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Original Article

Feasibility and safety of a novel reverse puncture device (RPD) for laparoscopic esophagogastrostomy/ esophagojejunostomy

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Abstract: Background: We aimed to report the feasibility and safety of the technique after laparoscopy-assisted total gastrectomy (LATG) or laparoscopy-assisted proximal gastrectomy (LAPG): intracorporeal circular stapling esophagogastrostomy/esophagojejunostomy using the reverse puncture device (RPD). Methods: Laparoscopy-assisted esophagogastrostomy/esophagojejunostomy was performed in 14 gastric cancer cases and 4 cases of cardiac stromal tumors using a newly developed RPD to place the anvil. After LATG or LAPG, an approximately 2 cm transverse incision was made at the esophagus anterior wall at 2 cm above the cardia and the RPD was then introduced via the incision. The end of the RPD was sutured out "reversely" at 3 cm above the esophagotomy incision. Double-stapling esophagogastrostomy/esophagojejunostomy with a circular stapler was then performed under laparoscopic assistance. Results: There was no intraoperative complication or conversion to open surgery, the mean operation time was 155 min, the mean anvil placement time was 12 min, and the mean blood loss was 75 mL. Patients resumed oral liquid diet on postoperative day 2, and discharged at day 10. There was no mortality, no anastomotic leakage, anastomotic stenosis, intra-abdominal infections or other complications. No recurrence was found during the 11 to 25 month follow up. Postoperative gastrointestinal iodine solution radiography revealed no anastomosis leakage or stenosis. Conclusions: We have successfully performed LATG or LAPG reconstruction using our technique in 18 patients without any complications. We believe that our procedure is a secure and reliable reconstruction method, and is especially useful in obese patients, in whom conventional manipulations are often difficult.

Keywords: Esophagogastrostomy, esophagojejunostomy, reverse puncture device

Introduction

Most laparoscopic esophagogastrostomies and esophagojejunostomies (Roux-en-Y) require placement of an anvil into the esophageal stump, which has always been the difficulties for such surgery because of its deep position [1]. In most early methods, the esophagus was transected first, and then a laparoscopic or small incision-assisted purse string suture was formed, followed by the placement of the anvil. However, the instability of the transected esophageal stump renders the surgical procedures technically challenging. Many modifications have been made to improve the techniques, each of which has its own advantages and disadvantages. We have designed a novel reverse puncture device for anvil placement, which has markedly simplified laparoscopic esophagogastrostomies and esophagojejunostomies. From August 2010 to October 2011, we performed laparoscopy-assisted esophagogastrostomy/ esophagojejunostomy on a total of 14 cases of gastric cancer and 4 cases of cardiac stromal tumors using the reverse puncture device. Here, we introduce the reconstruction method of intracorporeal circular stapling esophagogastrostomy/esophagojejunostomy using the reverse puncture device and report its feasibility and safety.

Patients and methods

Patients

We reviewed the surgical data of 14 patients with pathologically proven gastric cancer and 4 patients with cardiac stromal tumors. They included 12 males and 6 females patients with

Table 1. Characteristics of patients undergoing esophagogastrostomy/esophagojejunostomy with the reverse puncture device (n = 18)

Characteristics	
Sex	
Male/Female	12/6
Age (years)	
Mean	53 ± 4
Range	42-68
Body mass index (kg/m^2)	22 ± 3
Preoperative complication	
Diabetes	1 (6%)
Ischemic heart disease	0 (0%)
Liver cirrhosis	0 (0%)
Hypertension	1 (6%)
Type of gastric disease	
Cancer	14 (78%)
Stromal tumor	4 (22%)

Data values are presented as means ± SE. Body mass index = body weight/height^2 (kg/m^2).

a mean age of 53 ± 4 (range, 42 to 68) years (**Table 1**). Their major clinical manifestations were upper abdominal fullness, dull pain or swallowing difficulties. There were no positive signs upon physical examination. Upper abdominal CT scan revealed no apparent lymph node metastasis or organ metastasis in all cases. All gastric cancer patients underwent laparoscopic radical total/proximal gastrectomy plus D2 lymph node dissection, and cardiac stromal tumor patients underwent laparoscopic proximal gastrectomy.

The reverse puncture device

The reverse puncture device is shown in **Figure 1**. The body of the apparatus is an Ethicon circular stapler anvil 25 (ECS 25). Its trocar is secured with a 2-0 monofilament suture at the hole of the tip, and the suture tail is knotted to form a woven braid about 2 cm long with the total length of the traction suture being 4 cm.

