Current status of laparoscopic total gastrectomy

Yoshihiko Kawaguchi | Kensuke Shiraishi | Hidenori Akaike | Daisuke Ichikawa

First Department of Surgery, Faculty of Medicine, University of Yamanashi, Chuo, Yamanashi, Japan

Correspondence
Daisuke Ichikawa, First Department of Surgery, Faculty of Medicine, University of Yamanashi, Chuo, Yamanashi, Japan. Email: dichikawa@yamanashi.ac.jp

Abstract
In this article, the current state of laparoscopic total gastrectomy (LTG) was reviewed, focusing on lymph node dissection and reconstruction. Lymph node dissection in LTG is technically similar to that in laparoscopic distal gastrectomy for early gastric cancer; however, LTG for advanced gastric cancer requires extended lymph node dissections including splenic hilar lymph nodes. Although a recent randomized controlled trial clearly indicated no survival benefit in prophylactic splenectomy for lymph node dissection at the splenic hilum, some patients may receive prognostic benefit from adequate splenic hilar lymph node dissection. Considering reconstruction, there are two major esophagojejunostomy (EJS) techniques, using a circular stapler (CS) or using a linear stapler (LS). A few studies have shown that the LS method has fewer complications; however, almost all studies have reported that morbidity (such as anastomotic leakage and stricture) is not significantly different for the two methods. As for CS, we grouped various studies addressing complications in LTG into categories according to the insertion procedure of the anvil and the insertion site in the abdominal wall for the CS. We compared the rate of complications, particularly for leakage and stricture. The rate of anastomotic leakage and stricture was the lowest when inserting the CS from the upper left abdomen and was significantly the highest when inserting the CS from the midline umbilical. Scrupulous attention to EJS techniques is required by surgeons with a clear understanding of the advantages and disadvantages of each anastomotic device and approach.

Keywords
esophagojejunostomy, gastric cancer, laparoscopic total gastrectomy, lymphadenectomy, postoperative complication

1 | INTRODUCTION

Gastric cancer is the fifth most common malignancy and the third leading cause of cancer death in the world. Although various new drugs have been developed for its treatment, surgically curative resection is still the mainstay of treatment for gastric cancer. Since the first laparoscopic gastrectomy case was reported in 1991, it has gained widespread global popularity owing to laparoscopic hemostatic surgical devices and the standardization of techniques. Several randomized controlled trials (RCT) comparing laparoscopic distal gastrectomy (LDG) with conventional open distal gastrectomy (ODG) have reported superiority in the short-term advantages for LDG. Although RCT are ongoing in both Japan and Korea (JCOG0912 and KLASS012), several large-scale retrospective studies have shown acceptable prognostic results of LDG for patients with early gastric cancer. In recent years, LDG has been...
implemented in patients with advanced gastric cancer at high-volume centers, and RCT comparing the feasibility and long-term survival between LDG and ODG are currently ongoing in China (CLASS-01 trial), Korea (KLASS-02 trial), and Japan (JLSSG0901).

In contrast, laparoscopic total gastrectomy (LTG) is not common compared with LDG, which is carried out in only 25% (1556/6183) of total gastrectomy procedures, according to a questionnaire-based survey conducted by the Japan Society of Endoscopic Surgery in 2015, although the proportion of LDG had increased to 54% (6884/12 722). In this survey, the conversion rate in LTG was reported as 2.1% which was about three times as compared with 0.6% in LDG. Furthermore, according to the National Clinical Database (NCD), covering 95% of general surgery procedures in all of Japan, LTG is carried out in 18% (5749/32 144) of total gastrectomy procedures.

Several reports have already published data on the feasibility and safety of LTG, but these reports were mainly from high-volume centers, and almost all the LTG were carried out by surgeons who were already accustomed to laparoscopic gastrectomy. Many surgeons still hesitate to carry out LTG, and the main reasons are difficulty of lymphadenectomy at the splenic hilum and the high technical demands of esophagealjunostomy (EJS).

Two large-scale reports based on data from the National Clinical Database, one retrospective and the other prospective, have recently been reported as so-called “real-world data” in Japan, with controversial results about the occurrence of anastomosis-related complications.

In this article, the status of LTG was reviewed focusing on lymphadenectomy and reconstruction.

2 | LYMPHADENECTOMY

Lymphadenectomy, excision of the regional lymph nodes (LN) draining from a tumor, is an essential element in the surgical management of gastric cancer. The extent of systematic lymphadenectomy is defined, respectively, for each type of gastrectomy, according to Japanese gastric cancer treatment guidelines. In principle, D1 and D1 + lymphadenectomy is indicated for early gastric cancer, and D2 lymphadenectomy for advanced gastric cancer and cases with apparent metastasis at the regional lymph nodes, even in early gastric cancers. In D1 + lymph node dissection, differences between LDG and LTG are only left paracardial LN (No. 2), left greater curvature LN along the short gastric arteries (No. 4a) which is usually easily removed with the stomach in LTG, and proximal splenic artery LN (No. 11p) which is generally removed in LDG for early gastric cancer. In that sense, technical aspects of lymph node dissection in LTG are like those in LDG for early gastric cancer; therefore, the prognostic evidence based on results of RCT (JCOG 0912), which confirm that LDG is not inferior to ODG in efficacy for early gastric cancer, would be applicable to LTG.

However, LTG for advanced gastric cancer requires precise lymph node dissection. As for LDG, two RCT, JLSSG0901 and KLASS-02, are in progress and the results will soon be available; they compare long-term outcomes of LDG with those of ODG. In contrast, although some retrospective studies have reported that long-term outcome of LTG is equivalent to that of open total gastrectomy (OTG), RCT in LTG for advanced gastric cancer has just been started in Korea (KLASS-06).

Among several LN stations, splenic hilar (No. 10) and along the distal splenic artery (No. 11d), the LN are specific and are the most applicable regions for the procedure of LTG for advanced gastric cancers. Survival benefit of lymphadenectomy for these regions remains controversial not only for laparoscopic surgery, but also for open surgery of advanced gastric cancer.

