Novel Laparoscopic Gastric Tubing with Pyloromyotomy for Treatment of Esophageal Cancer

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Purpose: We report on a novel method and outcomes of laparoscopic gastric tubing with pyloromyotomy.

Methods: The abdominal procedure includes laparoscopic gastric mobilization, celiac axis lymph node dissection, formation of the gastric tube, and pyloromyotomy. Between January 2009 and April 2013, our minimally invasive esophagectomy (MIE) was performed on 54 patients with esophageal cancer. The short-term outcomes, including postoperative complications, were analyzed.

Results: There were no cases of conversion to open surgery. Of 54 patients, 52 patients had squamous cell carcinoma (SCC) and two had adenocarcinoma. The total operative time was

349.8±77.4 minutes, of which 90.6±27.6 minutes was required for the abdominal procedure. The mean estimated operative blood loss during the abdominal procedure was 40.0±35.5 ml. The postoperative complication rate was 24.1%; three patients died of pneumonia.

Conclusion: Laparoscopic gastric tubing with pyloromyotomy is a feasible and safe treatment option for patients with esophageal cancer.

Key words: Esophageal cancer, Minimally invasive, Laparoscopy, Gastric tubing, Feasibility

INTRODUCTION

Esophagectomy for esophageal cancer has remained the primary treatment for patients with localized disease. In this approach, the stomach is the most frequently accessed conduit organ.¹ Open esophagectomy is frequently associated with significant morbidity and mortality, even at highly rated treatment centers. Minimally invasive esophagectomy (MIE), which is less traumatic, allows for earlier postoperative recovery, and incurs fewer complications, has, not surprisingly, attracted a great deal of interest from surgeons and researchers.² Furthermore, the enhanced visualization afforded can facilitate intraoperative procedures, alleviate blood loss, and reduce complications. In fact, as part of an effort to reduce the risks of esophagectomy, MIE has been adopted in many specialized centers. Luketich et al.³ reported a method of MIE that yielded excellent outcomes. Although laparoscopic surgery for benign esophageal diseases has become widely accepted, its application to esoph-

ageal cancer has not, as yet, been well established.

At our institute since 2009, we have been developing a novel combined abdominal-thoracic approach to the surgical treatment of esophageal cancer. In the following pages, we report the method in more detail. Additionally, we analyze the postoperative short-term outcomes of its application to the treatment of 54 patients with esophageal cancer.

MATERIALS AND METHODS

1) Patients

All of the 54 patients enrolled in the present study received, prior to neoadjuvant chemotherapy or surgery, a complete evaluation that included physical examinations, blood tests, chest and abdominal x-rays, upper gastrointestinal endoscopy, endoscopic ultrasound, bronchoscopy, chest and abdominal computed tomography, and positron emission tomography-computed tomography (PET-CT). The operative procedure entailed laparoscopic gastric tubing with lymph node dissection, followed by thoracoscopic esophageal mobilization and esophagogastric anastomosis in the thorax or neck. Chart reviews of the patients yielded clinical data on age, gender, body mass index (BMI), operation time, length of postoperative hospital stay, and postoperative complications. Approval for this study was obtained from our Institutional Review Board (IRB).

Received March 26, 2014, Revised March 20, 2014,
Accepted June 2, 2014

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2) Abdominal procedure: total laparoscopy

(1) Laparoscopic gastric mobilization: The patient was positioned in a supine split leg position, with the surgeon operating on the right, the camera assistant in the middle, and the first assistant on the left. Under general anesthesia, pneumoperitoneum was established at the umbilicus via the open technique, and an intra-abdominal pressure of 12~15 mmHg was obtained. Four ports were placed under direct laparoscopic visualization. Access to the abdominal cavity was obtained using two 5-mm laparoscopic trocars and two 12-mm trocars (Fig. 1). The liver was retracted upward using a “V-shaped liver retraction” method described previously (Fig. 2).⁴

