

# Surgical outcomes of intracorporeal circular-stapled esophagojejunostomy using modified over-and-over suture technique in laparoscopic total gastrectomy

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Received: 1 June 2014 / Accepted: 12 January 2015 / Published online: 29 January 2015  
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## Abstract

**Background** Esophagojejunostomy in laparoscopic total gastrectomy (LTG) is a technically demanding procedure. Although several methods have been reported to date, none is considered consistently reliable. We developed a simple method for intracorporeal circular-stapled esophagojejunostomy using a modified over-and-over suture technique. The surgical outcomes of our technique were evaluated in comparison with those of open total gastrectomy (OTG).

**Methods** From April 2012 to August 2014, reconstruction using this method in LTG was performed for 21 consecutive patients with gastric cancer (LTG group). Their surgical outcomes were compared with those of 27 patients with gastric cancer who underwent OTG without splenectomy (OTG group) between January 2011 and April 2014.

**Results** Estimated blood loss was significantly lower, and the postoperative hospital stay was significantly shorter in the LTG group than in the OTG group. The operating time and the number of harvested lymph nodes were similar

between the two groups. The incidence of overall complications did not differ significantly between the two groups. Anastomotic leakage developed in one of the 21 patients in the LTG group and in two of the 27 patients in the OTG group. Anastomotic stenosis was observed in one patient in the LTG group.

**Conclusions** We consider this method as simple and feasible for most laparoscopic surgeons with basic laparoscopic suturing skills. This method might help LTG to become an accepted standard surgical option for treatment of patients with gastric cancer.

**Keywords** Esophagojejunostomy · Laparoscopy · Gastric cancer

Since the first report of laparoscopic distal gastrectomy (LDG) by Kitano et al. [1] in 1991, great efforts have been made to establish standardized reconstruction techniques during LDG. As a result, LDG has become widely accepted as a standard surgical option for gastric cancer because of its stability and feasibility [2–4]. In contrast, laparoscopic total gastrectomy (LTG) is not widely employed because it is technically demanding [5, 6], mainly because reconstruction of the esophagojejunostomy is difficult. Although several methods have been reported to date, none has been shown to be consistently reliable [7–11].

We developed a simple method for intracorporeal circular-stapled esophagojejunostomy using an over-and-over suture technique, which enables simple and reliable fixation of the anvil head to the esophageal stump, and allows anastomosis to be completed in a similar fashion to open surgery using a circular stapler. Here, we describe the key details of our procedures. The surgical outcomes of our technique were compared with those of open total gastrectomy (OTG).

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**Electronic supplementary material** The online version of this article (doi:10.1007/s00464-015-4073-5) contains supplementary material, which is available to authorized users.

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## Materials and methods

### Patients

Between April 2012 and August 2014, 21 patients with clinical T1N0 gastric cancer underwent LTG with intracorporeal esophagojejunostomy (LTG group) at our institutions. Intracorporeal esophagojejunostomy was performed using a 25-mm circular stapler with the hand-sewn over-and-over suture technique. The surgical outcomes in these patients were compared with those of 27 patients with gastric cancer who underwent OTG without splenectomy between January 2011 and April 2014 (OTG group). In OTG, esophagojejunostomy was performed using the conventional technique using a 25-mm circular stapler.

