

# Technical details of and prognosis for the "China stitch", a novel technique for totally laparoscopic hand-sewn esophagojejunostomy

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**SUMMARY** The current study describes the technical details of and the clinical prognosis for the "China stitch", a novel technique for hand-sewn esophagojejunostomy in totally laparoscopic total gastrectomy. This study also explores the feasibility and safety of the technique. Clinical data of 20 patients with esophagogastric junction cancer in Beijing Shijitan Hospital, Capital Medical University from January 2017 to April 2018 were retrospectively analyzed. All 20 patients underwent esophagojejunostomy via a novel hand-sewn technique that uses traction to turn the left or right wall of the esophagus into an anterior wall. This avoids the difficulty of suturing the posterior wall. All patients were followed until June 2019. All 20 patients successfully underwent the procedure. The mean operating time was  $216.5 \pm 24.9$  (176-254) min, the mean hand-sewn reconstruction time was  $44.4 \pm 9.4$  (26-61) min, intraoperative bleeding was  $141.2 \pm 24.9$  (130-160) mL, and the number of resected lymph nodes was  $23 \pm 8$  (14-33). After surgery, there was one case of anastomotic leakage and one case of anastomotic stenosis, but both were alleviated with conservative treatment. The mean duration of follow-up was 15 (4-33) months. There was no significant difference in postoperative complications of and short-term oncologic prognosis for the 20 patients who underwent hand-sewn esophagojejunostomy and the 21 patients who underwent mechanical esophagojejunostomy during the same period. In conclusion, the "China stitch", a novel hand-sewn technique, is a cost-effective, safe, and reliable method for esophagojejunostomy in totally laparoscopic total gastrectomy.

**Keywords** hand-sewn esophagojejunostomy, laparoscopic total gastrectomy, gastric cancer

## 1. Introduction

Laparoscopic total gastrectomy (LTG) is considered to be an effective option for treatment of esophagogastric junction (EGJ) cancer. LTG involves laparoscopic lymph node dissection and digestive tract reconstruction via open surgery. During totally laparoscopic total gastrectomy (TLTG), however, the entire surgery (including lymph node dissection and digestive tract reconstruction) is performed laparoscopically; an incision is made only to collect specimens, resulting in a smaller incision and a faster recovery.

Recent studies have indicated that TLTG is safe, feasible, and minimally invasive (1,2). However, the technique for laparoscopic esophagojejunostomy remains a major challenge. esophagojejunostomy is usually performed mechanically; techniques include end-to-side anastomosis using a traditional circular stapler, end-to-side anastomosis using a trans-orally inserted stapler anvil (OrVil<sup>TM</sup>) (3), and side-to-side anastomosis

using a linear stapler (4). However, these techniques still have many flaws such as the difficulty of placing anvil in esophageal stump laparoscopically, an unconfirmed resection margin, and expense (5). Recent studies have cited several flaws of hand-sewn esophagojejunostomy, including the difficulty of suturing the posterior wall due to technical complexity and the high level of suture skill (6,7).

In light of these circumstances, the current authors devised a novel suture technique for laparoscopic hand-sewn esophagojejunostomy. This technique can avoid the difficulty of suturing the posterior wall through an optimized procedure.

## 2. Materials and Methods

### 2.1. Patients

Potential subjects were patients diagnosed with Siewert II or Siewert III EGJ cancer who underwent TLTG

using the novel "China stitch" technique for hand-sewn esophagojejunostomy by the same surgeon at Beijing Shijitan Hospital from January 2017 to April 2018. Subjects were 20 patients who provided informed consent. The patients had an average age of 59 (45-89) years; 65% (13/20) of them were male. The control group consisted of patients who underwent TLTG with using mechanical esophagojejunostomy during the same period.

All patients underwent routine preoperative examinations, gastroscopy, endoscopic ultrasonography, and chest, abdomen, and pelvis CT scans to determine the clinical stage and pathological type. Patients who had distant metastases or peripheral tissue invasion were excluded. Of 20 patients in total, 2 had Siewert II EGJ cancer and 18 had Siewert III EGJ cancer. There were no significant differences in the preoperative baseline data for the hand-sewn esophagojejunostomy group and the control group (Table 1).

