Comparison of reverse puncture device and overlap in laparoscopic total gastrectomy for gastric cancer

Cheng Chen, Meng Wei, Xingbo Feng, Haifeng Han, Chao Wang, Qingsi He, Wenbin Yu
Department of General Surgery, Qilu Hospital of Shandong University, Jinan, Department of General Surgery, Central Hospital of Zaozhuang Coal Mining Group, Shandong Province, Zaozhuang, China

INTRODUCTION

Although laparoscopic total gastrectomy (LTG) for gastric cancer was first reported in 1999,[1] LTG has yet to gain widespread acceptance because of technical difficulties in digestive tract reconstruction, especially intracorporeal oesophagojejunostomy during LTG.[2] With the development of technologies and surgical instruments, LTG has become increasingly common, and oesophagojejunostomy has exhibited diversity.[3,4] Oesophagojejunostomy involves two kinds of stapler, namely circular staplers and linear staplers.[5] Circular staplers were previously used in oesophagojejunostomy. Purse string and anvil insertion are more difficult under laparoscopic conditions than

Abstract

Background: Intracorporeal oesophagojejunostomy is one of the key steps in laparoscopic total gastrectomy (LTG). At present, there is no widely accepted anastomosis technique in oesophagojejunostomy.

Materials and Methods: We retrospectively studied 63 patients with gastric cancer who underwent LTG. Two types of anastomosis techniques have been applied during LTG: the reverse puncture device (RPD) (28 patients) and overlap (35 patients).

Results: A total of 63 patients (51 males and 12 females: mean age = 58 years and mean body mass index [BMI] = 26.3 kg/m²) were enrolled in this study. There were no significant difference in age, BMI, duration of surgery, duration of anastomosis, blood loss, post-operative hospital stay, tumour location, tumour size, degree of tumour differentiation, Borrmann type, total number of lymph nodes, number of positive lymph nodes, hospital stay, hospitalisation costs, intra-operative complications, post-operative complications and prognosis between the RPD group and the overlap group. RPD group showed a significant advantage in terms of the distance between the top border of tumours and the top resection margin (P < 0.001). We further found that the oesophageal lateral negative surgical margin distance of the upper gastric cancer in the RPD group was significantly longer than that in the overlap group (P < 0.001).

Conclusions: Both the RPD and overlap techniques are safe and applicable in LTG. However, RPD has the advantage of obtaining an adequate safe margin compared with that of overlap technique, especially in patients with gastro-oesophageal junction carcinoma.

Keywords: Anastomosis technique, gastric cancer, laparoscopic total gastrectomy, oesophagojejunostomy
under open surgery conditions, but this problem is solved by the application of a reverse puncture device (RPD) and OrVil™.[6‑8] Compared with RPD, OrVil™ has the disadvantages of high cost and possible contamination of the abdominal cavity. In recent years, the use of linear stapler to construct oesophagojejunostomy has increasingly been recognised in the field of laparoscopic surgery. In a linear stapler application, the overlap technique is a representative.[6‑7] In terms of the superior type of staplers, a review has suggested that the use of circular staplers is associated with a considerably high risk of stenosis and leakage during oesophagojejunostomy.[5]

In our institute, we performed oesophagojejunostomy through RPD application and overlap anastomosis during LTG. This retrospective study aimed to compare the advantages and disadvantages of RPD application and overlap anastomosis during LTG.

MATERIALS AND METHODS

Patients
The same surgical team in Qilu Hospital treated 63 patients with gastric cancer through LTG with D2 lymphadenectomy between December 2014 and May 2016. Among those patients, 28 underwent oesophagojejunostomy with RPD (Group A), and 35 were subjected to oesophagojejunostomy with overlap (Group B). All of the patients underwent gastrografin meal examination on the post-operative day 7. Gastrografin examination was used to confirm the presence of anastomotic leakage. This retrospective study was approved by the Medical Ethics Committee of Qilu Hospital of Shandong University, Jinan, China (No. 2017128). In this study, gastric cancer was diagnosed in accordance with the Japanese gastric cancer treatment guidelines (2010) of the Japanese Gastric Cancer Association and the Japanese Classification of Gastric Carcinoma: Third English edition.[9,10]

Inclusion criteria
The inclusion criteria were as follows: (1) gastric adenocarcinoma confirmed by endoscopy and biopsy histopathologies; (2) no pre-operative treatment such as chemotherapy, radiotherapy, immunotherapy and endoscopic therapy; (3) no coexistence with other cancers or history of other malignancies and (4) no distant metastasis.

