ORIGINAL RESEARCH

Laparoscopically Assisted, Tubular, Stomach Construction for the Radical Resection of Esophageal Cancer

Dingming Zhou, BM; Xin Yu, BM; Yilin Wang, BM; Feng Tang, BM; Chao Yang, BM; Dong Luo, BM

ABSTRACT

Context • Tubular esophagogastrostomy is a digestive-tract reconstruction method that has emerged in recent years. Relevant research on totally laparoscopic, tubular, gastroesophageal resections remains limited.

Objective • The study aimed to explore the clinical efficacy of totally laparoscopic, tubular, gastroesophageal resection for esophageal-cancer patients who underwent the procedure.

Design • The research team designed a retrospective study of data from clinical files.

Setting • The study took place in the Department of Thoracic Surgery at Chongqing University Three Gorges Hospital in Chongqing, China.

Participants • Participants were 199 patients with esophageal cancer who underwent totally laparoscopic, tubular gastrectomy at the hospital between January 2022 and September 2022.

Outcome Measures • The research team measured: (1) the operations' lengths, (2) intraoperative blood loss, (3) the tubular stomach's length, (4) number of staples used, (5) total amount of thoracic drainage at 2 days postoperatively, (6) length of postoperative hospital stay, and (7) postoperative hospitalization stay. The research team also determined the incidence of postoperative complications, evaluated the surgical efficacy, and evaluated participants' quality of life.

Results • A summary analysis of the data, such as chest drainage and other indicators, showed that the means of the indicators were: (1) total operation time—223.13 ± 17.34 min, (2) intraoperative blood loss—300.00 ± 30.22 mL, (3) the tubular stomach's length—34.43 ± 14.12 cm, (4) number of staples used—2.33 ± 0.9, (5) total amount of chest drainage—approximately 453.32 ± 32.44 mL over 2 days, and (6) postoperative hospitalization stay—approximately 15.43 ± 2.33 days. Regarding surgical complications out of the 199 participants: (1) three had pulmonary infections; (2) two had anastomotic leakage, (3) one had a residual gastric fistula, (4) 10 had pleural effusion, and 5 had incision infections. No participants had co-infections. At 2 months postintervention, participants' lung function was in good condition, with no reduction, and the participants were satisfied, according to self-assessments of their quality of life. No anastomotic fractures, delayed anastomotic leakage, dilatation of the chest and stomach, or reflux esophagitis occurred. No participants died or experienced a recurrence of cancer.

Conclusions • Laparoscopically assisted, tubular stomach construction has a good clinical effect in patients with esophageal cancer and is worthy of promotion. (*Altern Ther Health Med.* 2023;29(2):200-205)

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Gastric cancer remains a common cause of cancer-related death worldwide.[1] Its incidence and mortality rates are high. Likewise, esophageal cancer is a common malignant tumor. It also has a high mortality rate, with the five-year survival rate ranging from 15% to 25% worldwide.[2] Esophageal cancer's diagnosis and treatment options have gradually diversified over time. However, at present, treatment options for patients are limited, and surgery and chemoradiotherapy are the primary methods, with immunotherapy being an auxiliary for those treatments.[3,4]

The standard operation for esophageal cancer includes posterolateral thoracotomy and thoracoabdominal incisions.

Traditional, left-chest, intrathoracic anastomosis involves digestive tract reconstruction using the whole stomach instead of the esophagus. This type of operation is characterized by a short operation time and simple anastomosis, and is easily generalized.[5]

However, given the progress in surgical technologies and concepts, medical practitioners have a greater understanding of the shortcomings of use of the whole stomach over the esophagus. Because of the extensive incisions and significant trauma, these surgeries often result in slow recovery and additional complications.[6]

Kane et al found that the incidence of anastomotic leakage after standard operations is approximately 4.9%, and mortality is 3.7%.[7] A retrospective study of 7595 cases of esophageal cancer showed that the incidence of atelectasis caused by compression was 23.4%.[8] In another study with 635 patients with esophageal cancer, chest-stomach distention affected cardiopulmonary function at an incidence rate of 17.5%.[9] Akiyama et al found that the incidence of gastric juice reflux and esophagitis was 15.3%.[10] Moreover, Chen and Jiang found that anastomotic leakage, due to extensive gastric-juice generation, can lead to severe intrathoracic infection and high mortality.[11]