This study was approved by the Ethics Committee of Beijing Shijitan Hospital. All patients provided written informed consent for participation in this study.

## 2.2. Protocol

### 2.2.1. Procedure

The 20 patients underwent TLTG and esophagojejunostomy

using the novel "China stitch" technique for laparoscopic hand-sewn esophagojejunostomy.

### 2.2.2. Body position

Patients were placed in the supine position under endotracheal intubation and general anesthesia. The surgeon stood on the patient's right side, the first assistant on his left side, and the laparoscopic assistant between his legs.

### 2.2.3. Placement of trocars

After establishing pneumoperitoneum, the first 10-mm trocar was inserted below the umbilicus, and a 12-mm trocar and three 5-mm trocars were inserted into the right abdomen, right upper abdomen, and left abdomen, respectively. Carbon dioxide pneumoperitoneum was set at 12-15 mmHg.

### 2.2.4. Total gastrectomy

Laparoscopic total gastrectomy was performed depending on the TNM stage preoperatively, followed by lymph node dissection. Surgery was standardized in accordance with the Guidelines for Laparoscopic Gastrectomy for Gastric Cancer (2016) of the Chinese Society of Surgery, Chinese Medical Association (8).

**Table 1. Patient characteristics.**

Variables	China stitch group (n = 20)	Mechanical suturing group (n = 21)	P value
Age (y, mean ± SD)	59.0 ± 8.9	58.4 ± 7.7	0.799
Gender (n)			
Male	13	15	0.986
Female	7	6	0.875
BMI (kg/m <sup>2</sup> , mean ± SD)	24.5 ± 2.5	23.9 ± 3.7	0.646
Siewert Classification			
Type II	2	2	0.956
Type III	18	19	0.921
ECOG score, n (%)			
0	14	15	0.943
1	4	5	0.936
2	2	1	0.867
Comorbidity, n (%)			
Hypertension	8	6	0.248
Diabetes mellitus	1	3	0.687
Cardiac disease	1	2	0.587
Pulmonary disease	1	0	0.536
Hepatic disease	2	1	0.687
Renal disease	0	1	0.432
Tumor location, n			
EGJ	16	18	0.777
Non-EGJ	4	3	
Tumor size (cm, mean ± SD)	4.8 ± 2.0	4.6 ± 1.8	0.761
Tumor stage*			
I	0	2	0.163
II	4	3	0.458
III	14	15	0.421
IV	2	1	0.687

EGJ = Esophagogastric junction. \* Seventh edition of the Union for International Cancer Control TNM classification.

2.2.5. The "China Stitch", a novel technique for laparoscopic hand-sewn esophagojejunostomy (Video 1, <https://pan.baidu.com/s/1o3zI3AC8AACVsko6ne9B9Q> Serial number: kkr2).

After specimen collection, the esophageal stump was removed by ultrasonic scalpel and taken as biopsy for frozen-section examination.

The jejunum was disconnected 15 cm distal from Treitz's ligament using the Endo-GIA stapler, the mesentery was freed, and then the distal jejunum was elevated to the esophageal hiatus above the colon.

If the resection margins were positive, the distal esophagus was resected for frozen-section examination again. Once a negative resection margin was confirmed, an end-to-side esophagojejunostomy was performed.

1) Prepare an anastomotic stoma on the jejunal side. Make a 3-cm incision 2 cm away from the jejunal stump, and dissect the seromuscular layer. Lift the mucous membrane from the seromuscular layer, and then remove the mucous membrane (Figure 1).

2) Place one suture on the center of the posterior wall of the esophagus and the center of the posterior wall of the jejunum using 3-0 absorbable suture, tie a knot, and fix the suture as a traction suture.

3) Place one suture on the center of the anterior wall of the esophagus and the center of the anterior wall of the jejunum using 3-0 absorbable suture, tie a knot, and fix the suture as a traction suture (Figure 2).

4) The assistant pulls the traction sutures outwards and turns the left wall of the anastomotic stoma into the anterior wall. Place a continuous full-thickness suture on the "anterior wall" using the right traction suture. Place 6 sutures in total about 1 cm apart, and tie a knot with the left traction suture.