The difficulty of lymphadenectomy of the region is due to anatomical variation of the splenic hilar vessels and the narrow and deep space, and lymphadenectomy increases the risks of operative morbidities including pancreatic fistula. In recent reports, the incidence of pancreatic fistula in LTG ranged between 0.2% and 2.7% and this rate is equivalent to OTG. Furthermore, some reports showed that the incidence of overall complications of LTG was equivalent to that of OTG, and other reports showed that the rate of complications was lower for LTG than for OTG. One of the reasons for this is the improvement of energy devices, which is described in many reports, and some researchers reported that preoperative assessment of splenic vascular anatomy using computed tomography (CT) with 3-D imaging was useful and correlated with shorter operative time, lower blood loss, and a larger number of retrieved lymph nodes.

Open total gastrectomy with splenectomy has been standard in Japan for complete removal of lymph nodes at the splenic hilum. Splenectomy can be done safely even in laparoscopic surgery by experienced surgeons, and the procedure itself is feasible with good short-term outcomes. Several recent retrospective reports, however, showed that splenectomy in open total gastrectomy could increase postoperative morbidity and mortality without survival benefit. In 2017, a multi-institutional RCT comparing splenectomy with spleen preservation in proximal gastric cancer was conducted in Japan. Splenectomy was associated with higher morbidity and greater blood loss, but had no survival benefit. The RCT concluded that prophylactic splenectomy, even in open surgery, should be avoided not only for operative safety but also for survival benefit, except for cases with tumors invading the greater curvature and with Borrmann type 4 tumors (limitis plastica).

Conversely, the clinical significance of lymph node dissection for cases with tumors invading the greater curvature and type 4 advanced gastric cancer remains a matter of debate. We reported that patients with tumors localized on the greater curvature and type 4 cancers might obtain relatively high survival benefits from splenic hilar lymph node dissection. Son et al reported long-term results of patients with splenic hilar lymph node metastasis treated by splenectomy (n = 258) or spleen-preserving hilar lymph node dissection (n = 344). They compared the therapeutic index of splenic hilar lymph node dissection to that for LN dissection at other extraperigastric lymph nodes, such as anterosuperior LN along the common
hepatic artery (No. 8a), celiac artery LN (No. 9) etc., and they demonstrated that both therapeutic efficacies were similar. From these findings, Son et al advocated that splenic hilar lymph node dissection is necessary to improve prognosis.

The only certainty at this point is that some patients may receive prognostic benefit from adequate splenic hilar lymph node dissection. Some experienced surgeons have reported laparoscopic techniques of spleen-preserving splenic hilum lymphadenectomy (SPSL). Mou et al\(^43\) developed a modified and some experienced surgeons have reported improved techniques cated SPSL. Most surgeons still adopt the suprapancreatic approach, – approach (combined supra

In 1999, Azagra et al\(^45\) reported the first case of EJS reconstruction after total gastrectomy in same institution.\(^46\) – laparotomy after LTG. Some other reports have demonstrated good short-term results after EJS with circular stapler (CS) carried out through a small incision.\(^46\) – laparotomy could also obtain similar short-term results concerning the number of retrieved splenic hilar lymph nodes and occurrence rates of postoperative complications. Further large-scale study should be conducted to establish the clinical significance of splenic hilar lymph node dissections.

### 3 | RECONSTRUCTIONS

In 1999, Azagra et al\(^45\) reported the first case of EJS reconstruction carried out by small laparotomy after LTG. Some other reports have demonstrated good short-term results after EJS with circular stapler (CS) carried out through a small incision.\(^46\) – However, inserting and fixing the anvil head into the esophageal stump is sometimes difficult in a narrow and deep operative field. Safe and secure anastomosis is difficult to carry out, requiring careful attention to avoid intervening in surrounding tissues between the anastomotic plane, especially in obese patients. Several intracorporeal EJS techniques have been developed as appropriate laparoscopic reconstruction methods after total gastrectomy. The techniques can be divided into two categories: those using a CS, and those using a linear stapler (LS).

A great advantage of the CS method is its familiarity in conventional open total gastrectomy. There are some other advantages of the CS method compared with the LS method, including no need for intracorporeal suturing procedures and longer trimming of the esophagus. In contrast, advantages of the LS method include better visual field during anastomosis and adaptability for intramediastinal anastomosis in cases with esophageal invasion.

Umemura et al\(^49\) reviewed 254 cases of the CS method and 729 cases of the LS method. They reported that the CS method was significantly associated with high rates of leakage (4.7% vs 1.1%, \(P < 0.001\)) and stenosis (8.3% vs 1.8%, \(P < 0.001\)) when compared with the LS method. However, the authors discussed that the complication rates partially depended on the experience of the surgeons. Inokuchi et al\(^50\) reviewed anastomotic complications in 46 case studies of LTG to compare various procedures for EJS. They classified anastomosis into six categories: (i) extracorporeal reconstruction by a single-stapling technique using a CS; (ii) intracorporeal reconstruction by a single-stapling technique using a CS; (iii) intracorporeal reconstruction by a double (or hemi-double) stapling technique using a CS with a transabdominally inserted anvil; (d) intracorporeal reconstruction by a double (or hemi-double) stapling technique using a CS with a transorally inserted anvil (Orvil, Medtronic plc, Dublin, Ireland); (e) intracorporeal reconstruction by side-to-side anastomosis using an LS; and (f) intracorporeal reconstruction by functional end-to-end