Surgical technique

The patient was placed in the supine position with legs open with the operator standing between the legs. The mirror-holder stood on the right side and the assistant on the left of the operating table. A pneumoperitoneum pressure of 14 mmHg was applied. A 4-port technique was used: A 10-mm trocar was placed on the umbilical region as the observation port, a 10-mm trocar at approximately 3 cm above the umbilical horizontal line across the left mid-clavicular line as the primary operating port, a 5-mm trocar at the corresponding position of the right upper quadrant as the secondary operating port, and a 10-mm trocar 2 cm below the xiphoid process for the assistant to place the penta-prongs retractor to fend off the liver (**Figure 2**). The tumor was located by exploration, and then laparoscopic proximal gastrec-

Figure 1. The reverse puncture device (RPD). The body is an Ethicon circular stapler anvil 25 (ECS 25), with its trocar secured with a 2-0 monofilament suture at the hole of the tip, and the suture tail knotted to form a woven braid about 2 cm long (the total length of the traction suture is 4 cm).

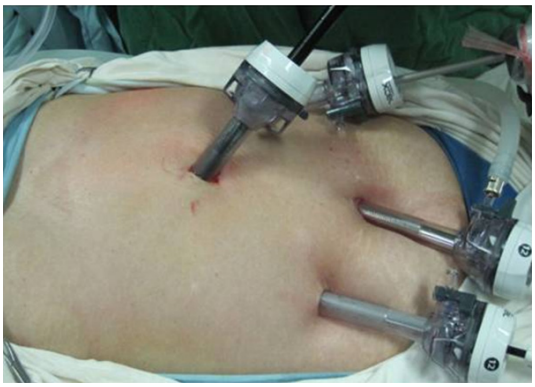

Figure 2. Port location. A 4-port technique was used: A 10-mm trocar was placed on the umbilical region as the observation port, a 10-mm trocar at approximately 3 cm above the umbilical horizontal line across the left mid-clavicular line as the primary operating port, a 5-mm trocar at the corresponding position of the right upper quadrant as the secondary operating port, and a 10-mm trocar 2 cm below the xiphoid process for the assistant to place the penta-prongs retractor to fend off the liver.