5) The assistant switches to the other traction suture. The assistant pulls outwards, turning the right wall of the anastomotic stoma into an anterior wall. Place a continuous full-thickness suture on the "anterior wall" using the right traction suture. Place 6 sutures in total about 1 cm apart, and tie a knot with the left traction suture. With this, full-thickness suturing of the esophagus and jejunum is finished (Figure 3).

6) Use horizontal mattress sutures to continue suturing the seromuscular layer of the "anterior wall" with the right traction suture.

7) The assistant switches to the other traction suture. The assistant pulls outwards again, turning the left wall of the anastomotic stoma into an anterior wall. Use single horizontal mattress sutures to suture the seromuscular layer of the "anterior wall" with the right traction suture. Once done, suturing of the seromuscular layer for anastomosis is done (Figure 4).

Afterwards, completed Roux-en-Y digestive tract reconstruction using the Endo-GIA stapler, performed side-to-side jejunojunctionostomy at the choledochopancreatic branch of the proximal jejunum

50 cm away from the esophago gastric anastomotic stoma, and closed the joint opening. Lastly, closed the mesenteric hiatus of the small intestine.

#### 2.2.6. Postoperative X-ray radiography

Each patient underwent gastrointestinal radiography on the second or third day post-operatively. Each patient started drinking water after that and started eating the next day.

#### 2.2.7. Follow-up

All patients underwent follow-up on an outpatient basis or by phone until June 2019. The follow-up included the patient's oncologic prognosis and gastroscopy, abdominal CT, tumor markers, and laboratory results. The follow-up also included changes in body weight, nutritional status, eating patterns, and the frequency of meals, the occurrence of dysphagia, and the occurrence of a burning sensation over the sternum and its severity.

### 3. Results

#### 3.1. Surgery details

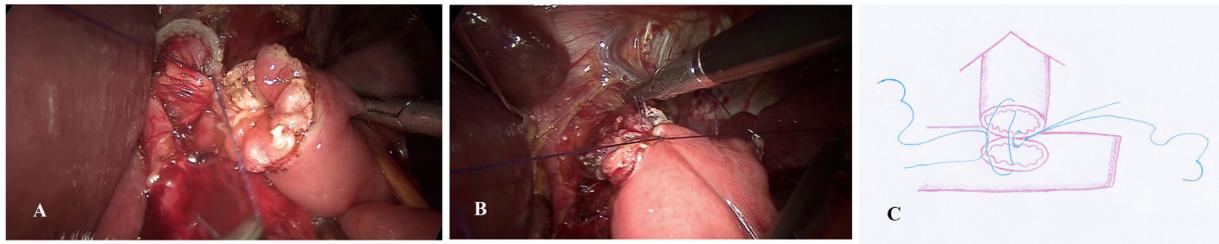
The 20 patients underwent esophagojejunostomy via the "China stitch" and TLTG. The operating time was  $216.5 \pm 24.9$  (176-254) min, intracorporeal suturing time was  $44.4 \pm 9.4$  (26-41) min, intraoperative bleeding was  $141.2 \pm 24.9$  (130-160) mL, and the number of resected lymph nodes was  $23 \pm 8$  (14-33). Patients who underwent hand-sewn esophagojejunostomy did not differ significantly from those who underwent conventional mechanical esophagojejunostomy (Table 2).

#### 3.2. Postoperative details

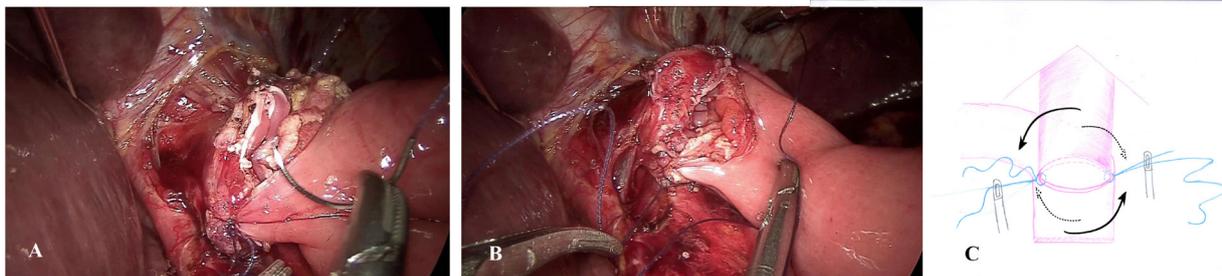
Postoperative routine gastrointestinal imaging revealed a case of anastomotic leakage, and a case of anastomotic stenosis was found about 6 months postoperatively, but there were no cases of postoperative hemorrhaging. The patient with anastomotic leakage underwent hand-sewn esophagojejunostomy since mechanical esophagojejunostomy failed. As a result, the blood supply to the anastomotic stoma was relatively poor. A drainage tube was inserted across the anastomotic stoma. Postoperative drainage was adequate without any signs of infection. After a month of conservative treatment, the drainage tube was gradually removed and the patient was discharged (Figure 5). The patient with anastomotic stenosis had a high anastomotic stoma; the upper margin of the neoplasm was 1 cm above the Z-line, and the resection line was about 4 cm above the Z-line. Therefore, the anastomotic stoma was under considerable tension. The patient experienced