Reconstruction by using the reverse puncture device
The RPD was prepared before the reconstruction.[11] A midline incision of approximately 5 cm was made on the abdomen as an entry point to the peritoneal cavity. Through this auxiliary incision, the RPD was inserted into the abdominal cavity. Then, re-establishing the pneumoperitoneum, after the cardia and the lower oesophagus were fully freed, a 2-cm transverse incision was made at the lateral wall of the oesophagus 3 cm above the cardia. The RPD was placed in the lower oesophagus as a whole with the headend towards the mouth through this incision. After the oesophagus was pierced from the inner side of the exterior, the anvil head was extracted through the anterior aspect of the oesophagus. The oesophagus was clipped close to the upper incision edge with Echelon™ EC60A (Johnson and Johnson, New Brunswick, NJ, USA). The proximal jejunum was transected approximately 20 cm from the ligament of Treitz by an Echelon™ EC60A. The proximal jejunal stump and the jejunum approximately 50 cm away from the stump were stapled together to perform a Roux-en-Y anastomosis using Echelon™ EC60A. A CEEA™ stapler was then inserted through the Roux limb after the pneumoperitoneum was re-established. The stapler body was attached to the anvil under laparoscopic monitoring to complete oesophagojejunostomy [Figure 1].
the stapler (Echelon™ EC60A) were inserted in each incision, and the forks of the stapler were closed and fired, achieving side-to-side oesophagojejunostomy. Afterward, the oesophagus was clipped close to the lower margin of the anastomosis with Echelon™ EC60A. After confirming that no bleeding was induced by common stab incision, the common stab was manually sutured [Figure 2].

Statistical analysis
Data were expressed as mean ± standard deviation. Statistical analysis between groups was conducted using Student's t-test in SPSS 19.0 (IBM Corporation, Chicago, Illinois, USA), and P < 0.05 was considered to be indicative of statistically significant differences.

RESULTS
Patient characteristics and operative data
A total of 63 patients were enrolled in this study (51 males and 12 females; average age = 58 years; mean body mass index [BMI] = 26.3 kg/m²), and nearly half (44.44%) of them had stage III advanced gastric cancer. Age, BMI, duration of surgery, duration of anastomosis, blood loss, post-operative hospital stay, tumour location, tumour size, degree of tumour differentiation, Borrmann type, total number of lymph nodes, number of positive lymph nodes, hospital stay and hospitalisation costs did not differ significantly between the two study groups. Group A showed a significant advantage in terms of the distance between the top border of tumours and the top resection margin (Group A, 56.79 ± 10.01 mm; Group B, 33.40 ± 9.78 mm; P < 0.001) [Table 1]. Adequate proximal negative surgical margin is important for radical resection of the upper gastric cancer, especially for gastro-oesophageal junction cancer. We further compared the distance between the top border of tumours and the top resection margin in patients with upper gastric cancer (Siewert II and Siewert III) in Group A and Group B. We found that the proximal negative surgical margin distance of the upper gastric cancer in Group A was significantly longer than that in Group B (Group A, 48.21 ± 4.41 mm; Group B, 23.86 ± 4.61 mm; P < 0.001) [Figure 3].

Intraoperative and post-operative complications
No intraoperative complications were observed in Group A, two cases of intraoperative complications were detected in Group B and no significant difference was exhibited between the two groups. Post-operative complications occurred in both groups, including two cases (anastomotic bleeding and pulmonary infection) in Group A and three cases (anastomotic leakage, wound infection and pulmonary infection) in Group B [Table 2]. These post-operative complications were cured by conservative treatment [Table 2].

Follow-up
Complete follow-up data of all patients in this study were obtained. The maximum follow-up time was 24 months. There was no significant difference in long-term survival between Group A and Group B (P = 0.9074) [Figure 4].