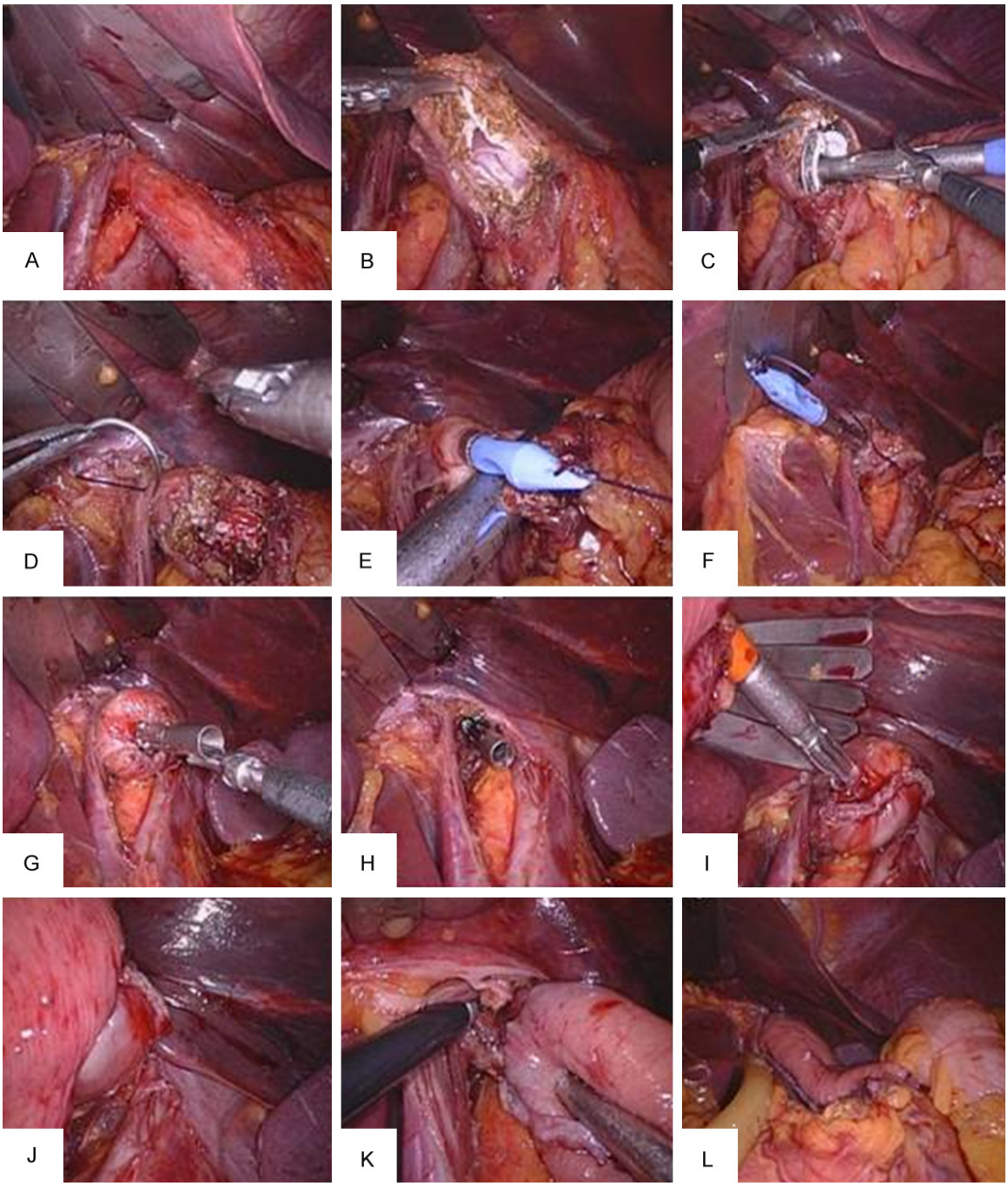

Figure 3. Surgical procedures. A. The cardia and esophagus are fully freed. B. A 2 cm transverse incision is made at the anterior wall of the esophagus 2 cm above the cardia. C. The RPD is put into the lower esophagus as a whole with the headend toward the mouth via this incision. D. The needle attached to the trocar of the anvil is advanced through the anterior esophageal wall about 3 cm above the incision "reversely." E. The esophagus is clipped close to the upper incision edge with Echelon, the trocar of the anvil is brought out through the esophagus wall followed by the anvil center rod, and then the head of the anvil is secured. F. The esophagus is transected. G. The trocar is detached from the anvil. H. The anvil retracts into the thoracic cavity, which suggests the incisal margin is very high. I. The stapler is joined under the laparoscope view. J. Esophagogastrostomy is completed. K. The anastomosis line. L. The remnant stomach anterior wall incision is closed under direct vision through a mini-laparotomy and a drainage tube is placed.

tomy was performed. The greater and lesser curvatures of the stomach were first fully freed, and the left gastroepiploic vessels, short gastric vessels, left gastric vessels, and post-gas-

Figure 4. Upper gastrointestinal iodine solution radiography revealed no anastomosis leakage or stenosis (esophagojejunostomy).

tric vessels were divided. The cardia and lower esophagus were freed. An approximately 2 cm transverse incision was made at the anterior wall of the esophagus 2 cm above the cardia with an ultrasonic scalpel. The reverse puncture device was then advanced as a whole via this incision into the lower esophagus with the head end toward the mouth. The needle attached to the trocar of the anvil was subsequently advanced through the anterior esophageal wall about 3 cm above the incision "reversely", and the traction suture was appropriately tightened. Then, a linear stapling device with a disposable GI cartridge (Echelon 60; EthiconEndo-Surgery) was used to clip the esophagus with the Echelon inferior margin close to the esophagus incision on the superior margin. The traction suture was vigorously drawn outward with a dissecting forcep, and the trocar of the anvil was then brought out through the esophagus wall followed by the anvil center rod. The head of the anvil was secured, followed by transection of the esophagus by firing the Echelon, and the trocar was detached from the anvil. With the anvil placed, the subxiphoid port was then extended longitudinally to become a median incision about 4 cm in length. After the incision was protected, the gastric remnant was taken out, and lumpectomy was performed with Echelon with the gastric remnant shaped into a tubular stomach. A 2 cm small incision was made on the anterior wall in the middle of the gastric remnant, and the

Figure 5. Incision appearance.

stapler body was placed through the small incision. After pneumoperitoneum was re-established, the stapler body joined the anvil under laparoscopic monitoring to complete esophagogastrostomy. Pneumoperitoneum was then released, and the incision of the gastric remnant anterior wall was closed under direct vision. After rinsing of the abdominal cavity, a drainage tube was placed near the esophagus-remnant stomach anastomotic stoma and brought out from the right upper quadrant port (**Figure 3**), and then each trocar site was closed.