**Figure 1. Prepare an anastomotic stoma on the jejunal side. A.** Make a 3-cm incision 2 cm away from the jejunal stump, and dissect the seromuscular layer. Lift the mucous membrane from the seromuscular layer. **B.** Remove the mucous membrane. **C.** Diagram of dissection of the seromuscular layer and removal of the mucous membrane.



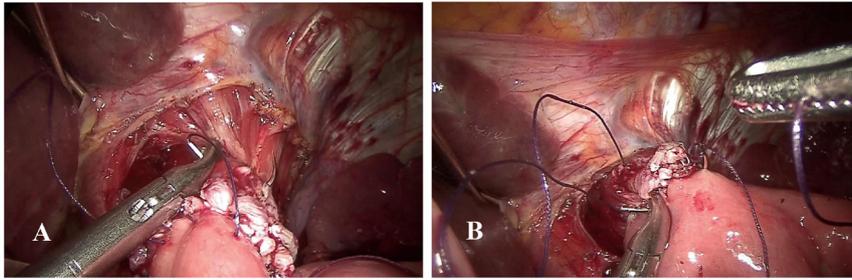
**Figure 2. Place a fixation suture on the anterior and posterior walls. A.** Place one suture on the center of the posterior wall of the esophagus and the center of the posterior wall of the jejunal stoma using 3-0 absorbable suture, tie a knot, and fix the suture as a traction suture. Remove the stump of the esophagus and perform a rapid frozen section pathological examination. **B.** Place one suture on the center of the anterior wall of the esophagus and the center of the anterior wall of the jejunum using 3-0 absorbable suture, tie a knot, and fix the suture as another traction suture. **C.** Diagram of the fixation sutures on the anterior and posterior walls.



**Figure 3. Esophagojejunostomy with full-thickness sutures all in the anterior wall. A.** The assistant pulls the traction suture outwards and turns the left wall of the anastomotic stoma into an anterior wall. Place a continuous full-thickness suture on the “anterior wall” using the right traction suture; place 6 sutures in total, and tie a knot with the left traction suture. **B.** The assistant switches to the other traction suture. The assistant pulls outwards, turning the right wall of the anastomotic stoma into an anterior wall. Place a continuous full-thickness suture on the “anterior wall” using the right traction suture. Place 6 sutures in total about 1 cm apart, and tie a knot with the left traction suture. With this, full-thickness suturing of the esophagus and jejunum is finished. **C.** Diagram of esophagojejunostomy with full-thickness sutures all in the anterior wall. The solid line is the direction of pull that rotates the stoma 90 degrees, turning the left wall of the esophagus into an anterior wall. The dashed line is the direction of pull to turn the right wall of the esophagus into an anterior wall.