### TABLE 1  Summary reported comparing circular stapler and linear stapler after total gastrectomy in same institution

| Authors       | No. of patients | Stapler | Method             | Mean operative time (min) | Mean blood loss (ml) | Morbidity (%) | Leakage rate (%) | Stricture rate (%) | Mortality (%) | LOH (day) | Year |
|---------------|----------------|---------|--------------------|---------------------------|----------------------|---------------|------------------|-------------------|---------------|------------|------|
| Kim EY\(^52\) | 29             | CS      | mini-laparotomy    | 230.3                     | 106.3                | 17.2          | 0                | 3.4               | 0             | 9.7        | 2016 |
| 27            | LS             | linear  |                    | 228.9                     | 90.9                 | 18.5          | 3.7              | 0                 | 0             | 13.6       |      |
| Kawamura H\(^53\) | 49           | CS      | Orvil              | 259.5                     | 53.3                 | 8.2\*         | 4.1              | 4.1\*             | NA            | NA         | 2017 |
| 139           | LS             | overlap |                    | 276.5                     | 69.7                 | 0.7*          | 0.7              | 0*                | NA            | NA         |      |
| Gong CS\(^54\) | 266           | CS      | mini-laparotomy    | 170                       | NA                   | NA            | 5.6              | 1.1               | NA            | 7          | 2017 |
| 421           | LS             | FEEA    |                    | 149                       | NA                   | NA            | 3.6              | 0.5               | NA            | 6.8        |      |
| Yasukawa D\(^55\) | 51           | CS      | Orvil              | 346.1                     | 34                   | 9.8           | 3.9              | 0                 | 0             | 13.0       | 2017 |
| 18            | LS             | FEEA    |                    | 348.4                     | 35                   | 5.6           | 5.6              | 0                 | 12.0          |           |      |
| Kyogoku N\(^51\) | 83           | CS      | Orvil or mini-laparotomy | 330*                     | 100*                 | 25            | 4.0              | 7.0               | NA            | 10*        | 2018 |
| 208           | LS             | FEEA or overlap |                    | 297*                     | 23*                  | 20            | 1.0              | 5.0               | NA            | 13*        |      |
| Yoshikawa K\(^56\) | 36           | CS      | Orvil              | 345*                     | 45*                  | 13.9          | 0                | 8.3               | 2.8           | 17.2       | 2018 |
| 47            | LS             | overlap |                    | 398*                     | 126*                 | 10.6          | 4.3              | 0                 | 19.5          |           |      |

CS, circular stapler; FEEA, functional end-to-end anastomosis; LS, linear stapler; LOH, length of hospital stay; NA, not available.

\(^*\)P < 0.05
| Authors       | Nation     | Method         | No. of patients | Morbidity | Leakage | Stricture | Year  |
|--------------|------------|----------------|-----------------|-----------|---------|-----------|-------|
| Usui S       | Japan      | PSI            | 15              | NA        | 0 (0)   | 0 (0)     | 2008  |
| Kinoshta T   | Japan      | hand-sewn      | 10              | NA        | 0 (0)   | 0 (0)     | 2010  |
| Lee JH       | South Korea| PSI            | 79              | NA        | 2 (2.5) | 0 (0)     | 2012  |
| Shim JH      | South Korea| hand-sewn      | 12              | NA        | 2 (1.7) | 5 (42)    | 2013  |
| Kim HI       | South Korea| hand-sewn      | 36              | NA        | 0 (0)   | 0 (0)     | 2013  |
| Yoshikawa T  | Japan      | hand-sewn      | 20              | NA        | 0 (0)   | 0 (0)     | 2013  |
| Du J         | China      | hand-sewn      | 52              | NA        | 0 (0)   | 0 (0)     | 2014  |
| Matsuda T    | Japan      | hand-sewn      | 21              | 3 (14.3)  | 1 (4.8) | 1 (4.8)   | 2015  |
| Kosuga T     | Japan      | hand-sewn      | 65              | 11 (16.9) | 2 (3.1) | 4 (6.2)   | 2015  |
| Yamada T     | Japan      | hand-sewn      | 10              | 0 (0)     | 0 (0)   | 0 (0)     | 2015  |
| Chen K       | China      | hand-sewn      | 18              | 5 (27.8)  | 1 (5.6) | 1 (5.6)   | 2016  |
| Amisaki M    | Japan      | PSI            | 10              | NA        | 0 (0)   | 0 (0)     | 2016  |
| Kim Ey       | South Korea| hand-sewn      | 29              | 5 (17.2)  | 0 (0)   | 1 (3.4)   | 2016  |
| Gong CS      | South Korea| minilapatomy   | 266             | 74 (27.8) | 15 (5.6)| 3 (1.1)   | 2017  |
| Okuno K      | Japan      | PSI            | 94              | NA        | 0 (0)   | 2 (2.1)   | 2017  |
| Liu W        | China      | PSI            | 41              | NA        | 0 (0)   | 0 (0)     | 2017  |
| **Total**    |            |                | 778             | 23 (3.0)  | 17 (2.2)*|           |       |
| Omori T      | Japan      | HDST           | 10              | NA        | 0 (0)   | 0 (0)*    | 2009  |
| Muguruma K   | Japan      | HDST           | 32              | NA        | 0 (0)   | 0 (0)*    | 2014  |
| Zhao YL      | China      | HDST           | 26              | NA        | 0 (0)   | 0 (0)*    | 2014  |
| Kim JH       | South Korea| DST            | 58              | 8 (13.8)  | 0 (0)   | 1 (1.7)*  | 2015  |
| Ichikawa D   | Japan      | HDST (lift up)| 58              | 9 (15.5)  | 0 (0)   | 2 (3.4)*  | 2015  |
| Wang H       | China      | HDST           | 42              | NA        | 1 (2.4) | 2 (4.8)*  | 2015  |
| Kosuga T     | Japan      | HDST (lift up)| 71              | 23 (32.4) | 7 (9.9) | 13 (18.3)*| 2015  |
| Ali B        | South Korea| HDST           | 58              | NA        | 3 (5.2) | 5 (8.6)*  | 2017  |
| Li X         | China      | HDST           | 24              | 3 (12.5)  | 1 (4.2) | 0 (0)*    | 2017  |
| **Total**    |            |                | 379             | 12 (3.2)  | 23 (6.1)*|           |       |
| Jeong O      | South Korea| Orvil          | 16              | NA        | 0 (0)   | 0 (0)*    | 2009  |
| Sakuramoto S | Japan      | Orvil          | 24              | NA        | 0 (0)   | 0 (0)*    | 2010  |
| Kachikwu EL  | United States| Orvil       | 16              | NA        | 0 (0)   | 3 (18.8)* | 2011  |
| Kunisaki C   | Japan      | Orvil          | 30              | 2 (6.7)   | 1 (3.3) | 0 (0)*    | 2011  |
| Marangoni G  | United Kingdom| Orvil  | 13              | NA        | 0 (0)   | 0 (0)*    | 2012  |
| Jung YJ      | South Korea| Orvil          | 40              | NA        | 2 (5)   | 1 (2.5)*  | 2013  |
| Liao GQ      | China      | Orvil          | 21              | NA        | 1 (4.8) | 1 (4.8)*  | 2013  |
| Shim JH      | South Korea| Orvil          | 12              | NA        | 2 (1.7) | 4 (33)*   | 2013  |
| Xie JW       | China      | Orvil          | 28              | NA        | 0 (0)   | 0 (0)*    | 2013  |
| Zuiki T      | Japan      | Orvil          | 52              | NA        | 1 (1.9) | 11 (21)*  | 2013  |
| Lafemina J   | United States| Orvil   | 17              | NA        | 1 (5.9) | 1 (5.9)*  | 2013  |
| Hiyoshi Y    | Japan      | Orvil          | 21              | NA        | 2 (9.5) | 0 (0)*    | 2014  |
| Ito H        | Japan      | Orvil          | 117             | NA        | 2 (1.7) | 2 (1.7)*  | 2014  |
| Kwon Y       | South Korea| Orvil          | 36              | 20 (55.6) | 1 (2.8) | 2 (5.7)*  | 2014  |
| Wang H       | China      | Orvil          | 42              | NA        | 0 (0)   | 2 (4.8)*  | 2015  |
| Ichikawa D   | Japan      | Orvil          | 28              | 5 (17.9)  | 0 (0)   | 1 (3.6)*  | 2015  |