The stomach remains the most commonly used reconstruction organ in esophageal-cancer surgery.[12] However, due to the high incidence of complications, such as thoracogastric syndrome, reflux esophagitis, atelectasis, and pulmonary infection after total gastric replacement of the esophagus, such reconstructions have a great impact on perioperative recovery and postoperative quality of life, and surgeons have rarely performed them.[13]

Endoscopic Surgery

In recent years, the surgical method for esophageal cancer has developed rapidly, shifting from open surgery to endoscopic surgery. Clinicians have widely recognized endoscopic, minimally invasive, radical esophagectomy for its safety and efficacy.[14]

With advances in surgical technology, medical equipment, and instruments, operations using endoscopic treatments for esophageal cancer have continued to increase.[15] With the latest developments in thoracoscopic surgery, endoscopic esophagectomy has gradually shifted from endoscope-assisted small incisions to laparoscopically assisted thoracoscopic esophagectomy.[16] This modification has resulted in significantly reduced operation time and postoperative trauma.

Tubular Esophagogastrostomy

Tubular esophagogastrostomy is a digestive-tract reconstruction method that has emerged in recent years.[17] Total gastric esophageal anastomosis primarily aims to place the esophagus in the esophageal bed, but because the stomach occupies a large space in the chest cavity, this adjustment may compress the lungs and heart, resulting in the development of thoracic-gastric syndrome. Since the diameter of a constructed tubular stomach is similar to that of the esophagus, tubular esophagogastrostomy can prevent the accumulation of pressure in the chest and stomach, reduce the occurrence of gastric retention, and control the occurrence of thoracic-gastric syndrome.[18]

Wang et al found that tubular esophagogastrostomy's curative effect is more precise, and it can effectively reduce compression on the digestive system, circulatory system, and lungs; improve lung function; reduce reflux esophagitis; and improve postoperative quality of life.[19] Those researchers also found that the incidence of thoracic-gastric syndrome and anastomotic leakage in intravenous gastroesophageal stoma was significantly lower than that of total gastroesophageal stoma. However, other studies have found that patients with a tubular stomach have a higher incidence of anastomotic leakage.[20]

Ohi et al found that tubular esophagectomy and total esophagogastrostomy have similar clinical efficacy.[21] Shimakawa et al's clinical study found that patients' pulmonary function after tubular esophagectomy was significantly better than that of patients after total gastric esophagogastrostomy, indicating that tubular esophagogastrostomy can effectively reduce the negative impact on patients' pulmonary function.[22]

Lu and Ren's study on esophageal cancer found that the application of a tubular stomach can reduce the occurrence of anastomotic fistula.[23] Watanabe et al found that preserving the vascular network in the muscle layer of the stomach wall during the operation, could ensure a sufficient blood supply to the stomach wall, thereby promoting shortened healing and reducing the incidence of elongated anastomoses.[24] Another study found that tubular gastroesophageal anastomosis was better for improving the quality of life of patients.[25]

Current Study

However, relative to the current open surgery for tubular gastroesophageal resection, relevant research on totally laparoscopic, tubular, gastroesophageal resection remains limited.

The current study aimed to explore the clinical efficacy of totally laparoscopic, tubular, gastroesophageal resection for esophageal-cancer patients who underwent the procedure.

METHODS

Participants

The research team designed a retrospective study of data from clinical files. The study took place in the Department of Thoracic Surgery at Chongqing University Three Gorges Hospital in Chongqing, China. Prospective participants were patients with esophageal cancer who underwent totally laparoscopic, tubular gastrectomy at the hospital between January 2022 and September 2022.

Subjects were included in the study if they: (1) were in clinical stage I, II, IIIa, or IIIB of esophageal cancer according to Recommendations for Pathologic Staging (pTNM) of Cancer of the Esophagus and Esophagogastric Junction for the 8th edition;[26] (2) had normal liver and kidney function; and (3) had a normal coagulation function.