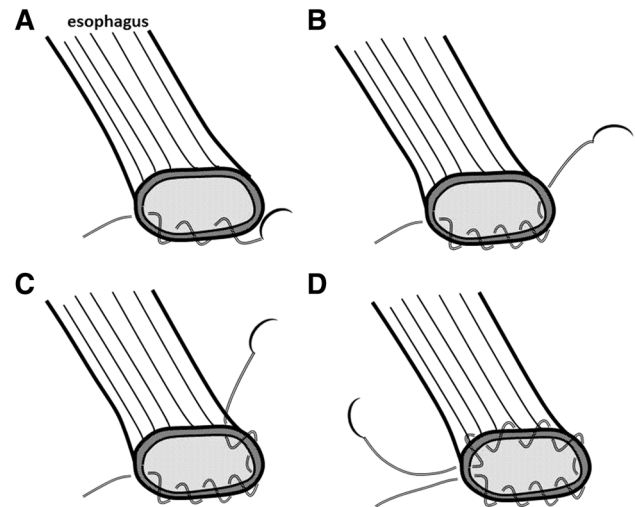
### Surgical procedures

#### LTG

LTG was performed using five ports, and radical lymphadenectomy was performed for all patients. The abdominal esophagus was sufficiently exposed along the esophageal hiatus after all other laparoscopic procedures, including lymphadenectomy and mobilization of the stomach, were completed. Laparoscopic intestinal clamping was applied to the abdominal esophagus just below the esophageal hiatus so that the cut end of the esophagus was not pulled up into the mediastinum. The esophagus was transected using a linear stapler, and then, the stomach was extracted through a small incision of approximately 4 cm through the umbilical port. The anvil head was placed into the abdominal cavity through a small incision, which was covered with a latex-free surgical glove.

The esophageal stump was dissected using laparoscopic ultrasonic coagulating shears, and the esophageal lumen was opened. An over-and-over suture using a 2–0 monofilament was placed counterclockwise starting from the right side of the cut end in an outside-to-inside direction (Fig. 1A) till the left side, where it was converted to an inside-to-outside direction (Fig. 1B), and was continued counterclockwise to the right side (Fig. 1C, D; Video 1). Throughout the procedure, an over-and-over suture was placed using a forehand stroke with a needle-driver held in the surgeon's right hand via the right lower port.

The suture was ligated by a double half-knot and clipped at the end of the thread so that it would not detach from the esophagus. Then, the intestinal clamp was removed, and the anvil head was inserted into the esophagus using an anvil head holder. A suture ligated in advance was tied once, and then, the position of the anvil head was adjusted and fixed in the proper position by additional ligation of the thread, which was reinforced using an Endoloop<sup>®</sup> ligature (Ethicon Endo-Surgery, Inc., Cornelia, GA, USA; Video 2).



**Fig. 1** Schematic representation of the modified over-and-over suture technique at the cut end of the esophagus. **A** An over-and-over suture using a 2–0 monofilament was placed counterclockwise from the right side of the cut end of the esophageal in an outside-to-inside direction. **B** The suture was converted to an inside-to-outside direction at the left side. **C, D** Over-and-over suture was continued counterclockwise to the right side in an inside-to-outside direction

Reconstruction was performed using the Roux-en-Y method. A 25-mm circular stapler, which was introduced through a surgical glove, was inserted into the Roux limb and intracorporeally combined with the anvil head under pneumoperitoneum. Esophagojejunostomy was performed by firing the stapler, and the open end of the Roux limb was closed using a linear stapler (Video 3). Finally, a side-to-side jejunojunction was intracorporeally performed using a linear stapler.

#### OTG

Following radical LN dissection, the purse-string instrument (PSI) was applied to the esophagus, and a purse-string suture was placed on the esophagus through the PSI using a 2-0 monofilament suture. After esophageal transection, the stomach was extracted from the abdominal cavity. The anvil head of a 25-mm circular stapler was introduced into the esophagus and fixed by suture ligation. A circular stapler was introduced through the distal end of the jejunal limb, and esophagojejunostomy was performed by firing the stapler. A jejunojunctional anastomosis was performed in a side-to-side fashion using the hand-sewn suture technique or a linear stapler.

#### Statistical analysis

All data were expressed as mean values. Categorical variables were analyzed using the Chi square test and Fisher's exact test. Student's *t* test was used to compare the

means of continuous variables. *P* values of <0.05 were considered statistically significant.

## Results

The patient and tumor characteristics of both groups are summarized in Table 1. The mean patient age in the LTG group was 10 years higher than that in the OTG group. In addition, patients with more advanced-stage cancers were more common in the OTG group than in the LTG group.