DISCUSSION
Since the first report of laparoscopy-assisted distal gastrectomy for gastric cancer in 1994,[12] the number of patients undergoing laparoscopic gastrectomy in China has grown rapidly with the development of technology and equipment. In comparison with laparoscopy-assisted gastrectomy, LTG has the advantages of better exposure, less traction, wider surgical field

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Figure 2: Representative example of overlap. (a) Completed lateral anastomosis of oesophagus and jejunum (b) Checked the anastomosis. (c) Transection of the oesophagus. (d) The common stab was manually sutured

Figure 3: Comparison of the distance between the top border of tumours and the top resection margin in patients with upper gastric cancer (Siewert II and Siewert III) in Groups A and B (P < 0.001)
and less invasiveness. With these advantages, LTG has been widely accepted by surgeons. However, some difficulties, including laparoscopic spleen-preserving splenic hilar lymphadenectomy and intracorporeal digestive tract reconstruction, have become significant factors restricting the application of LTG. This study focused on intracorporeal digestive tract reconstruction in LTG, that is, oesophagojejunostomy. We compared RPD application and overlap technique in laparoscopic oesophagojejunostomy since they were known as the representatives of circular and linear anastomosis.

Table 1: Association of clinicopathological characteristics with Groups A and B

| Gender | Group=A (n=28) | Group=B (n=35) | P  |
|--------|---------------|---------------|----|
| Age    | 56.32±10.65   | 59.80±9.73    | 0.176 |
| Male   | 23 (82.14)    | 28 (80.00)    | 1.000 |
| Female | 5 (17.86)     | 7 (20.00)     |     |
| BMI    | 26.5±4.2.17   | 26.12±2.72    | 0.510 |
| Total operation time (min) | 293.64±21.88 | 300.89±24.05 | 0.217 |
| Anastomosis time (min) | 56.25±7.99 | 58.11±9.92 | 0.420 |
| Tumour location (U/M/L) | l | 7 (20.00) | |
| M     | 11 (39.29)    | 14 (40.00)    |     |
| U     | 14 (50.00)    | 14 (40.00)    |     |
| Tumour diameter (cm) | ≤3 | 15 (53.57) | 0.714 |
| >3    | 13 (46.43)    | 19 (54.29)    |     |
| Differentiation | Poor | 24 (68.57) | 0.929 |
| Well  | 11 (31.43)    |               |     |
| Borrmann type | I | 4 (11.43) | 0.759 |
| II    | 13 (46.43)    | 14 (40.00)    |     |
| III   | 11 (39.29)    | 17 (48.57)    |     |
| Total lymph nodes | 43.82±10.76 | 47.89±9.54 | 0.112 |
| Positive lymph nodes | 3.89±4.64 | 3.94±4.61 | 0.966 |
| TNM   |                |               |     |
| I     | 5 (17.86)     | 8 (22.86)     | 0.883 |
| II    | 8 (28.57)     | 9 (25.71)     |     |
| III   | 15 (53.57)    | 18 (51.43)    |     |
| Distance between top border of tumours and top resection margin (mm) | 56.79±10.01 | 33.40±9.78 | <0.001 |
| Intraoperative bleeding (mL) | 54.32±11.65 | 51.00±10.97 | 0.245 |
| Post-operative hospitalisation (days) | 12.14±2.56 | 12.74±4.64 | 0.540 |
| Hospitalisation costs (RMB) | 64.99±4.79k | 65.04±6.90k | 0.978 |
| Intraoperative complications | No | 28 (100.00) | 0.574 |
| Yes  | 0 (0.00)      | 2 (5.71)      |     |
| Anastomotic complications | No | 27 (96.43) | 1.000 |
| Yes  | 1 (3.57)      | 1 (2.86)      |     |
| Post-operative complications | No | 26 (92.86) | 1.000 |
| Yes  | 2 (7.14)      | 3 (8.57)      |     |

BMI: Body mass index, TNM: Tumour-node-metastasis, RMB: China Yuan (CNY)

Table 2: Post-operative complications

| Gender | Age | Method | Complication | Treatment | Outcome |
|--------|-----|--------|--------------|-----------|---------|
| Male   | 63  | RPD    | Pulmonary infection | Conservative treatment | Cured |
| Female | 64  | RPD    | Anastomotic bleeding | Conservative treatment | Cured |
| Male   | 68  | Overlap | Pulmonary infection | Conservative treatment | Cured |
| Male   | 64  | Overlap | Wound infection | Conservative treatment | Cured |
| Male   | 60  | Overlap | Anastomotic leakage | Conservative treatment | Cured |