**Table 2. Surgical outcomes**

Variables	China stitch group (n = 20)	Mechanical suturing group (n = 21)	P value
Lymphadenectomy			
D2 + no. 10	3	2	0.556
D2	17	19	0.716
Lymph nodes acquired	23 ± 8	24 ± 7	0.842
Total operating time (min, mean ± SD)	216.5 ± 24.9	203.2 ± 30.5	0.344
Reconstruction (min, mean ± SD)	44.4 ± 9.4	40.1 ± 5.4	0.012
Estimated blood loss (ml, mean ± SD)	141.2 ± 24.9	138.8 ± 79.9	0.934
Incision length (cm, mean ± SD)	6.6 ± 0.4	7.2 ± 1.7	0.125
Proximal margin (mm, mean ± SD)	30.6 ± 16.4	28.0 ± 19.4	0.611
Time to first ambulation (d, mean ± SD)	2.6 ± 0.8	3.0 ± 1.7	0.344
Time to first flatus (d, mean ± SD)	3.1 ± 0.8	3.2 ± 0.7	0.827
Time to resumption of liquids (d, mean ± SD)	3.1 ± 0.9	3.3 ± 1.5	0.209
Time to first liquid meal (d, mean ± SD)	4.2 ± 1.2	4.8 ± 2.8	0.650
Time to first soft meal (d, mean ± SD)	5.9 ± 2.0	6.5 ± 2.8	0.396
Postoperative hospitalization (d, mean ± SD)	8.8 ± 5.0	9.6 ± 3.9	0.042



**Figure 4. Esophagojejunostomy with suturing of the seromuscular layer all in the anterior wall.** A. The seromuscular layer of the "anterior wall" is sutured with horizontal mattress sutures using the traction suture on the right. B. The assistant switches to the other traction suture. The assistant pulls outwards again, turning the right wall of the anastomotic stoma into an anterior wall. The seromuscular layer of the "anterior wall" is sutured with single horizontal mattress sutures using the traction suture on the right. Once done, suturing of the seromuscular layer is finished.



**Figure 5. Imaging study of a patient suffering from anastomotic leakage.** A. Gastroscopy revealed that the drainage tube crossed the anastomotic stoma. B. A CT scan indicated that the anastomotic stoma was draining adequately. There was no fluid accumulation around the anastomotic stoma.



**Figure 6. Imaging study of a patient suffering from anastomotic stenosis.** A. Anastomotic stenosis was evident during gastroscopy since the gastroscope could not pass. B. A balloon expander was used to dilate the anastomotic stoma during gastroscopy. C. The anastomotic stoma after balloon dilatation.

dysphagia symptoms 6 months postoperatively, and examinations revealed anastomotic stenosis. This was alleviated using endoscopic dilatation (Figure 6).

The patients' first passage of gas via the anus occurred at  $2.6 \pm 0.8$  days (1-3) postoperatively, first liquid intake occurred  $3.1 \pm 0.8$  (3-6) days postoperatively, and the first intake of semi-liquid food occurred  $4.2 \pm 1.2$  (4-8) days postoperatively. The mean duration of postoperative hospitalization was  $8.8 \pm 5.0$  (9-13) days. Patients who underwent hand-sewn esophagojejunostomy did not differ from those who underwent conventional mechanical esophagojejunostomy in terms of complications during or after surgery. The mean follow-up was 15 (4-33) months (Table 3).

#### 4. Discussion

During most total gastrectomies, digestive tract reconstruction is still performed laparoscope-assisted, but total laparoscopic total gastrectomy has developed rapidly over the past 10 years (9). Due to its technical complexity, total laparoscopic esophagojejunostomy has always been a major challenge in TLTG (10). Currently there are no standard procedures for intracorporeal esophagojejunostomy.

For a laparoscopic esophagojejunostomy, side-to-end anastomosis can be performed with a circular stapler or side-to-side anastomosis can be performed with an Endo-GIA stapler, followed by suturing of the joint opening or

**Table 3. Comparison of complications**

Variables	China stitch group (n = 20)	Mechanical suturing group (n = 21)	P value
<b>Intraoperative Complications</b>			
Splenic ischemia	0	0	0.956
Vessel bleeding	0	1	0.943
Liver laceration due to the retractor	0	1	0.943
<b>Postoperative Complications<sup>*</sup></b>			
No complications	18	17	0.553
Grade I	0	1	0.943
Grade II	6	6	0.932
Grade IIIa	1	0	0.952
Grade IIIb	0	1	0.943
<b>Complications in detail</b>			
Anastomosis-related complications	2	3	0.758
Leakage	1	1	0.956
Stenosis	1	2	0.913
Bleeding	0	0	0.956
Intra-abdominal infection	3	4	0.843
Pancreatic fistula	0	1	0.943
Lymphatic fistula	0	1	0.943
Pneumonia	3	2	0.812
Wound infection	1	0	0.943
Overall	7	8	0.714