**Table 1** Patient and tumor characteristics

	LTG ( <i>n</i> = 21)	OTG ( <i>n</i> = 27)	<i>P</i>
Age (range)	64 (44–79)	74 (52–88)	0.001
Sex, <i>n</i> (%)			0.240
Male	14 (66.7)	22	
Female	7 (33.3)	5	
BMI(kg/m <sup>2</sup> ), (range)	23 (19–31)	22 (18–30)	0.875
ASA classification, <i>n</i> (%)			0.983
1	3 (14.2)	4 (14.8)	
2	17 (81.0)	22 (81.5)	
3	1 (4.8)	1 (3.7)	
Cellular classification, <i>n</i> (%)			0.184
Intestinal	10 (55.6)	18 (66.7)	
Diffuse	11 (44.4)	9 (33.3)	
pT <sup>a</sup> , <i>n</i> (%)			0.028
T1a	10 (50.0)	4 (14.8)	
T1b	7 (38.9)	6 (22.2)	
T2	2 (5.6)	6 (22.2)	
T3	2 (5.6)	7 (25.9)	
T4	0 (0)	4 (14.8)	
pN <sup>a</sup> , <i>n</i> (%)			0.058
N0	21 (100)	19 (70.4)	
N1	0 (0)	3 (11.1)	
N2	0 (0)	2 (7.4)	
N3	0 (0)	3 (11.1)	
pStage <sup>a</sup> , <i>n</i> (%)			0.072
IA	17 (88.9)	10 (37.0)	
IB	2 (5.6)	4 (14.8)	
IIA	2 (5.6)	4 (14.8)	
IIB	0 (0)	5 (18.5)	
IIIA	0 (0)	1 (3.7)	
IIIB	0 (0)	1 (3.7)	
IIIC	0 (0)	2 (7.4)	
Adjuvant chemotherapy, <i>n</i> (%)			0.006
Yes	0 (0)	8 (29.6)	
No	21 (100)	19 (70.4)	

<sup>a</sup> Tumors were classified according to the American Joint Committee on Cancer (AJCC)/TNM system

Intraoperative and postoperative results are shown in Table 2. Estimated blood loss was significantly lower and postoperative hospital stay was significantly shorter in the LTG group than in the OTG group. In contrast, the operating time and the number of harvested LNs did not differ significantly between the two groups. The incidence of overall complications did not differ significantly between the groups (Table 3). The incidence of anastomotic leakage at the esophagojejunostomy was similar between the groups. Anastomotic stenosis, however, was observed in only one patient in the LTG group.

In LTG group, the mean time for fixation of the anvil to the esophagus (from insertion of 2–0 monofilament into the abdominal cavity to completion of reinforcement using an Endoloop<sup>®</sup> ligature) was 15 min for the last ten consecutive patients.

## Discussion

LDG is currently a standard surgical option for treatment of gastric cancer worldwide [2–4], which is mainly because of successful standardization of the surgical techniques, including reconstruction and lymph node dissection. In particular, reconstruction after LDG can be extracorporeally performed through a minilaparotomy in a similar fashion to open surgery, resulting in wide acceptance of this procedure by many general and laparoscopic surgeons. Even intracorporeal reconstruction after LDG has been standardized in recent years [12, 13]. Conversely, there are several problems with the technical aspects of LTG that must be resolved. Because esophagojejunostomy after LTG is technically challenging, standardization of this procedure is essential before LTG is widely accepted as a surgical option for gastric cancer.

To date, several methods have been developed to overcome the technical aspects of LTG [7–11], which can be classified into two representative approaches: one that employs a linear stapler and the other with a circular stapler for anastomosis. In the former, the overlap method, which was first reported by Inaba et al. [7] in 2010, remains popular. This method seems to have an advantage of better surgical view under the limited laparoscopic vision over the use of a circular stapler. Moreover, it does not require minilaparotomy for anastomosis. However, a longer dissection to the abdominal esophagus from the diaphragmatic crus is necessary to ensure a sufficient length of the esophagus for anastomosis. In addition, when the jejunal limb is lifted to the esophageal stump with a linear stapler, the end of the jejunal limb can be injured by the tip of the stapler fork because of excessive tension during repositioning. Once injury occurs to the end of the jejunal limb, repair becomes extremely difficult.