(Continues)
anastomosis using LS. Inokuchi and colleagues reported that the incidence of EJS leakage was similar (1.1%-3.2%), although the incidence of EJS stenosis was relatively high when the OrVil device was used (8.8%) compared with other procedures (1.0%-3.6%). They discussed the use of a small anvil in some cases for easy passage through the esophageal entrance as the presumed cause of high rates of stenosis. Kyogoku et al. reported that there was no difference in the postoperative complication rates related to the type of stapler when surgeons accredited through the Endoscopic Surgical Skill Qualification System of the Japanese Society of Endoscopic Surgery carried out EJS. The authors concluded that determination of the EJS procedure should be selected by preference and experience of the surgeon.

In Table 1, literature that compares two anastomosis methods in a single institution is shown. Five of the studies reported that morbidity such as anastomotic leakage and stricture were not significantly different in CS and LS methods; however, one report showed that the LS method has fewer complications.

### TABLE 2 (Continued)

| Authors    | Nation     | Method | No. of patients | Morbidity | Leakage | Stricture | Year |
|------------|------------|--------|-----------------|-----------|---------|-----------|------|
| Lu X95     | China      | Orvil  | 25              | 7 (28.0)  | 0 (0)   | 0 (0)*    | 2016 |
| Brenkman HJ56 | Netherlands | Orvil | 47              | 24 (51.1) | 6 (12.8) | 11 (23)*  | 2016 |
| Shida A97  | Japan      | Orvil  | 100             | 11 (11.0) | 4 (4.0) | 4 (4)*     | 2016 |
| Yasukawa D55 | Japan     | Orvil  | 51              | 5 (9.8)   | 2 (3.9) | 0 (0)*     | 2017 |
| Kawamura H52 | Japan    | Orvil  | 49              | 4 (8.2)   | 2 (4.1) | 2 (4.1)*   | 2017 |
| Li X83     | China      | Orvil  | 19              | 1 (5.3)   | 0 (0)   | 1 (5.3)*   | 2017 |
| Yoshikawa K56 | Japan    | Orvil  | 36              | 5 (13.9)  | 0 (0)   | 3 (8.3)*   | 2018 |
| Total      |            |        | 840             | 27 (3.2)  | 49 (5.8)*|           |      |

DST, double-stapling technique; HDST, hemi-double-stapling technique; NA, not available; PSI, purse-string suture instrument; SST, single-stapling technique.

Orvil, Medtronic plc, Dublin, Ireland.

*P < 0.05 (Chi-square test)

Esophagojejunostomy using LS is mainly divided into two types: a functional end-to-end anastomosis (FEEA) and a side-to-side anastomosis (called the “overlap method”).

Uyama et al. first reported EJS using LS by a completely intrabdominal approach. Since then, the required knowledge and skills for the FEEA procedure have been reported in several papers. Although this method is simple, sufficient mobilization of the esophageal stump and the jejunal limb is required to reduce tension at the anastomotic site. Furthermore, side-to-side anastomosis is occasionally difficult as a result of the peri-hiatal restricted space, especially in proximal cancer with esophageal invasion and esophagogastric junction cancer. Based on these weaknesses, Inaba et al. reported another side-to-side anastomosis method called the “overlap method”. Furthermore, in recent years, several modified procedures of the overlap method have been reported. Nagai et al. made the anastomosis in an inverted T-shape to prevent the anastomosis from slipping into the mediastinum. Yamamoto et al. transected the esophagus while being rotated by 90 degrees, making suturing of the entry hole easier. In either method, a 45-mm cartridge is usually used in the anastomosis of the LS, and there is an advantage that the anastomosis diameter can be made larger as compared with the EJS using a CS.

Many papers have reported the safety and feasibility of EJS conducted by LS. However, the need for suturing technique and enough mobilization of the esophageal stump may sometimes cause nonexpert laparoscopic surgeons to hesitate about introducing EJS using the LS. Recent development and application of a barbed absorbable closure device (V-Loc; Medtronic plc, Dublin, Ireland) may eliminate the hesitation about hand-sewn suturing.

Interestingly, esophageal hiatal hernia has recently been reported as a postoperative complication of EJS using LS after LTG. Ito et al. reported that postoperative esophageal hiatal hernia occurred in seven (9%) of 78 patients who underwent LTG for gastric cancer, and all of them were patients who had an incision in the diaphragm. They concluded that when the crus was incised to improve the visual field of the anastomosis, it should have been repaired.

### 5 CIRCULAR STAPLER

As described above, many surgeons are familiar with reconstruction methods using the CS. Therefore, the CS method has been more widespread than the LS method, especially in the introductory period. Since the transorally inserted anvil (OrVil) was developed, it is easier and very convenient to carry out intracorporeal EJS and esophagogastrectomy. Several reports have reported the safety and feasibility of EJS carried out by the CS method in LTG. However, some papers noted a high incidence of postoperative complications in CS methods.