Results

All the surgical operations were completed under laparoscopic-assistance. No intraoperative complication was observed. In addition, there was no conversion to open surgery. The mean operative time was 155 (range, 125 to 235) min, and the mean anvil placement time was 12 (range, 9 to 15) min. The mean estimated blood loss was 75 (range, 60 to 100) mL. The patients received mechanical ventilation on the 2nd to 3rd postoperative day, and were discharged on the 7th to 13th postoperative day. No mortality occurred and there was no anastomotic leakage or stenosis. No intra-abdominal infections or other complications were reported, and there was no recurrence during 11 to 25 months of follow up. All cases underwent postoperative upper gastrointestinal iodine solution radiography, which revealed no anastomosis leakage or stenosis (**Figure 4**). Postoperative gastric cancer pathology showed that the mean number of lymph node dissec-

tion at the greater curvature was 7 (range, 4 to 14), and that at the lesser curvature was 21 (range, 18 to 22), and that at the hepatoduodenal ligament was 3 (range, 2 to 5). Postoperative immunohistochemistry confirmed cardiac stromal tumors in 4 cases. The incision healed well (**Figure 5**).

Discussion

Most laparoscopic esophagogastrostomies and esophagojejunostomies (Roux-en-Y) require placement of an anvil on the esophageal stump, which is difficult surgically because of its deep position. These laparoscopic operations are especially challenging in the obese due to a thick abdominal wall in these patients [2, 3]. Various modified surgical procedures have been proposed: one technique upholds the complicated purse-string suture procedure by starting with esophagus transection in most instances followed by a laparoscopic or small incision-assisted purse-string suture and anvil placement. Due to the instability of the transected esophageal stump, it is technically difficult and hard to guarantee the quality and tightness of the purse-string suture. Usui[2] in Japan made slight improvement by using a newly developed purse-string suture device "Endo-PSI", which is designed specifically for hand-assisted laparoscopic surgery. The hand shaft and occlusion shaft of the device are shorter than conventional ones, and the needle groove is funnel-shaped, which brings some convenience to laparoscopic purse-string suture. But the tightness of the purse knot is still a concern, requiring additional reinforcement manipulation with a ligator. The device applies only to hand-assisted procedures with a larger incision and expensive "lap disc." Yu *et al.* in China made further improvement by introducing a semi-circumferential esophagotomy at the anterior esophageal wall first followed by a purse-string suture and anvil placement. The purse suture knot was then tightened and finally the remaining semi-circle esophagus was finally cut off. This method ensures the stability of the esophagus during anvil placement. Though it has certain advantages, the previously mentioned purse-string suture quality and degree of tightness are still a concern, and the manipulation remains rather complicated.

The other technique is to abandon the complicated purse-string suture procedure, which, compared to the former technique, has made significant progress and can be subdivided into two approaches. The first is side-to-side anastomosis. Kim [4] in S. Korea advocated making a small hole first in the esophagus and the jejunum wall of proposed anastomosis, respectively. Then, a laparoscopic linear stapler (Echelon) was placed through the two holes and esophagojejunostomy was performed, followed by resection of redundant esophagus and jejunum with Echelon above the two holes and perpendicular to the anastomotic stoma. The advantages of this approach include a large anastomotic stoma, no need to place an anvil, simple manipulations and easy observation of anastomotic bleeding or other conditions. Wang [5] in China published a report of 14 cases using the approach, but its manipulation is still complicated, and the total cost is high. Most importantly, it needs clipping both the esophagus and jejunum before anastomosis; therefore, it is impossible to be completed within a narrow space such as the mediastinum, rendering obtaining a higher cutting edge impossible, limiting its use range; The second is end-to-end (circular) anastomosis, which can be performed in the mediastinum; therefore, it can obtain a higher margin than the first approach. Jeong [6] in S. Korea firstly reported 16 cases of laparoscopic esophagojejunostomy with the OrVilTM device for anvil placement. In his approach, the esophageal stump was closed with Echelon, and then, a small hole was cut open in the center of the stump, the tip of the gastric tube was pulled out through the hole until the gastric tube-connected anvil trocar and rod were led out and the head of the anvil was secured. The connecting-thread of the gastric tube and the anvil was cut out, and the anvil trocar was removed to complete anvil placement. This specific design is very clever, and significantly reduces technical difficulty. We also managed 34 cases using the OrVilTM device (publication in Chinese). The disadvantage of OrVilTM is higher cost, possibility of damage to the esophageal mucosa due to the wrong angle or intensity of the anvil leading, therefore, high technical requirements.

