men and 12 women) underwent LTG with curative intent in our institute. Their mean age was 62.0 years (range 35–83 years) and mean body mass index was 23.0 (range 17.7–35.7). The indications for surgery were six early gastric cancers, 18 advanced gastric cancers and three cancers of the gastroesophageal junction. All patients underwent successful LTG with intracorporeal EJS as a part of Roux-en-Y reconstruction using a linear stapler and two knotless unidirectional barbed suture devices. One patient simultaneously received laparoscopy-assisted partial resection of the transverse colon because of colon cancer. The mean total operation time was 367 min (range 245–497 min) and mean suturing time for the EJS was 19.1 min (range 11.4–35.0 min). There were no surgical complications such as gastrointestinal tears or injuries during the suture or any need for blood transfusions during surgery. In terms of postoperative morbidities, no anastomosis-related complications, including Grade 2 or greater anastomotic leakage, were observed, and there was no mortality in the present series.

Table 1 Patient demographics and postoperative outcomes

Characteristics	Values ($n=27$)
Age (years)	62.0 ± 12.3
Male:female	15:12
Body mass index (kg/m^2)	23.0 ± 4.3
Comorbidity	17 (63.0%)
ASA PS (1/2/3)	11/13/3
Anastomotic time (min)	19.1 ± 9.5
Blood loss (ml)	69.4 ± 102.3
Operation time (min)	367 ± 87.7
Time to liquid diet (days)	3.3 ± 1.2
Hospital stay (days)	12.1 ± 2.4
Complications, Clavien–Dindo classification ≥ II	7 (25.9%)

Continuous variables are presented as the mean ± standard deviation

ASA PS American Society of Anesthesiologists physical status

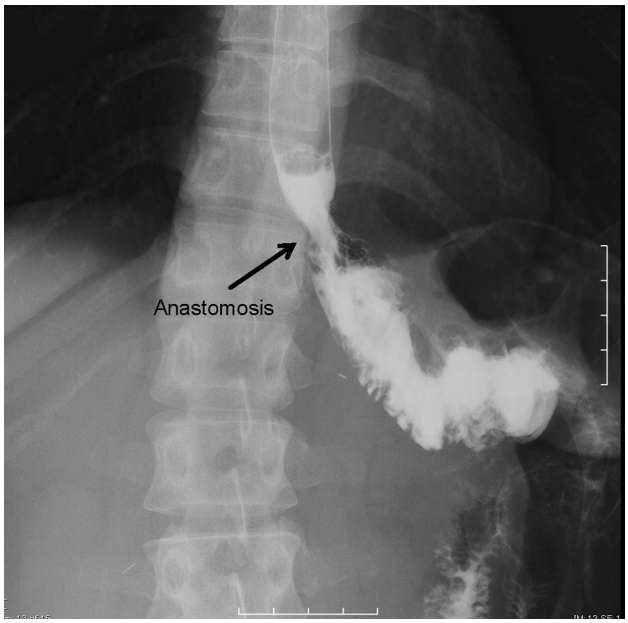


Fig. 11 Postoperative fluorography showing smooth passage of oral water-soluble contrast medium without leakage or stenosis of the anastomosis

The patients tolerated a liquid diet at 3.3 days (range 2–7 days) after surgery, and the mean hospital stay was 12.1 days (range 9–18 days). Figure 11 shows an upper-gastrointestinal contrast study on postoperative day 3, demonstrating the shape of the EJS and the absence of obstruction or leakage.

Discussion

Between April 2000 and October 2017, 1432 patients with gastric malignancies underwent laparoscopic gastric resections with curative intent at Osaka Medical College Hospital, Japan. The laparoscopic resections consisted of 847 (59.1%) distal gastrectomies, 243 (17.0%) pylorus-preserving gastrectomies, 130 (9.1%) proximal gastrectomies, 117 (8.2%) total gastrectomies, and 95 (6.6%) wedge resections. The LG procedure was introduced in our unit in 2000 to treat patients with early gastric cancers. Based on our clinical experience and on improvements in our technique, the indications have been expanded to include those with advanced gastric cancers [16–18]. In 2010, we reported a single-center retrospective study of 601 LG procedures, with overall 5-year patient survival rates of 93.4% for those with T1 tumors, 70.0% for those with T2 tumors, and 57.1% for those with T3 tumors [17]. These results were similar to those of open resection [19, 20].