For this paper, a literature retrieval was carried out in PubMed for January 1, 1997 through April 30, 2018. The search terms included “laparoscopic,” “total gastrectomy,” and “gastric cancer.” Reports in languages other than English, reviews, and meta-analyses were excluded, and cases <10 were also excluded.
We reviewed anastomotic complications, especially those reported on leakage and stricture, in 43 extracted studies of LTG.33,46,48,52–56,63–97 We compared the surgical results of various anastomotic procedures for EJS using the CS, with attention to the insertion procedure of the anvil and the insertion site of the anastomotic device.

First, the insertion procedure of the anvil was classified into the following three categories: (i) single-stapling technique (SST) using}

### TABLE 3

Summary reported of esophagojejnostomy insertion site of circular staler n (%)

| Authors       | Nation       | Method | No. of patients | Leakage | Stricture | Year |
|---------------|--------------|--------|-----------------|---------|-----------|------|
| Left upper    |              |        |                 |         |           |      |
| Omori T       | Japan        | DST    | 10              | 0 (0)   | 0 (0)     | 2009 |
| Sakuramoto S  | Japan        | Orvil  | 24              | 0 (0)   | 0 (0)     | 2010 |
| Jung YJ       | Korea        | Orvil  | 40              | 2 (5)   | 1 (2.5)   | 2013 |
| Du J          | China        | SST    | 52              | 0 (0)   | 0 (0)     | 2014 |
| Muguruma K    | Japan        | DST    | 32              | 0 (0)   | 0 (0)     | 2014 |
| Hiwoshi Y     | Japan        | Orvil  | 21              | 2 (9.5) | 0 (0)     | 2014 |
| Kwon Y        | Korea        | Orvil  | 36              | 1 (2.8) | 2 (5.6)   | 2014 |
| Ichikawa D    | Japan        | DST & Orvil | 86  | 0 (0) | 3 (3.5) | 2015 |
| Amada T       | Japan        | SST    | 10              | 0 (0)   | 0 (0)     | 2015 |
| Lu X          | China        | Orvil  | 25              | 0 (0)   | 0 (0)     | 2016 |
| Liu W         | China        | SST    | 41              | 0 (0)   | 0 (0)     | 2017 |
| Total         |              |        | 379             | 5 (1.3)* | 6 (1.6)* |      |
| Left lower    |              |        |                 |         |           |      |
| Kachikwu EL   | United States | Orvil | 16              | 0 (0)*  | 3 (18.8)* | 2011 |
| Lee JH        | South Korea  | SST    | 79              | 2 (2.5)* | 0 (0)*    | 2012 |
| Kim HI        | South Korea  | SST    | 36              | 0 (0)*  | 0 (0)*    | 2013 |
| Kim JH        | Korea        | DST    | 58              | 0 (0)*  | 1 (1.7)*  | 2015 |
| Wang H        | China        | DST & Orvil | 84  | 1 (1.2)* | 4 (4.8)*  | 2015 |
| Amisaki M     | Japan        | SST    | 10              | 0 (0)*  | 0 (0)*    | 2016 |
| Ali B         | Korea        | DST    | 58              | 3 (5.2)* | 5 (8.6)*  | 2017 |
| Okuno K       | Japan        | SST    | 94              | 0 (0)*  | 2 (2.1)*  | 2017 |
| Total         |              |        | 435             | 6 (1.4)* | 15 (3.4)* |      |
| Umbilical     |              |        |                 |         |           |      |
| Usui S        | Japan        | SST    | 15              | 0 (0)*  | 0 (0)*    | 2008 |
| Jeong O       | South Korea  | Orvil  | 16              | 0 (0)*  | 0 (0)*    | 2009 |
| Kinoshita T   | Japan        | SST    | 10              | 0 (0)*  | 0 (0)*    | 2010 |
| Kunisaki C    | Japan        | Orvil  | 30              | 1 (3.3)* | 0 (0)*    | 2011 |
| Yoshikawa T   | Japan        | SST    | 20              | 0 (0)*  | 0 (0)*    | 2013 |
| Liao GQ       | China        | Orvil  | 21              | 1 (4.8)* | 1 (4.8)*  | 2013 |
| Xie JW        | China        | Orvil  | 28              | 0 (0)*  | 0 (0)*    | 2013 |
| Zuiki T       | Japan        | Orvil  | 52              | 1 (1.9)* | 11 (21)*  | 2013 |
| Zhao YL       | China        | Orvil  | 26              | 0 (0)*  | 0 (0)*    | 2014 |
| Matsuda T     | Japan        | SST    | 21              | 1 (4.8)* | 1 (4.8)*  | 2015 |
| Kosuga T      | Japan        | SST & DST | 136 | 9 (6.6)* | 17 (12.5)* | 2015 |
| Brenkman H    | Netherlands  | Orvil  | 47              | 6 (12.8)* | 11 (23.4)* | 2016 |
| Shida A       | Japan        | Orvil  | 100             | 4 (4.0)* | 4 (4.0)*  | 2016 |
| Li X          | China        | DST & Orvil | 43  | 1 (2.3)* | 1 (2.3)*  | 2017 |
| Yasukawa D    | Japan        | Orvil  | 51              | 2 (3.9)* | 0 (0)*    | 2017 |
| Total         |              |        | 616             | 26 (4.2)* | 46 (7.5)* |      |

DST, double stapling technique; SST, single-stapling technique.

Orvil, Medtronic plc, Dublin, Ireland.

\*P < 0.05 (Chi-square test).
hand-sewn purse-string suture or purse-string instrument (PSI); (ii) double-stapling technique (DST)/hemi-double-stapling technique (HDST) with transabdominally inserted anvil; or (iii) DST/HDST with transorally inserted anvil (OrVil) (Table 2).

No significant differences were found in these three categories in the frequency of anastomotic leakage. However, the rate of anastomotic stricture was the lowest in SST and the highest in DST/HDST with a transabdominally inserted anvil.

Comparing this result with the review by Inokuchi et al.50 our results showed that the occurrence of anastomotic stricture was equivalent in cases of SST reconstruction (2.2% and 2.1%, respectively); however, the incidence rate was lower than that of results in OrVil reconstruction (5.8% and 8.8%, respectively). Standardization of the procedures and recognition of necessary skills for reconstruction using OrVil, including minimization of a small incision through which the tube is pulled out and tension-free anastomosis, may have contributed to the recent reduction of anastomotic stricture.