Takeshi *et al*. [7] proposed the technique used in this article, and reported 10 cases of gastric cancer patients with laparoscopic total gastrectomy plus esophagojejunostomy, which received good efficacy, but Takeshi did not desig-

nate the device, and there are no further follow-up reports.

The current procedure is indicated for laparoscopic surgical resection of gastric cancer and is not being explored for use in open surgery as in the latter case the surgical incision is of a sufficient size to allow the hand of the surgeon to enter to complete the conventional purse-string suture procedure. The current authors completed the procedure in 18 cases and prove again that this method is feasible, safe and effective for laparoscopy-assisted esophagogastrostomy/esophagojejunostomy, and we formally designated the device as the reverse puncture device. The benefits of this approach are as follows: 1) A laparoscopic linear stapler (Echelon) replaces the traditional purse-string suture, the incisal margins are tidier and the manipulation is more convenient. 2) It belongs to the circular anastomosis category, which can obtain a higher margin (**Figure 3H** is very intuitive) than side-to-side anastomosis, and from the surgical procedures, it can be seen that the anvil can be placed at about 1 cm proximal to wherever the esophagus can be stapled transected, which makes the incisal margins much higher and minimize the possibility of laparotomy or even thoracotomy. Takeshi [7] reported that one patient with positive esophagus margins on intraoperative frozen pathology underwent transverse clipping of the esophageal stump again, and the anvil was placed again in the same manner, followed by the transection of the esophageal stump and esophagojejunostomy, which avoids thoracotomy, and the clinical outcome of this patient was very good. 3) In this method, the traction suture is first sutured out of the esophagus wall, which ensures the accuracy for locating the anvil during follow-up; not pulling traction suture to lead the anvil trocar out until clipping and stabilizing the esophagus ensures the stability of the esophagus during anvil placement. Thus, it avoids injuries and inconveniences related to the unstable esophagus, which cannot be avoided in many other methods, even in OrVilTM. 4) The diameter of the opening hole to let out the anvil in the esophagus wall is smaller than that in OrVilTM or other methods, and it may be the smallest among the currently available methods in which the anvil is better secured, and the sloshing is avoided of the anvil rod or esophageal tear around the anvil rod resulting from the large opening hole. 5) In OrVilTM and some other methods, anesthetist plays a very important role by helping insert the gastric tube with an anvil, the learning curve is long, and poor cooperation may lead to esophageal mucosal injury. Our method does not have this kind of problems. The mean anvil placement time in our group is only 12 min, which shows its simplicity. 6) In our method, the commonly used circular stapler anvil is turned into reverse puncture device just after appropriate transformation, and the cost is lower.

The surgeon should pay attention to the following tips in this method: 1). Opening incision of the anterior wall of the esophagus should be horizontal; if it is vertical, the incisal margins are artificially raised, which may cause unnecessary troubles. 2) The opening incision of the esophagus should not be too small so as not to cause difficulties for placement of the reverse puncture device, and the incision should also not be too large to avoid the failure to maintain tension of the residual esophagus. Thus, it increases the instability during placement of the reverse puncture device or even causes residual esophageal avulsion. 3) When placing the reverse puncture device, the surgeon needs to confirm the esophageal lumen by identifying the esophageal mucosa to avoid forcible submucosal placement. 4) The traction suture should be straightened as soon as the needle goes out to avoid being tangled with the subsequent cutting line, and the woven braid should be pulled completely out of the esophagus so as not to slip back into the esophageal lumen.

In summary, according to our clinical experience of 18 cases, the use of the reverse puncture device for laparoscopic esophageal stump anvil placement and subsequent esophagogastrostomy/esophagojejunostomy can avoid the complicated operation of purse-string suture in the esophagus. It is simpler and safer and can obtain higher incisal margins. Compared to the OrVilTM and other surgical procedures, it is more economical and does not need an anesthetist to place the gastric tube with an anvil; therefore, it has fewer interference factors and is more controllable. We believe that our procedure is a secure and reliable reconstruction method in laparoscopic surgery, which is especially useful in obese patients, in whom conventional manipulations are often difficult.

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Disclosure of conflict of interest

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