RPD: Reverse puncture device

Figure 4: Overall survival. No significant differences in long-term survival were found between Groups A and B (P = 0.9074)
The circular stapler is preferred in oesophagojejunostomy in LTG, because it has been used in conventional open approaches. However, placement of the anvil of circular stapler can be technically challenging in this procedure due to the difficulty in performing a purse-string suture to fix it to the oesophageal stump in oesophagojejunostomy. To overcome this difficulty, researchers developed several methods, such as RPD and OrVil™, for placing the anvil of the circular stapler. Some studies have also suggested that the use of circular staplers is associated with oesophagojejunostomy stenosis and leakage.[5,16,20,21] From our experience, the application of RPD has been successful, indicating that RPD is safe and feasible for anastomosis.

Linear stapler was invented after the development of a circular stapler, and the former was completely different from the latter. Some scholars proposed that the discovery of linear stapler is revolutionary, considering that these instruments have been used in total laparoscopic surgery for gastric cancer with safety and efficiency.[23] The most representative anastomosis techniques involving linear stapler are side-to-side anastomosis reported by Okabe et al. and overlap side-to-side anastomosis presented by Inaba et al.[6,23] The overlap technique with a linear stapler is often utilised by our surgical team.

Overlap and RPD techniques are widely used in oesophagojejunostomy. However, RPD and overlap have yet to be compared. In this study, we retrospectively studied and comprehensively compared the two anastomosis techniques. There was no significant difference between the application value of overlap and RPD in terms of surgery duration, anastomosis duration and intraoperative bleeding. These findings indicate that the operability of the two anastomosis techniques was similar and that we were skilled in performing the two anastomosis techniques to ensure the effectiveness of this study. There was no significant difference between overlap and RPD applications in post-operative hospitalisation and hospitalisation cost, suggesting that no significant variation existed in post-operative recovery after using the two anastomosis techniques. Five cases of post-operative complications were recorded, and there was no significant difference between the two groups in this matter. Complications associated with the anastomatic site were anastomotic bleeding in Group A and anastomotic leakage in Group B. Previous reports revealed that the rate of anastomotic stenosis after oesophagojejunostomy in LTG is 3.2%–17%.20,21,24 The risk factors of anastomotic stenosis include 21 mm-diameter circular stapler, female patients, double-staple anastomosis and long-term post-operative fasting.[20,25–27] In our study, no anastomotic stenosis occurred in Group A possibly, because we used a 25-mm diameter circular stapler. Anastomotic stenosis rarely occurs in oesophagojejunostomy through overlap technique mainly because of a wide anastomotic stoma, which comprises a side-to-side stapled suture and a hand-sewn closure of the entry hole.[27] This view was supported by our findings, that is, no anastomotic stenosis occurred in Group B. We performed anastomosis in oesophagojejunostomy using 60-mm long linear cut staplers in Group B; therefore, the diameter of the anastomotic stoma in Group B was >3 cm.

We also observed two cases of intraoperative complications, namely oesophageal tear and pseudo-tract anastomosis (the muscular layer of the oesophagus was anastomosed with the whole jejunum), associated with the use of overlap technique. We analysed these two cases to find that both occurred at the early stages of this study. The occurrence of these intraoperative complications might be related to the lack of proficiency and cooperation during operation. With the improvement of the surgical team's technical proficiency and cooperation, no similar complications occurred in the middle and late surgical cases. In oesophageal laceration, anastomosis was modified into an RPD for remediation, and no anastomotic complications were detected. Pseudo-tract anastomosis was caused by the placement of a cutting closure device without clamping the full thickness of the oesophagus without a mucosal layer. Remediation was performed with endoscopic manual anastomosis in this case, but post-operative anastomotic leakage was occurred. Fortunately, the anastomotic leakage healed after 37 days of conservative treatment. In subsequent surgeries, we had an anaesthesiologist who assisted in placing a gastric tube in the oesophagus to avoid pseudo-tract anastomosis. No similar complications occurred after this improvement. Good anaesthetic and good cooperation with anaesthesiologists during the implantation of anastomosis remarkably contributed to the prevention of intraoperative complications.