Subjects were excluded from the study if they: (1) were in clinical stage IIIC or IV of esophageal cancer, (2) had severe hepatic and renal dysfunction, (3) had poor lung function, and (4) had a history of abdominal surgery.

All participants signed written informed consent forms. The ethics committee of the hospital approved the study's protocols (No. 164 of Scientific Research in 2021). The research team carried out the study according to the requirements of Declaration of Helsinki.

Procedures

Data collection. The research team identified participants' ages and genders and summarized and analyzed their tumor locations, preoperative tumor stages, histological types, American Society of Anesthesiologists (ASA) grades, and other basic diseases.

Construction method for tubular stomach. Three doctors with more than 15 years of experience operated on all participants. The routine operation involves constructing a tubular stomach after gastric dissociation and before anastomosis. For that construction, the surgeon: (1) cuts off the right gastric artery from the angle of the stomach and uses a straight-line cutting stapler to treat it along a parallel direction of the stomach's greater curvature; (2) at the same time, excises the gastric wall, part of the gastric fundus, and the cardia on the lesser curvature side, and (3) makes the stomach into a tube with a diameter of 4-5 cm.

For the optimized method of constructing a tubular stomach, the surgeon: (1) stretched flat the cardia and the stomach's lesser curvature; (2) treated the cardia, the stomach's lesser curvature, and part of the gastric fundus with a linear cutting and suturing device; suturing and reinforcement occurred at the device's junction as well as the gastric wall's bleeding area; (3) sutured and strengthened the start and end of the gastric wall's cutting edge; (4) embedded the gastric wall's incision edge in a purse string; and (5) used the interrupted, large-space, folded, seromuscular layer suture to cover the gastric wall's cutting edge.

Postoperative nursing. Postoperatively, all patients fasted, received nutritional support, ate a reasonable diet, and received specialist nursing and other routine treatment.

Outcome Measures. The research team evaluated postoperative monitoring indices, determined the incidence of postoperative complications, recorded short-term follow-up observations about surgical efficacy, tested the lung function, and at baseline and postoperatively, administered the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30).[27]

Intervention

Operation. For the operation, the patient was in a supine position with the surgeon on the right side and an assistant on the left. Laparoscopic-equipment entrance (Figure 1E): (1) after the patient had received general anesthesia with conventional endotracheal intubation, placed five abdominal ports on the patient's anterior abdominal wall; (2) placed a 10-mm trocar under the umbilicus, a 12-mm trocar under the left costal margin as the main operation hole, and a 5-mm trocar on the left and right sides as the auxiliary operation holes; (3) released CO2 into the patient's abdominal cavity to form a pneumoperitoneum and maintained the intra-abdominal pressure at 12 mmHg. The dissected, left gastric artery and vein (Figure 1B): (1) isolated the left superior gastric artery, the short gastric artery, and the peritoneum covering the abdominal esophagus using an ultrasonic scalpel (Harmonic ACE36E, Johnson & Johnson, New Brunswick, NJ, USA); (2) retracted the liver's left lobe upward with intestinal forceps to expose the gastrohepatic ligament and abdominal esophagus; (3) dissociated the stomach's greater curvature with the ultrasonic scalpel; (4) cut the greater omentum to the left to the colon's splenic flexure and cut the gastric spleen, gastrophrenic ligament, and phrenoesophageal ligament; (5) dissociated the posterior wall of the stomach and cardia; (6) exposed the esophageal hiatus and diaphragm; (7) released the posterior part of the phrenoesophageal ligament and expanded the esophageal hiatus to 5 cm; (8) clamped the two ends of the left gastric artery and separated them with ligating forceps; (9) located the anastomotic site 5 cm above the tumor; the anastomotic site of the lower esophageal cancer was below the aortic arch and the anastomotic site of the middle esophageal cancer was above the aortic arch; Continuous-suture gastric cutting (Figure 1A): (1) created the gastric tube, stretching flat the stomach's cardia and lesser curvature; (2) treated the cardia, the stomach's lesser curvature, and part of the stomach's fundus with a linear cutting and closing device. The freed lower end of the esophagus and the sweeping of the lower-end lymph nodes (Figure 1C): (1) sutured and reinforced the junction of the cutting and suturing device as well as the gastric wall's bleeding area; (2) sutured and strengthened the beginning and end points of the gastric wall; (3) embedded the gastric wall's incision edge with purse string; (4) used the interrupted, large-spacing, folded, seromuscular layer suture to cover the gastric wall's incision edge. The completed surgery (Figure 1D): the lymph nodes in each group were routinely dissected. Thereafter, the surgeon attached the enteral nutrition tube to the distal part of the pylorus, approximately 15 cm, and the gastric tube to the middle and lower part of the tubular stomach and fixed it properly.