In principle, the success of reconstruction mainly depends on sufficient blood supply and tension-free anastomosis. For sufficient blood supply, the length of detachment from the esophageal stump should be the minimum required for EJS anastomosis. For anastomotic tension, Okata reported that anastomosis under tension significantly increases anastomatic complications.98 Some efforts to decrease the tension, such as dissecting a marginal artery of the jejunum, sacrificing the jejunum, and elevating the jejunum through the retrocolic route, should be considered during the operation in the case of EJS under tension.

Next, all of the studies retrieved above were summarized according to the insertion site of the suture instrument, such as left upper, left lower, and umbilical (Table 3).33,46,48,55,63-71,73-86,88-90,92,94-97 As shown in Figure 1, the visual field differed depending on the approach of the anastomotic device, and the left upper abdomen provided the widest visual field of the anastomotic plane.

Results showed that the occurrence rates of anastomotic leakage and stricture were the lowest in the left upper abdomen approach, and anastomatic complications were significantly higher in a midline umbilical approach. These results suggested that a good visual field may reduce anastomotic complications, and surgeons should be particularly attentive to maintaining a good visual field for the anastomotic plane, even in the umbilical approach, and avoiding unnecessary tension during anastomosis.

The flexible laparoscope should be useful in obtaining a good view where a straightforward view is difficult. However, only a few reports were confirmed to use the flexible laparoscope in each approach; therefore, it is not yet clear whether these complications can be reduced by the use of a flexible scope.

6 | CONCLUSION

We reviewed several recent reports on lymphadenectomy and reconstruction in LTG. As cancers located at the upper third of the stomach and at the esophagogastric junction have increased in recent years,100 in the future, safe and secure LTG is important. According to the Japanese gastric cancer treatment guidelines, LTG for clinical stage I gastric cancer may be carried out; however, it is recommended that the procedure be conducted under the guidance of experienced surgeons. In contrast, LTG has been rated by the guidelines of the Japan Society for Endoscopic Surgery (2014) as recommendation C1 (may be considered for a patient in need of total gastrectomy, but no scientific evidence in support of the procedure is currently available). Those who consider challenging the procedure should plan to do so with sufficient caution as postoperative complications were reported to occur significantly more often in the first year of its introduction.24

Concerning advanced cancer, a Korean group has launched a large multi-institutional clinical study for prognostic evaluation of lymph node dissection in LTG for advanced gastric cancer (KLASS-06). LTG for advanced gastric cancer should be carried out on a trial basis until the definitive results are available, and surgeons should be particularly attentive to nodes No. 10 and 11d in a lymphadenectomy without lessening the quality of lymph node dissection compared with OTG.

Then again, inappropriate reconstruction sometimes results in postoperative complications, some of which have recently been reported to correlate with poor long-term oncological outcome.101,102 In that sense, surgeons must give scrupulous attention to leakage and stricture after EJS while understanding the advantages and disadvantages of each anastomotic device and approach.