In the case of oesophageal laceration, remediation was achieved by modifying the anastomosis from overlap to an RPD, indicating that compared with overlap, RPD can remove more terminal oesophagus without affecting the anastomosis. Our results showed that the RPD group significantly differed from the overlap group in terms of the distance between the top border of the tumours and the top resection margin. We further compared the proximal negative surgical margin distance of the upper gastric cancer (Siewert II and Siewert III) in RPD group and overlap group. We found that the proximal negative margin of the upper gastric cancer in RPD group was significantly longer than that in overlap group. When using overlap
technique, a sufficient portion of the oesophagus must be reserved (at least 6 cm when using 60 mm long linear cut staplers or at least 4.5 cm when using 45-mm long linear cut staplers) for the anastomosis, which was not necessary for RPD. Therefore, for patients with gastro-oesophageal junction carcinoma, RPD can ensure an adequate proximal margin.

Our follow-up results showed no significant difference in prognosis between the two groups. We believe that there may be two reasons for this result. First, the difference between the two groups was the reconstruction of the digestive tract, and there was no significant difference in lymph node clearance and post-operative treatment between the two groups. The other reason was that our follow-up time was not long enough.

Several limitations exist in this study. This is a retrospective, observational, and non-experimental study with a small sample size, and the post-operative follow-up time was short; thus, prospective and randomised trials with larger sample size are needed to further verify our conclusion.