**Table 2** Intraoperative and postoperative results

	LTG ( <i>n</i> = 21)	OTG ( <i>n</i> = 27)	<i>P</i>
Operative time, min (range)	341 (280–446)	322 (229–602)	0.315
Estimated blood loss, ml (range)	46 (5–150)	501 (30–1,540)	<0.001
No. of harvested lymph nodes, <i>n</i> (range)	49 (22–84)	40 (20–83)	0.260
Lymphadenectomy, <i>n</i> (%)			1.000
D1+	18 (100)	27 (100)	
D2	0 (0)	0	
Route of the jejunal limb, <i>n</i> (%)			<0.001
Antecolic	20	0	
Retrocolic	1	27	
Conversion to open surgery, <i>n</i> (%)	0 (0)		NA
Postoperative hospital stay, days (range)	16 (8–47)	33 (11–91)	0.008

**Table 3** Mortality and complications

	LTG ( <i>n</i> = 21)	OTG ( <i>n</i> = 27)	<i>P</i>
Operative mortality, <i>n</i> (%)	0 (0)	0 (0)	1.000
Overall complications, <i>n</i> (%)	3 (18.5)	9 (33.3)	0.131
SSI	0 (0)	2 (7.4)	
Pneumonia	0 (0)	3 (11.1)	
Anastomotic leakage	1 (4.8)	2 (7.4)	
Anastomotic stenosis	1 (4.8)	0 (0)	
Bleeding <sup>a</sup>	1 (4.8)	0 (0)	
Intestinal obstruction	1 (4.8)	1 (3.7)	
Reflux	0 (0)	2 (7.4)	
Pancreatic fistula	0 (0)	1 (3.7)	
Ventral hernia	0 (0)	2 (7.4)	

<sup>a</sup> Bleeding at the jejunojejunal anastomosis

Conversely, several groups have reported the use of a circular stapler for esophagojejunostomy in LTG [8–11, 14, 15]. In conventional open total gastrectomy, esophagojejunostomy using a circular stapler is the most common and popular method. Therefore, various LTG approaches adopting a circular stapler have been developed to achieve similar results to open esophagojejunostomy. For example, Omori et al. [9] reported a novel circular-stapled esophagojejunostomy in which the anvil is introduced via the esophagotomy at the anterior esophageal wall and fixed to the esophageal stump using a linear stapler. This method eliminates the need for placement of purse-string sutures, which is considered a leading obstacle in esophagojejunostomy after LTG. Hiki et al. [14] also described a laparoscopic esophago-gastric circular-stapled anastomosis technique without the use of purse-string sutures. In their method, the anvil is introduced into the esophagus through a small gastrotomy using a nasogastric tube as a guide and fixed to the esophageal stump using a linear stapler alone. In the OrVil system, the anvil is fixed at the esophageal stump in a similar fashion [15]. However, attachment of the anvil to an orogastric tube must be introduced to the esophageal stump through the mouth. These three methods

are well established; however, all incorporate a double-stapling technique (DST). Reportedly, DST poses a potentially high risk of the development of anastomotic stenosis in colorectal surgery as well as upper gastrointestinal surgery [16, 17]. Therefore, the single-stapling technique (SST) is favorable in esophagojejunostomy after LTG.