Subsequently, first, the greater omentum was divided proximally about 4 to 5 cm from the mid portion of the right gastroepiploic arcade toward the junction of the left- and right-side gastroepiploic arcades, using an ultrasonic scalpel (Ethicon Endo-Surgery Inc., Cincinnati, OH). The left gastroepiploic and short gastric vessels were divided in order to mobilize the fun-

dus of the stomach. We then moved backward to the roots of the right-side gastroepiploic vessels. Second, the hepatogastric ligament was divided beyond the right gastric vessels to enable access to the lesser sac and to expose the right crus of the esophageal hiatus.

(2) Celiac axis lymph node dissection: The lymph nodes with fatty tissue along the anterosuperior aspect of the common hepatic artery, the celiac axis, and the proximal splenic artery⁵ were dissected along each artery using an ultrasonic dissector and a hook-type monopolar bovie (Fig. 3). The left gastric vein was divided, and the root of the left gastric artery was exposed and divided with double clipping, thereby allowing dissection of the left gastric artery lymph nodes. The perigastric lymph nodes were dissected along the upper lesser curvature up to the esophagogastric junction. The esophageal hiatus opening of the diaphragm was enlarged to facilitate exposure and smooth passage of the gastric tube.

(3) Formation of gastric tube: First, the mid portion of the lesser curvature was dissected preparatory to stapling. The first

Fig. 1. Trocar placement.

Fig. 2. Liver retraction.

Fig. 3. Lymph node dissection around celiac axis. LGA, left gastric artery; CHA, common hepatic artery; SA, splenic artery.

Fig. 4. Gastric tube formation using stapler.

Fig. 5. Pyloromyotomy using monopolar cautery.

linear endostapler 45 mm (Covidien, Norwalk, CT, USA) fired on the just above the angle of the lesser curvature. Then, one or two additional staplings were performed in a curvilinear fashion (Fig. 4). To facilitate both delivery to the chest and insertion of the circular stapler body into the tubed stomach, the stomach was not completely divided.

(4) Pyloromyotomy: In this final step, pyloromyotomy in place of pyloroplasty was performed. The pyloric ring was identified, and a 1 cm-long pyloromyotomy was performed using monopolar cautery (Fig. 5).

3) Thoracic procedure (VATS)

The patient's position was changed to left lateral decubitus and right side chest was entered. We made a 6 cm utility incision with other three or four port incisions. The operator was usually located on the patient's left side. A 10.5 mm camera port was placed in the 7th or 8th intercostal space at midaxillary line. We used 30-degree telescope. A utility incision was made along the anterior axillary line at the 5th or 6th intercostal space without division of the rib or utilization of rib retractor. A thin plastic wound protector (Applied Medical, Rancho Santa Margarita, CA, USA) was applied for easy instrumentation and for avoiding tumor contamination during specimen removal. A 5 mm port was placed below the scapular tip for the assistant. The third 10.5 mm port was inserted at the anterior axillary line of the 3rd intercostal space. Recently fourth port was inserted a little anterior side of posterior axillary line at the 5th intercostal space for assistance. After selective single lung ventilation, the azygos vein was divided using the endostapler (TriStapler, Covidien, Norwalk, CT) or 10 mm sized Hemolok. The mediastinal pleura was opened over the esophagus entirely. Esophageal dissection was performed using the Harmonic scalpel. During esophageal dissection, regional lymph nodes and soft tissue were removed from the level of thoracic inlet

to the diaphragm including recurrent laryngeal lymph nodes and subcarinal lymph nodes. The thoracic duct was routinely clipped at the possible lowest level. After the entire intrathoracic esophagus was mobilized, a single muscular purse-string suture was placed at the highest proximal esophagus using 2-0 Prolene.