CONCLUSIONS

Digestive tract reconstruction, especially intracorporeal oesophagojejunostomy, is one of the technical challenges in LTG. RPD and overlap techniques are widely used in LTG by many surgeons. These techniques have similar clinical effects, and both have proven safe and feasible, but RPD is superior to overlap technique in obtaining a safe proximal margin, in patients with gastro-oesophageal junction carcinoma. Therefore, RPD is more suitable for patients with gastro-oesophageal carcinoma, especially those with tumours invading the end of the oesophagus.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Azagra JS, Goergen M, De Simone P, Ibañez-Aguirre J. Minimally invasive surgery for gastric cancer. Surg Endosc 1999;13:351-7.
2. Shim JH, Yoo HM, Oh SI, Nam MJ, Jeon HM, Park CH, et al. Various types of intracorporeal esophagojejunostomy after laparoscopic total gastrectomy for gastric cancer. Gastric Cancer 2013;16:420-7.
3. Okabe H, Tsunoda S, Tanaka E, Hisamori S, Kawada H, Sakai Y. Is laparoscopic total gastrectomy a safe operation? A review of various anastomotic techniques and their outcomes. Surg Today 2015;45:549-58.
4. Kunisaki C, Makino H, Takagawa R, Kimura J, Ota M, Ichikawa Y, et al. A systematic review of laparoscopic total gastrectomy for gastric cancer. Gastric Cancer 2015;18:218-26.
5. Umemura A, Koeda K, Sasaki A, Fujiiwara H, Kimura Y, Iwaya T, et al. Totally laparoscopic total gastrectomy for gastric cancer: Literature review and comparison of the procedure of esophagojejunostomy. Asian J Surg 2015;38:102-12.
6. Inaba K, Sato S, Ishida Y, Taniguchi K, Isogaki J, Kanaya S, et al. Overlap method: Novel intracorporeal esophagojejunostomy after laparoscopic total gastrectomy. J Am Coll Surg 2010;211:e25-9.
7. Kitagami H, Morimoto M, Nakamura K, Watanabe T, Kurashima Y, Nonoyama K, et al. Technique of Roux-en-Y reconstruction using overlap method after laparoscopic total gastrectomy for gastric cancer: 100 consecutively successful cases. Surg Endosc 2016;30:4086-91.
8. Omori T, Oyama T, Motiyanai M, Sakai K, Akamatsu H, et al. A simple and safe technique for esophagojejunostomy using the hemidouble stapling technique in laparoscopy-assisted total gastrectomy. Am J Surg 2009;197:e13-7.
9. Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2010 (ver. 3). Gastric Cancer 2011;14:111-23.
10. Japanese Gastric Cancer Association. Japanese Classification of Gastric Carcinoma – 2nd English Edition. Gastric Cancer 2011;14:101-12.
11. Chen D, Cheng P, Ding D, Ke Z. Feasibility and safety of a novel reverse puncture device (RPD) for laparoscopic esophagogastric/ esophagojejunostomy. Int J Clin Exp Med 2014;7:2497-503.
12. Kitano S, Iso Y, Motiyanai M, Sugimachi K. Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc 1994;4:446-8.
13. Song KY, Park CH, Kang HC, Kim JH, Park SM, Jun KH, et al. Is totally laparoscopic gastrectomy less invasive than laparoscopy-assisted gastrectomy? Prospective, multicenter study. J Gastrointest Surg 2008;12:1015-21.
14. Ikeda O, Sakaguchi Y, Aoki Y, Harimoto N, Taomoto J, Masuda T, et al. Advantages of totally laparoscopic distal gastrectomy over laparoscopically assisted distal gastrectomy for gastric cancer. Surg Endosc 2009;23:2374-9.
15. Kim HS, Kim MG, Kim BS, Lee IS, Lee S, Yook JH, et al. Comparison of totally laparoscopic total gastrectomy and laparoscopic-assisted total gastrectomy methods for the surgical treatment of early gastric cancer near the gastroesophageal junction. J Laparoendosc Adv Surg Tech A 2013;23:204-10.
16. Okabe H, Obama K, Tsunoda S, Tanaka E, Sakai Y. Advantages of completely laparoscopic gastrectomy with linear staple reconstruction: A long-term follow-up study. Ann Surg 2014;259:109-16.
17. Okabe H, Obama K, Kan T, Tanaka E, Itami A, Sakai Y. Medical approach for laparoscopic total gastrectomy with splenic lymph node dissection. J Am Coll Surg 2010;211:e1-6.
18. Tsunoda S, Okabe H, Obama K, Tanaka E, Hisamori S, Kinjo Y, et al. Short-term outcomes of totally laparoscopic total gastrectomy: Experience with the first consecutive 112 cases. World J Surg 2014;38:2662-7.
19. Lin M, Huang CM, Zheng CH, Li P, Xie JW, Chen QY, et al. Totally laparoscopic total gastrectomy for locally advanced middle-upper-third gastric cancer. J Vis Surg 2017;3:46.
20. Zuki T, Hosoya Y, Kameda Y, Kurashima K, Saito S, Uii T, et al. Stenosis after use of the double-stapling technique for reconstruction after laparoscopy-assisted total gastrectomy. Surg Endosc 2013;27:3683-9.
21. Inokuchi M, Otsuki S, Fujimori Y, Sato Y, Nakagawa M, Kojima K. Systematic review of anastomotic complications of esophagojejunostomy after laparoscopic total gastrectomy. World J Gastroenterol 2015;21:9656-65.
22. Li X, Hong L, Ding D, Liu Y, Niu G, Li L, et al. Comparison of OrVil™ and RPD in laparoscopic total gastrectomy for gastric cancer. Surg Endosc 2017;31:4773-9.
23. Okabe H, Obama K, Tanaka E, Nomura A, Kawamura J, Nagayama S, et al. Intracorporeal esophagojejunostomy after laparoscopic total gastrectomy for patients with gastric cancer. Surg Endosc 2009;23:2167-71.
24. Liao GQ, Ou XW, Liu SQ, Zhang SR, Huang W. Laparoscopy-assisted total gastrectomy with trans-orally inserted anvil (OrVil™): A single institution experience. World J Gastroenterol 2013;19:755-60.
25. Fukagawa T, Gotoda T, Oda I, Deguchi Y, Saka M, Morita S, et al. Stenosis of esophago-jejuno anastomosis after gastric surgery. World J Surg 2010;34:1859-63.
26. Kataoka M, Masaoka A, Hayashi S, Honda H, Hotta T, Niwa T, et al. Problems associated with the EEA stapling technique for esophagojejunostomy after total gastrectomy. Ann Surg 1989;209:99-104.
27. Kawamura H, Ohno Y, Ichikawa N, Yoshida T, Homma S, Takahashi M, et al. Anastomotic complications after laparoscopic total gastrectomy with esophagojejunostomy constructed by circular stapler (OrVil) versus linear stapler (overlap method). Surg Endosc 2017;31:5175-82.