In 2005, Takiguchi et al. [10] reported a SST method using the Endostitch<sup>®</sup> semiautomatic suturing device (Covidien Ltd., Dublin, Ireland), which simplifies placement of encircling purse-string sutures at the esophageal stump, allowing esophagojejunostomy by SST in a similar fashion to that of open surgery. However, the Endostitch<sup>®</sup> semiautomatic suturing device requires use of an additional 33-mm trocar. Usui et al. [11] also developed a new endoscopic purse-string suture instrument, the Endo-PSI (II) in which esophagojejunostomy can be performed using SST. However, handling of this device under narrow laparoscopic vision is sometimes difficult because of its relatively large size. In addition, laparoscopically passing a straight needle with a 2–0 polypropylene suture through this instrument is difficult in obese patients with voluminous intra-abdominal fat. Importantly, both methods

require the use of specialized devices and have relatively complex technical aspects.

Kinoshita et al. [8] reported a simple and classic method using a circular stapler combined with hand-sewn purse-string sutures that does not require the use of specialized devices to perform anastomosis in a very similar fashion to that in conventional open surgery. According to the authors, this procedure would be feasible even in countries with limited access to new specialized devices. One concern associated with this method is that laparoscopic hand-sewn purse-string sutures are placed using the backhand style, which is considered very difficult even for skilled laparoscopic surgeons and thus is an important obstacle to the popularization of this method.

We modified the suturing technique of Kinoshita et al. [8] to make it simpler and easier so that more laparoscopic surgeons can place hand-sewn sutures along the cut end of the esophagus for fixation of the anvil. In our method, the use of an over-and-over suture instead of a purse-string suture is employed, and the suturing direction is switched from outside–inside to inside–outside at the halfway point. Thus, placement of encircling hand-sewn sutures to the esophagus can be completed using the forehand style throughout the procedure. The right lower and upper ports are operated by the surgeon's right and left hands, respectively. The key point of this procedure is switching of suturing direction at the left side of the esophageal stump. At this point, suturing direction should be switched at the short step. Otherwise, ligation for anvil fixation may be insufficient at the left side of the esophagus. We recommend using a pre-tied loop, such as the Endoloop<sup>®</sup> ligature, to confirm reinforcement of fixation. Another important point is the use of an anvil holder during insertion of the anvil in the esophagus. If bowel forceps are used instead of an anvil holder, the anvil can easily slip from the bowel forceps, requiring extra attention from the surgeon not to drop it. These situations can lead to possible injury to the esophagus by unintended traction of the esophageal wall by the surgeon's left hand. Therefore, the use of an anvil holder is beneficial to secure anvil insertion.

We consider that our method is safe and feasible for most laparoscopic surgeons with basic skills in laparoscopic suturing. Moreover, the surgical outcomes of this technique were comparable with those of OTG. Although further analyses of a larger number of patients are essential for a definitive conclusion, this method might help LTG to become accepted as a standard surgical option for treatment of patients with gastric cancer.

**Disclosures** Takeru Matsuda, Takeshi Iwasaki, Masaaki Mitsutsuji, Kenro Hirata, Yoko Maekawa, Daisuke Tsugawa, Yutaka Sugita, Etsuji Shimada, and Yoshihiro Kakeji have no conflicts of interest or financial ties to disclose.