![Figure 1](https://example.com/figure1.png)
REFERENCES

1. Torre LA, Bray F, Siegel RL, Ferlay J, Lortet-Tieulent J, Jemal A. Global cancer statistics, 2012. CA Cancer J Clin. 2015;65:87–108.
2. Kitano S, Iso Y, Moriyama M, Sugimachi K. Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc. 1994;4:146–8.
3. Kodera Y, Fujiwara M, Ohashi N, et al. Laparoscopic surgery for gastric cancer: a collective review with meta-analysis of randomized trials. J Am Coll Surg. 2010;211(5):677–86.
4. Peng JS, Song H, Yang ZL, Xiang J, Diao DC, Liu ZH. Meta-analysis of laparoscopy-assisted distal gastrectomy and conventional open distal gastrectomy for early gastric cancer. Chin J Cancer. 2010;29(4):349–54.
5. Memon MA, Khan S, Yunus RM, Barr R, Memon B. Meta-analysis of laparoscopic and open distal gastrectomy for gastric carcinoma. Surg Endosc. 2008;22:1781–9.
6. Viñuela EF, Gonen M, Brennan MF, Coit DG, Strong VE. Laparoscopic versus open distal gastrectomy for gastric cancer: a meta-analysis of randomized controlled trials and high-quality non-randomized studies. Ann Surg. 2012;255:446–56.
7. Ohtani H, Tamamori Y, Noguchi K, et al. A meta-analysis of laparoscopic surgery for clinical stage IA gastric cancer (JCOG0912). Jpn J Clin Oncol. 2010;40(1):95–100.
8. Liang Y, Li G, Chen P, Ju Y, Zhang C. Laparoscopic versus open gastrectomy for early gastric cancer: a meta-analysis. ANZ J Surg. 2011;81:673–80.
9. Chen XZ, Hu JK, Yang K, Wang L, Lu QC. Short-term evaluation of laparoscopy-assisted distal gastrectomy for predictive early gastric cancer: a meta-analysis of randomized controlled trials. Surg Endosc Percutan Tech. 2009;19:277–84.
10. Deng Y, Zhang Y, Guo TK. Laparoscopy-assisted versus open distal gastrectomy for early gastric cancer: a meta-analysis based on seven randomized controlled trials. Surg Oncol. 2015;24(2):71–7.
11. Nakamura K, Katai H, Mizusawa J, et al. A phase III study of laparoscopy-assisted versus open distal gastrectomy with nodal dissection for clinical stage IA/IB gastric cancer (JCOG0912). Jpn J Clin Oncol. 2013;43(3):324–7.
12. Kim HH, Hyung WJ, Cho GS, et al. 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. 2010;251(3):417–20.
13. Kitano S, Shiraishi N, Uyama I, Sugihara K, Tanigawa N. Japanese Laparoscopic Surgery Study Group: a multicenter study on oncologic outcome of laparoscopic gastrectomy for early cancer in Japan. Ann Surg. 2007;245:68–72.
14. Song J, Lee HJ, Cho GS, et al. Recurrence following laparoscopy-assisted gastrectomy for gastric cancer: a multicenter retrospective analysis of 1,417 patients. Ann Surg Oncol. 2010;17:1777–86.
15. Lee JH, Yom CK, Han HS. Comparison of long-term outcomes of laparoscopy-assisted and open distal gastrectomy for early gastric cancer. Surg Endosc. 2009;23:1759–63.
16. Kim YW, Yoon HM, Yun YH, et al. Long-term outcomes of laparoscopy-assisted distal gastrectomy for early gastric cancer: result of a randomized controlled trial (COACT 0301). Surg Endosc. 2013;27:4267–76.
17. Zhao XF, Jeong O, Jung MR, Ryu SY, Park YK. A propensity score-matched case-control comparative study of laparoscopic and open extended (D2) lymph node dissection for distal gastric carcinoma. Surg Endosc. 2013;27(8):2792–800.
18. Hu Y, Huang C, Sun Y, et al. Morbidity and mortality of laparoscopic versus open D2 distal gastrectomy for advanced gastric cancer: a randomized controlled trial. J Clin Oncol. 2016;34(12):1350–7.
19. Hur H, Lee HY, Lee HJ, et al. Efficacy of laparoscopic subtotal gastrectomy with D2 lymphadenectomy for locally advanced gastric cancer: the protocol of the KLAS-02 multicenter randomized controlled clinical trial. BMC Cancer. 2015;15:355.
20. Inaki N, Etoh T, Ohyama T, et al. A multi-institutional, prospective, phase II feasibility study of laparoscopy-assisted distal gastrectomy with D2 lymph node dissection for locally advanced gastric cancer (JLSSG0901). World J Surg. 2015;39:2734–41.
21. Watanabe I, Inomata M, Terachi T, et al. 13th nationwide survey of endoscopic surgery in Japan. J Jpn Soc Endosc Surg. 2016;21(6):655–810.
22. Kodera Y, Yoshida K, Kumamaru H, et al. Introducing laparoscopic total gastrectomy for gastric cancer in general practice: a retrospective cohort study based on a nationwide registry database in Japan. Gastric Cancer. 2018; [Epub ahead of print].
23. Etoh T, Honda M, Kumamaru H, et al. Morbidity and mortality from a propensity score-matched, prospective cohort study of laparoscopic versus open total gastrectomy for gastric cancer: data from a nationwide web-based database. Surg Endosc. 2018;32(6):2766–73.
24. Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2014 (ver. 4). Gastric Cancer. 2017;20(1):1–19.
25. Chen K, Pan Y, Zhai ST, et al. Totally laparoscopic versus open total gastrectomy for gastric cancer: a case-matched study about short-term outcomes. Medicine (Baltimore). 2017;96(38):e8061.
26. Lin JX, Lin JL, Zheng CH, et al. Short- and long-term outcomes of laparoscopic-assisted versus open total gastrectomy for gastric cancer: a propensity score-matched analysis. Oncotarget. 2017;8(45):80029–38.
27. Havercamp L, Weijs TJ, van der Sluis PC, van der Tweel I, Ruurda JP, van Hillegersberg R. Laparoscopic total gastrectomy versus open total gastrectomy for cancer: a systematic review and meta-analysis. Surg Endosc. 2013;27(5):1509–20.
28. Cheng H, Hsiao CW, Clymer JW, et al. Gastrectomy and D2 lymphadenectomy for gastric cancer: a meta-analysis comparing the harmonic scalpel to conventional techniques. Int J Surg Oncol. 2015;2015:397260.
29. Fujita J, Takiguchi S, Nishikawa K, et al. Randomized controlled trial of the LigaSure vessel sealing system versus conventional open gastrectomy for gastric cancer. Surg Today. 2014;44(9):1723–9.
30. Wang JB, Huang CM, Zheng CH, et al. Role of 3DCT in laparoscopic total gastrectomy with spleen-preserving splenic lymph node dissection. World J Gastroenterol. 2014;20(16):4779–805.
31. Kinoshita T, Shibasaki H, Enomoto N, Sunagawa H, Nishida T. Laparoscopic splenic hilar lymph node dissection for proximal gastric cancer using integrated three-dimensional anatomic simulation software. Surg Endosc. 2016;30(6):2613–9.
32. Usui S, Tashiro M, Haruki S, et al. Spleen preservation versus spleenectomy in laparoscopic total gastrectomy with D2 lymphadenectomy for gastric cancer: a comparison of short-term outcomes. Asian J Endosc Surg. 2016;9(1):5–13.
33. Lee JH, Ahn SH, Park DJ, Kim HH, Lee HJ, Yang HK. Laparoscopic total gastrectomy with D2 lymphadenectomy for advanced gastric cancer. World J Surg. 2012;36(10):2394–9.
34. Nakata K, Nagai E, Ohuchida K, Shimizu S, Tanaka M. Technical feasibility of laparoscopic total gastrectomy with spleenectomy for gastric cancer: clinical short-term and long-term outcomes. Surg Endosc. 2015;29(7):1817–22.

DISCLOSURE

Conflict Of Interest: Authors declare no conflict of interests for this article.