<sup>\*</sup> According to the Clavien-Dindo classification.

delta-shaped anastomosis (11-14). Esophagojejunostomy may also be performed using hand-sewn technique. However, this procedure is used much less often than other procedures in clinical practice because suturing the seromuscular layer of the posterior wall is difficult and a high level of suturing skill is required (7). The purpose of the current study was to devise and attempt a new hand-sewn technique for esophagojejunostomy. Traction supplied by an assistant is used to turn both the left and right walls of the esophagus into an anterior wall, avoiding the difficulty of suturing a posterior wall. The current authors look forward to the spread of this procedure.

Anastomosis techniques using a circular stapler include a manual technique, a purse-string technique, Hiki's modified stapler anvil technique (15), a stapler anvil (OrVil™) inserted trans-orally (16), and use of a reverse puncturing device (17). The rationale for circular stapler anastomosis is similar to that for open surgery, so it is easily understood by surgeons. The OrVil™ technique or the reverse puncturing device technique is most commonly used in clinical practice. The OrVil™ technique facilitates a intracorporeal circular stapling esophagojejunostomy using a stapler anvil that is inserted trans-orally. This technique has a significant advantage since it avoids the necessity of placing the stapler anvil in the abdominal cavity in the event of a high anastomotic plane. This technique is relatively easy to master. Several advantages of this technique are that purse-string sutures are not needed and that the technique is simpler. A special device is not needed to place the stapler anvil. However, the OrVil™ was designed for insertion of the stapler anvil into the esophagus via the oral cavity; this site is not aseptic, so

there is a risk of abdominal infection and oral cavity or esophageal injury (16,18). Some statistical data have indicated that the risk of postoperative anastomotic stenosis after use of a circular stapler is about 2.8% (19). In addition, expense has also limited the clinical use of this technique.

Side-to-side anastomosis techniques using the Endo-GIA stapler include the overlap method (11) and functional end-to-end anastomosis (FEEA) (20-22). These anastomosis techniques are less technically complex. They can effectively prevent the occurrence of anastomotic stenosis (23-26). However, the closure of the joint opening with the Endo GIA makes the overlap procedure easier but tends to cause stenosis. These techniques cannot completely guarantee that resection margins are negative, which runs counter to the surgical principle of removing the neoplasm. When using such a technique for reconstruction, the neoplasm should be carefully defined pre- and intraoperatively. In addition, both anastomosis techniques require a relatively long esophageal stump and are performed at a relatively low position. Thus, these techniques are limited to a benign esophageal stump with adequate length.

The hand-sewn esophagojejunostomy technique only using small instruments such as a needle holder and grasping forceps had the advantage of avoiding flaws related to use of large instruments. The hand-sewn technique is less expensive than mechanical reconstruction, and it does not require a long esophageal stump, so this technique has obvious advantages. Failed mechanical anastomosis or anastomotic stenosis resulting in an esophageal stump of insufficient length to complete mechanical reconstruction present difficulties in clinical practice.

Hand-sewn esophagojejunostomy might be the only salvage technique that can be performed with a short esophageal stump. However, this technique is technically complex and takes longer for reconstruction than other techniques, so it can sometimes only be performed by an experienced surgeon. Therefore, surgeons need more training and time to overcome the learning curve. The "China stitch" hand-sewn esophagojejunostomy technique reduces the difficulty of manual reconstruction and the time needed to perform anastomosis. It is also amenable to certain unexpected situations that might occur during the use of stapler. This was a retrospective observational study. A new technique has been explored in order to reduce operating time, to reduce the difficulty of procedure, and to enable repeated pathological examination of surgical margins.

It should be noted that this was a retrospective observational study, without patients randomized controlled in the two groups. There was probably selection bias because the patients with cancer in early stages or cancer located distal from the dentate line were tended to underwent this hand-sewn esophagojejunostomy technique when it started to be performed. Randomized controlled trails with larger series are important to evaluate its safety and effects on short-term oncological prognosis compared with mechanical esophagojejunostomy.

## 5. Conclusion

The "China stitch", a novel hand-sewn esophagojejunostomy technique for total laparoscopic total gastrectomy, is a cost-effective, safe, and effective method for reconstruction.

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