## References

1. Kitano S, Iso Y, Moriyama M, Sugimachi K (1994) Laparoscopy-assisted Billroth I gastrectomy. *Surg Laparosc Endosc* 4:146–148
2. Kim HH, Hyung WJ, Cho GS, Kim MC, Han SU, Kim W, Ryu SW, Lee HJ, Song KY (2010) Morbidity and mortality of laparoscopic gastrectomy versus open gastrectomy for gastric cancer: an interim report—a phase III multicenter, prospective, randomized Trial (KLASS Trial). *Ann Surg* 251:417–420
3. Kodera Y, Fujiwara M, Ohashi N, Nakayama G, Koike M, Morita S, Nakao A (2010) Laparoscopic surgery for gastric cancer: a collective review with meta-analysis of randomized trials. *J Am Coll Surg* 211:677–686
4. Lee JH, Han HS (2005) A prospective randomized study comparing open vs laparoscopy-assisted distal gastrectomy in early gastric cancer: early results. *Surg Endosc* 19:168–173
5. Huscher CG, Mingoli A, Sgarzini G, Brachini G, Binda B, Di Paola M, Ponzano C (2007) Totally laparoscopic total and subtotal gastrectomy with extended lymph node dissection for early and advanced gastric cancer: early and long-term results of a 100-patient series. *Am J Surg* 194:839–844 (discussion 844)
6. Tanimura S, Higashino M, Fukunaga Y, Kishida S, Ogata A, Fujiwara Y, Osugi H (2007) Laparoscopic gastrectomy with regional lymph node dissection for upper gastric cancer. *Br J Surg* 94:204–207
7. Inaba K, Satoh S, Ishida Y, Taniguchi K, Isogaki J, Kanaya S, Uyama I (2010) Overlap method: novel intracorporeal esophagojejunostomy after laparoscopic total gastrectomy. *J Am Coll Surg* 211:e25–e29
8. Kinoshita T, Oshiro T, Ito K, Shibusaki H, Okazumi S, Katoh R (2010) Intracorporeal circular-stapled esophagojejunostomy using hand-sewn purse-string suture after laparoscopic total gastrectomy. *Surg Endosc* 24:2908–2912
9. Omori T, Oyama T, Mizutani S, Tori M, Nakajima K, Akamatsu H, Nakahara M, Nishida T (2009) A simple and safe technique for esophagojejunostomy using the hemidouble stapling technique in laparoscopy-assisted total gastrectomy. *Am J Surg* 197:e13–e17
10. Takiguchi S, Sekimoto M, Fujiwara Y, Miyata H, Yasuda T, Doki Y, Yano M, Monden M (2005) A simple technique for performing laparoscopic purse-string suturing during circular stapling anastomosis. *Surg Today* 35:896–899
11. Usui S, Nagai K, Hiranuma S, Takiguchi N, Matsumoto A, Sanada K (2008) Laparoscopy-assisted esophagoenteral anastomosis using endoscopic purse-string suture instrument “Endo-PSI (II)” and circular stapler. *Gastric Cancer* 11:233–237
12. Kanaji S, Harada H, Nakayama S, Yasuda T, Oshikiri T, Kawasaki K, Yamamoto M, Imanishi T, Nakamura T, Suzuki S, Tanaka K, Fujino Y, Tominaga M, Kakeji Y (2014) Surgical outcomes in the newly introduced phase of intracorporeal anastomosis following laparoscopic distal gastrectomy is safe and feasible compared with established procedures of extracorporeal anastomosis. *Surg Endosc* 28:1250–1255
13. Kanaya S, Gomi T, Momoi H, Tamaki N, Isobe H, Katayama T, Wada Y, Ohtoshi M (2002) Delta-shaped anastomosis in totally laparoscopic Billroth I gastrectomy: new technique of intraabdominal gastroduodenostomy. *J Am Coll Surg* 195:284–287
14. Hiki N, Fukunaga T, Yamaguchi T, Nunobe S, Tokunaga M, Ohyama S, Seto Y, Muto T (2007) Laparoscopic esophagogastric circular stapled anastomosis: a modified technique to protect the esophagus. *Gastric Cancer* 10:181–186
15. Jeong O, Park YK (2009) Intracorporeal circular stapling esophagojejunostomy using the transorally inserted anvil (OrVil) after laparoscopic total gastrectomy. *Surg Endosc* 23:2624–2630

16. Bannura GC, Cumsille MA, Barrera AE, Contreras JP, Melo CL, Soto DC (2004) Predictive factors of stenosis after stapled colorectal anastomosis: prospective analysis of 179 consecutive patients. *World J Surg* 28:921–925
17. Zuiki T, Hosoya Y, Kaneda Y, Kurashina K, Saito S, Ui T, Haruta H, Hyodo M, Sata N, Lefor AT, Yasuda Y (2013) Stenosis after use of the double-stapling technique for reconstruction after laparoscopy-assisted total gastrectomy. *Surg Endosc* 27:3683–3689