ORCID

Daisuke Ichikawa http://orcid.org/0000-0003-0093-2206
35. Csendes A, Burdiles P, Rojas J, et al. A prospective randomized study comparing D2 total gastrectomy versus D2 total gastrectomy plus splenectomy in 187 patients with gastric carcinoma. Surgery. 2002;131:401–7.
36. Yu W, Choi GS, Chung HY. Randomized clinical trial of splenectomy versus splenic preservation in patients with proximal gastric cancer. Br J Surg. 2006;93:559–63.
37. Oh SJ, Hyung WJ, Li C, et al. The effect of spleen-preserving lymphadenectomy on surgical outcomes of locally advanced proximal gastric cancer. J Surg Oncol. 2009;99:275–80.
38. Yang K, Chen XZ, Hu JK, et al. Effectiveness and safety of splenectomy for gastric carcinoma: a meta-analysis. World J Gastroenterol. 2009;15:5352–9.
39. Sano T, Sasako M, Mizusawa J, et al. Randomized controlled trial to evaluate splenectomy in total gastrectomy for proximal gastric cancer. Ann Surg. 2017;265(2):277–83.
40. Kosuga T, Ichikawa D, Okamoto K, et al. Survival benefits from splenic hilar lymph node dissection by splenectomy in gastric cancer patients: relative comparison of the benefits in subgroups of patients. Gastric Cancer. 2011;14:172–7.
41. Son T, Kwon IG, Lee JH, et al. Impact of splenic hilar lymph node metastasis on prognosis in patients with advanced gastric cancer. Oncotarget. 2017;8(48):84515–28.
42. Uyama I, Sugioaka A, Sakurai Y, et al. Hand-assisted laparoscopic function-preserving and radical gastrectomies for advanced-stage proximal gastric cancer. J Am Coll Surg. 2004;199:508–15.
43. Mou TY, Hu YF, Yu J, Liu H, Wang YN, Li GX. Laparoscopic splenic hilum lymph node dissection for advanced proximal gastric cancer: a modified approach for pancreas- and spleen-preserving total gastrectomy. World J Gastroenterol. 2013;19(30):4992–9.
44. Huang CM, Chen QY, Lin JX, et al. Laparoscopic spleen-preserving splenic hilar lymphadenectomy performed by following the perigastric fascias and the intrafascial space for advanced upper gastric cancer. PLoS ONE. 2014;9(3):e90345.
45. Azagra JS, Goergen M, De Simone P, Ibañez-Aguirre J. Minimally invasive surgery for gastric cancer. Surg Endosc. 1999;13:351–7.
46. Kunisaki C, Makino H, Oshima T, et al. Application of the transorally inserted anvil (OrVil) after laparoscopy-assisted total gastrectomy. Surg Endosc. 2011;25(4):1300–5.
47. Li P, Huang CM, Zheng CH, et al. Laparoscopic spleen-preserving splenic hilar lymphadenectomy in 108 consecutive patients with upper gastric cancer. World J Gastroenterol. 2014;20(32):11376–83.
48. Jung YJ, Kim DJ, Lee JH, Kim W. Safety of intracorporeal circular stapling esophagojejunostomy using trans-orally inserted anvil (OrVil) following laparoscopic total or proximal gastrectomy -comparison with extracorporeal anastomosis. World J Surg Oncol. 2013;23(11):209.
49. Umemura A, Koeda K, Sasaki A, et al. Totally laparoscopic total gastrectomy for gastric cancer: literature review and comparison of the procedure of esophagojejunostomy. Asian J Surg. 2015;38(2):102–12.
50. Inokuchi M, Otsuki S, Fujimori Y, Sato Y, Nakagawa M, Kojima K. Systematic review of anastomotic complications of esophagojejunosumy after laparoscopic total gastrectomy. World J Gastroenterol. 2015;21(32):9656–65.
51. Kyogoku N, Ebihara Y, Shichinohe T, et al. Circular versus linear stapling in esophagojejunosumy after laparoscopic total gastrectomy for gastric cancer: a propensity score-matched study. Langenbecks Arch Surg. 2018;403:463–71.
52. Kim EY, Choi HJ, Cho JB, Lee J. Totally laparoscopic total gastrectomy versus laparoscopically assisted total gastrectomy for gastric cancer. Anticancer Res. 2016;36(4):1999–2003.
53. Kawamura H, Ohno Y, Ichikawa N, et al. Anastomotic complications after laparoscopic total gastrectomy with esophagojejunosumy constructed by circular stapler (OrVil™) versus linear stapler (overlap method). Surg Endosc. 2017;31(5):5175–82.
54. Gong CS, Kim BS, Kim HS. Comparison of totally laparoscopic total gastrectomy using an endoscopic linear stapler with laparoscopic-assisted total gastrectomy using a circular stapler in patients with gastric cancer: a single-center experience. World J Gastroenterol. 2017;23(48):8553–61.
55. Yasukawa D, Hori T, Kadokawa Y, et al. Impact of stepwise introduction of esophagojejunostomy during laparoscopic total gastrectomy: a single-center experience in Japan. Ann Gastroenterol. 2017;30(3):564–70.
56. Yoshikawa K, Shimada M, Higashijima J, et al. Usefulness of the transoral anvil delivery system for esophagojejunostomy after laparoscopic total gastrectomy: a single-institution comparative study of transoral anvil delivery system and the overlap method. Surg Laparosc Endosc Percutan Tech. 2018;28(2):e40–3.
KAWAGUCHI ET AL.
80. Kim JH, Choi CI, Kim DI, et al. Intracorporeal esophagojejunostomy using modified over-and-under suture technique in laparoscopic total gastrectomy. Surg Endosc. 2015;29(11):3386–91.
81. Kosuga T, Hiki N, Nunobe S, et al. Does the single-stapling technique for circular-stapled esophagojejunostomy reduce anastomotic complications after laparoscopic total gastrectomy? Ann Surg Oncol. 2015;22(11):3606–12.
82. Chen K, He Y, Cai JQ, et al. Comparing the short-term outcomes of intracorporeal esophagojejunostomy with extracorporeal esophagojejunostomy after laparoscopic total gastrectomy for gastric cancer. BMC Surg. 2016;21(16):13.
83. Li X, Hong L, Ding D, et al. Comparison of OrVil™-assisted total gastrectomy with trans-orally inserted anvil in Roux-en-Y reconstruction after laparoscopic total gastrectomy for gastric cancer. World J Surg Oncol. 2014;12:49.
84. Jeong O, Park YK. Intracorporeal circular stapling esophagojejunal reconstruction after total gastrectomy for gastric cancer using a transorally inserted anvil delivery system. Ann Surg Oncol. 2013;20:2975–83.
85. Hiyoshi Y, Oki E, Ando K, et al. Outcome of esophagojejunostomy during totally laparoscopic total gastrectomy: a single-center retrospective study. Anticancer Res. 2014;34:7227–32.
86. Kachikwu EL, Trisal V, Kim J, Pigazzi A, Ellenhorn JD. Minimally invasive total gastrectomy with trans-orally inserted anvil (OrVil™): a single institution experience. World J Gastroenterol. 2013;19:755–60.
87. Marangoni G, Villa F, Shamil E, Botha AJ. OrViITM-assisted anastomosis in laparoscopic upper gastrointestinal surgery: friend of the laparoscopic surgeon. Surg Endosc. 2012;26:811–17.
88. Liao GQ, Ou XW, Liu SQ, Zhang SR, Huang W. Laparoscopy-assisted total gastrectomy with trans-orally inserted anvil (OrViITM): comparison of outcomes with conventional technique. World J Gastroenterol. 2015;21(1):260–65.