The esophagus was opened longitudinally 4 to 5 centimeters below purse-string suture. Additional full length esophageal stitch was placed and tied just above proximal end of esophagotomy to prevent further upward laceration during anvil placement. A 28 mm of anvil was placed in the proximal esophagus and secured with a purse-string suture. The esophagus was divided just below the tied purse-string. The stomach was pulled into the thorax through esophageal hiatus. The esophagus and stomach were pulled out through the utility incision and takedown of specimen and final gastric tubing procedure was done extracorporeally using linear stapler leaving 4 cm opening for EEA body insertion (DST EEA 28; Tyco, Healthcare, Norwalk, CT). The stomach graft was then returned back into the thoracic cavity. A 28mm size EEA body was inserted into thoracic cavity through utility incision. Then EEA head portion was gently introduced into stomach graft through the gastric opening and spike pierced posterior upper part of the stomach. Careful coaptation of anvil and body is needed; gentle and tensionless approximation of stomach and esophagus without any interference by adjacent soft tissue. Firm and sustained squeezing of the handle can make a good intrathoracic anastomosis. Anastomotic stapled line can be observed internally with thoracoscopy. Remained stomach opening was closed with linear stapler. The anastomosis was also examined outside and a few clips were applied alongside anastomosis for later identification by x-ray. The gastric tube was positioned deep into mediastinum and incised pleura was sutured or sutured to the stomach wall for prevention of gastric bulging or elongation into pleural cavity.

4) Statistical analysis

Continuous data were expressed as the mean±standard deviation. Data analysis was performed using SPSS software (version 12.0; SPSS, Chicago, Ill).

RESULTS

As indicated in Table 1, a total of 54 patients, 49 of whom were male, were enrolled in the study. Most of the patients (96.3%) had squamous cell carcinoma (SCC); 12 (22.2%) received neoadjuvant chemoradiotherapy. Half of the patients had

Table 1. Clinicopathological characteristics of patients

Characteristics	Values (n=54)
Age, years ($\pm$ standard deviation)	65.3 $\pm$ 10.1
Sex	
Male	49 (90.7)
Female	5 (9.3)
Body mass index*	24.2 $\pm$ 3.3
Comorbidities	27 (50.0)
Hypertension	21
Diabetes	5
COPD	2
Tuberculosis	2
CVA	2
Others	5
Neoadjuvant CRRT	
Yes	12 (22.2)
No	42 (77.8)
Location of tumor	
Middle	38 (70.4)
Lower	16 (29.6)
Pathology	
SCC	52 (96.3)
Adenocarcinoma	2 (3.7)
Differentiation	
Well	5 (9.3)
Moderate	9 (16.7)
Poorly	40 (74.0)
Tumor depth	
Tis/T1	33 (61.1)
T2	8 (14.8)
T3	13 (24.1)
Examined lymph nodes	27.1 $\pm$ 14.3

*Continuous variables are presented as the mean $\pm$ standard deviation (range). SCC, squamous cell carcinoma. COPD = chronic obstructive pulmonary disease. CVA = Cerebrovascular accident.

co-morbidities such as heart disease or pulmonary issues. The perioperative data are presented in Table 2. There were no cases of conversion to open laparotomy. The mean total operative time was 349.8 $\pm$ 77.4 minutes, of which the abdominal procedure required 90.6 $\pm$ 27.6 minutes. The mean estimated operative blood loss during the abdominal procedure was 40.0 $\pm$ 355.5 ml. The mean length of hospital stay after surgery was 16.7 $\pm$ 12.8 days. The postoperative complication rate was 24.1%. There were two cases of anastomotic leakage, one case of anastomotic bleeding, and three cases of postoperative pneumonia. The three patients with pneumonia died.