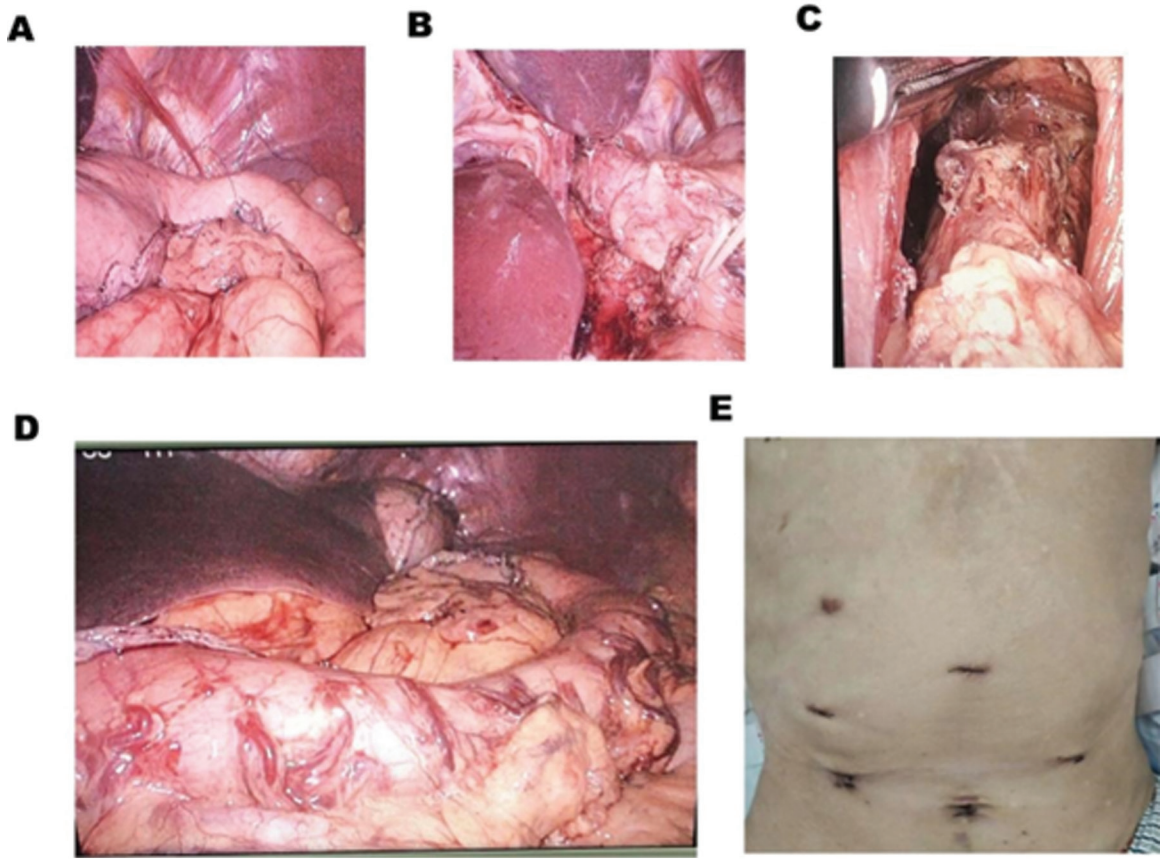
Outcome Measures

Postoperative monitoring indices. The research team measured: (1) the operations' lengths, (2) intraoperative blood loss, (3) the tubular stomach's length, (4) number of staples used, (5) total amount of thoracic drainage at 2 days postoperatively, and (6) length of postoperative hospital stay.