In our early procedures, we performed laparoscopy-assisted gastrectomy, in which, although lymph node dissection was performed intracorporeally, transection of the stomach and the anastomosis were performed through a minilaparotomy made on the epigastrium. We often had difficulty performing the anastomosis in this narrow and restricted space, especially in obese patients with thick abdominal walls and patients with a small remnant stomach. To overcome the drawbacks of such cumbersome reconstructions, in 2004 we introduced the use of intracorporeal stapled gastroduodenostomy and gastrojejunostomy after laparoscopic distal gastrectomy (LDG) [21, 22]. Through our experience, we have noted that intracorporeal anastomosis subsequent to LDG has several advantages over laparoscopy-assisted DG with extracorporeal anastomosis, including a smaller wound, reduced invasiveness, and a safer anastomosis [8]. However, intracorporeal suturing and knot tying for anastomoses remain tedious and time-consuming procedures in such surgery. This surgery requires the use of very safe and reproducible techniques because leaks and fistulas result in morbidity and mortality [2, 18, 23–25]. We hypothesized that a barbed suture might improve the efficiency and safety of intracorporeal reconstruction of the digestive tract as well as reduce its cost by allowing closure of the entry hole for the stapler and minimizing the time required for suturing. Therefore, in 2011, we introduced the use of barbed sutures for closing the stapler enterotomy. By the end of October 2017, we had performed 652 intracorporeal anastomoses using barbed sutures in 434 patients with gastric cancer. Encouragingly, only one patient developed an anastomotic complication related to postoperative bleeding. Over a follow-up of 33.9 months, we observed reduced mortality, and no patients required conversion to standard sutures or mechanical closure of the entry hole, or reoperation because of adhesive obstructions. We are therefore confident that this novel technique can improve surgical outcomes in patients requiring LG.

At our institute, esophagojejunal anastomosis following LTG had been performed for the first 84 patients from the initial series by the double-stapling technique using circular stapler devices [26]. Of these patients, four suffered anastomotic leakage of the EJS, giving a leak rate of 4.7%. Six patients (7.1%) developed anastomotic stenosis, which was treated by endoscopic dilatation. In addition, we were aware of potential problems in using circular staplers under the limited laparoscopic view available while a stapling device is applied. To avoid these potential problems, we initiated linear-stapled EJS after LTG in 2012. However, even with this procedure, it could be difficult to close the access opening securely after a common hole was created by the application of the linear stapler. Some studies have reported closure by further application of a linear stapler [27–29]. In that method, the application of the second linear stapler to close the entry hole is not easy under the limited laparoscopic view of the deep and narrow operation field, and consequently, this technique can lead to stenosis of the anastomosis. Others have reported closure with hand sutures, which takes longer to perform and requires a higher degree of surgical skill [30]. To overcome these issues, we made some modifications to the procedure for linear-stapled EJS [12]. First, for easier suturing of the entry hole for the stapler, a side-to-side anastomosis was created around the left dorsal wall of the esophagus, resulting in the common stab incision opening upwards. Second, the use of knotless, unidirectional barbed sutures enabled the surgeon to work efficiently with both hands and focus exclusively on subsequent stitch placement, without the need to maintain tension on preceding throws to prevent slippage, even within the deep area. Third, the effective retraction of the remaining thread by the assistant helps to make space and lifts the suturing field upwards for better viewing. In the present series, suturing in the lower mediastinum was performed in three patients with cancer of the gastroesophageal junction; this technique was effective and achieved good surgical outcomes. In all 27 consecutive patients, we successfully performed intracorporeal Roux-en-Y reconstruction and experienced neither anastomotic leakage nor stenosis.

Conclusion

In conclusion, our extensive experience with this new closure device in LG satisfies us that this method is feasible and reliable and will promote the acceptance of LTG as a promising surgical option.

Compliance with ethical standards

Disclosures Sang-Woong Lee, Masaru Kawai, Keitaro Tashiro, Satoshi Kawashima, Ryo Tanaka, Keitaro Tanaka, Eiji Nomura, and Kazuhisa Uchiyama have no conflicts of interest or financial ties to disclose.

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