Table 2. Surgical and early postoperative outcomes

Variables	Values
Total operation time (minutes)*	349.8 $\pm$ 77.4 (180~565)
Abdominal operation time (minutes)	90.6 $\pm$ 27.6 (40~185)
Blood loss (ml)*	460 $\pm$ 355.5 (50~2,200)
Number of transfused patients (%)	6 (11.1%)
Perioperative abdominal complication: n (%)	13 (24.1%)
Anastomosis bleeding	1
Anastomosis leakage	2
Pneumonia	5
Ileus	2
Intraabdominal bleeding	1
Lt. pleural effusion	1
Bronchoesophageal fistula	1
Conversion to open gastrectomy	0
Mortality	3 (5.6%)
Pneumonia	3
Postoperative hospital stay (day)*	16.7 $\pm$ 12.8 (9~92)

*Continuous variables are presented as the mean $\pm$ standard deviation (range). Mortality cases include.

DISCUSSION

Since laparoscopic cholecystectomy was first performed in 1989, laparoscopic surgery has been widely applied in patients with various gastrointestinal diseases.⁶ Laparoscopic surgery has several advantages over conventional open surgery, including lesser invasiveness, less pain, earlier recovery, and better cosmesis.⁷ This minimally invasive surgical technique has been refined in conjunction with the development of advanced surgical instrumentation, and has been applied to more complicated organ systems and disease processes. The indications of laparoscopic surgery have been extended to malignant diseases such as involve the colon, stomach, liver, and other organs and tissues.⁸ Esophageal surgeons also have increasingly incorporated minimally invasive surgery into their practices; several clinical series, in fact, have demonstrated the benefits of minimally invasive surgery in the treatment of gastroesophageal reflux disease,⁹ achalasia,¹⁰ and other benign esophageal diseases.

Although laparoscopic surgery is now a widely accepted modality for benign esophageal diseases, this is not yet the case for esophageal cancer. Interest recently, however, has been growing: a minimally invasive approach to the treatment of esophageal cancer is theoretically attractive, as it is less traumatic, allows for faster and easier postoperative recovery, and incurs fewer incision- or cardiopulmonary-related complications. Enhanced visualization, moreover, can facilitate intraoperative procedures, minimize blood loss, and reduce complications. In

1998, Luketich et al.³ reported eight cases of the minimally invasive approach to esophagectomy, including one case of total thoracoscopic and laparoscopic esophagectomy with cervical anastomosis. In the latter, combined approach, thoracoscopy was performed to mobilize the thoracic esophagus, followed by laparoscopy to prepare the gastric conduit, and finally by esophagogastrostomy performed on the neck. In 2003, Luketich et al.¹¹ published promising results for 222 consecutive patients who had undergone this treatment. The procedure was successfully completed in 93% of the patients.

Our institution developed and standardized operative techniques based on the multidisciplinary approach. The abdominal component is performed by a gastrointestinal surgeon (Song KY) with an abundance of experience in laparoscopic gastrectomy. (Laparoscopic surgery for treatment of gastric cancer, along with an effective screening system, has been well developed in Korea due to the high incidence of that malignancy among Koreans.) As is well known, the Ivor Lewis operation should include two-field or three-field lymph node dissection in cases where radical surgery is required, to which lymph node dissection around the celiac axis is critical. In this respect, extensive node dissection experience can enhance the efficacy of the abdominal component. We applied the principles and empirical record of laparoscopic gastrectomy to esophageal cancer surgery in several aspects including trocar placement, liver retraction, gastric mobilization, celiac node dissection, and stapling. We did not perform pyloroplasty but rather, pyloromyotomy. No patient experienced gastric stasis or passage disturbance, even though all had undergone total vagotomy.

For the postoperative complication, we showed reasonable rate of it. As we showed in table 2, the morbidity associated with abdominal procedure was 2 ileus and 1 intraabdominal bleeding. Only 1 patient who had a postoperative intraoperative bleeding was needed a re-operation, while others were managed conservatively.

Although we didn't show the results, the rate of complication was not different between open and laparoscopic procedure

(27.9 vs. 24.1%, respectively).

Overall, we consider that this novel method of total laparoscopic gastric tube formation and pyloromyotomy can greatly facilitate MIE.

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