Postoperative complications. The research team also determined the incidence of postoperative complications: pulmonary infection, anastomotic fistula, residual gastric fistula, pleural effusion, and incision infection.

Surgical efficacy. At 2 months postintervention, the team recorded short-term follow-up observations about

Figure 1. Steps for Thoracic Surgery. Figure 1A shows continuous-suture gastric cutting; Figure 1B shows the dissected, left gastric artery and vein; Figure 1C shows the freed lower end of the esophagus and the sweeping of the lower-end lymph nodes; Figure 1D shows the completed surgery; and Figure 1E shows the laparoscopic-equipment entrance



surgical efficacy—participants' pulmonary function, quality of life, and incidence of complications, including delayed anastomotic leakage, anastomotic stenosis, thoracic gastric dilatation, and reflux esophagitis. To further clarify the intervention's impact on the long-term survival rate and recurrence rate in patients, the team followed up with all patients for 18 months, using telephone contacts.

EORTC QLQ-C30.[27] The questionnaire has five subdomains: (1) social functioning, (2) role functioning, (3) cognitive functioning, (4) physical functioning, and (5) emotional functioning. The questionnaire uses 4-point Likert-type response scales, with higher scores indicating better health.

Statistical Analysis

The research team used the Statistical Package for Social Science (SPSS) Statistics 22.0 software (SPSS Inc., Chicago, IL, USA) for data analysis. The team analyzed: (1) measurement data, statistically expressing the data as means ± standard deviations (SDs), using *t* test and analysis of variance for inter-group comparison, and count data, recorded as numbers and percentages, using chi-square test.

RESULTS

Participants

The study included and analyzed the data of 199 participants, 126 males and 73 females. Their average age was 67.32 ± 3.22 years (Table 1).

Postoperative Monitoring Indices

The mean total operation time was 223.13 ± 17.34 min, intraoperative blood loss was 300.00 ± 30.22 mL, the tubular stomach's length was 34.43 ± 14.12 cm, number of staples used was 2.33 ± 0.9, total amount of thoracic drainage over 2 days postintervention was 453.32 ± 32.44 mL, and postoperative hospital stay was 15.43 ± 2.33 days (Table 2).

Postoperative Complications

The postoperative complications included three participants with pulmonary infections, two with anastomotic leakage, one with a residual gastric fistula, 10 with pleural effusion, and 5 with incision infections (Table 3).

Surgical Efficacy

Participants' lung function was in good condition with no decreases in function, and they were satisfied with the quality of life at two months postintervention (Table 4). No participants experienced anastomotic stenosis, delayed

Table 1. Participants' Demographic and Clinical Characteristics at Baseline (N = 199)

Characteristic	Mean ± SD n (%)
Gender	
Male	126 (63.32)
Female	73 (36.68)
Age, y	67.32 ± 3.22
Tumor Location	
Upper	36 (18.09)
Middle	75 (37.69)
Lower	88 (44.22)
Preoperative Staging	
I	10 (5.03)
IIa	20 (10.05)
IIb	69 (34.67)
IIIa	68 (34.17)
IIIb	32 (16.08)
Histological Types	
Squamous carcinoma	169 (84.93)
Adenocarcinoma	30 (15.07)
ASA Classification	
1, a normal healthy patient	54 (27.14)
2, a patient with mild systemic disease	145 (72.86)
Basic Diseases	
Hypertension	26 (13.07)
Diabetes mellitus	32 (16.08)
Lacunar infarction	14 (07.04)

Note: Not all participants had a basic disease.

Abbreviations: ASA, American Society of Anesthesiologists.

anastomotic leakage, thoracogastric dilatation, reflux esophagitis, or other complications. No participants died or experienced a recurrence of cancer.

EORTC QLQ-C30

Participants' scores for social, role, cognitive, physical, and emotional functioning significantly improved between baseline and postintervention (Table 5).

DISCUSSION

The current study found that laparoscopically assisted tubular stomach construction doesn't increase the incidence of anastomotic leakage. Participants' lung function was normal after surgery.

The current research team believed that inserting the stomach catheter into the esophageal bed and embedding it can effectively reduce the space occupied by the stomach in the thoracic cavity, reduce the impact on the circulatory and respiratory systems, and prevent the occurrence of respiratory complications. The current research team long-term expectations indicate that the overlap of anastomotic calibers is 0%. We believe that the insertion of a gastroesophageal gastrostomy typically keeps the stomach enlarged by 5-8 cm, which can reduce the tension of the anastomosis.

Table 2. Surgical Outcomes of Participants Receiving the Optimized Procedure

Outcomes	Mean ± SD
Operation time, min	223.13 ± 17.34
Intraoperative blood loss, ml	300.00 ± 30.22
Length of the tubular stomach, cm	34.43 ± 14.12
Number of staples used, n	2.33 ± 0.9
Total thoracic drainage, ml	1453.32 ± 32.44
Postoperative hospital stay, d	15.43 ± 2.33

Table 3. Incidence of Postoperative Complications (N = 199)

Complication	n (%)
Pulmonary infection	3 (1.51)
Anastomotic leakage	2 (1.01)
Residual gastric fistula	1 (0.50)
Pleural effusion	10 (5.03)
Incision infection	5 (2.52)

Table 4. Participants' Long-term Effects (N = 199)

Efficacy	Mean ± SD n (%)
Lung function	
FVC%	69.44 ± 11.34
FEV1%	65.44 ± 10.28
MVV%	62.87 ± 11.45
Satisfaction with quality of life	(91.96)
Complication	
Anastomotic stenosis	0 (0.00)
Delayed anastomotic leakage	0 (0.00)
Thoracogastric dilatation	0 (0.00)
Reflux esophagitis	0 (0.00)

Abbreviations: FVC, forced vital capacity; FEV1, forced expiratory volume over 1 s; MVV, maximal voluntary ventilation.

Table 5. EORTC QLQ-C30 Score

Subscale	Baseline	Postintervention
Social functioning	46.21 ± 4.33	80.23 ± 5.32
Role functioning	56.76 ± 6.44	79.54 ± 4.32
Cognitive functioning	45.45 ± 4.86	86.34 ± 3.28
Physical functioning	60.12 ± 7.46	82.32 ± 6.32
Emotional functioning	62.18 ± 2.45	79.98 ± 3.44

Abbreviations: EORTC QLQ-C30, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire.

Furthermore, the results of this study found that laparoscopically assisted tubular stomach construction can lead to longer operation time and high consumption of high-value consumables; however, the amount of blood loss, incidence of postoperative complications, and patient satisfaction with prognosis were improved compared to the traditional operation.

The research team analyzed the advantages of laparoscopically assisted resection of esophageal cancer with a tubular stomach. The team believes that this type of operation can directly anastomose after the stomach is completely free. The remnant stomach is tubular, which is easy to construct, simplifies the operation steps, and reduces the damage to surrounding tissue. The team has made surgical improvements to the traditional procedure, which can further reduce the numbers of anastomosis and gastrostomies, reduce damage to the gastric wall, and reduce the incidence of residual gastric bleeding and fistula. In addition, because the postoperative gastric tube retention function of the patients is preserved, the incidence rates of weight loss, reflux esophagitis, and chest circumference are greatly reduced, and patient quality of life is further improved.

The current study still some limitations. It's a single-center retrospective study and the number of participants was limited. Multicenter randomized controlled trials are needed for further verification. Also, because the research team hasn't analyzed participants' tumor sites , the experimental results may not be accurate. Future studies will include this analysis.

CONCLUSIONS

The current study found that laparoscopically assisted, tubular stomach construction has a good clinical effect in patients with esophageal cancer and is worthy of promotion.

AUTHORS' DISCLOSURE STATEMENT

The authors declare that they gave no conflicts of interest related to the study.

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