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Original Article / Özgün Makale

Minimally invasive Ivor-Lewis esophagectomy for esophageal cancer

Özofagus kanserinde minimal invaziv Ivor-Lewis özofajektomi

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ABSTRACT

Background: In this study, we present our minimally invasive Ivor-Lewis esophagectomy technique and survival rates of this technique.

Methods: Between September 2013 and December 2020, a total of 140 patients (56 males, 84 females; mean age: 55.5±10.3 years; range, 32 to 76 years) who underwent minimally invasive Ivor-Lewis esophagectomy for esophageal cancer were retrospectively analyzed. Preoperative patient data, oncological and surgical outcomes, pathological results, and complications were recorded.

Results: Primary diagnosis was esophageal cancer in all cases. Minimally invasive Ivor-Lewis esophagectomy was carried out in all of the cases included in the study. Neoadjuvant chemoradiotherapy was administrated in 97 (69.3%) of the cases. The mean duration of surgery was 261.7±30.6 (range, 195 to 330) min. The mean amount of intraoperative blood loss was 115.1±190.7 (range, 10 to 800) mL. In 60 (42.9%) of the cases, complications occurred in intraoperative and early-late postoperative periods. The anastomotic leak rate was 7.1% and the pulmonary complication rate was 22.1% in postoperative complications. The mean hospital stay length was 10.6±8.4 (range, 5-59) days and hospital mortality rate was 2.1%. The median follow-up duration was 37 (range, 2-74) months and the three- and five-year overall survival rates were 61.8% and 54.6%, respectively.

Conclusion: Minimally invasive Ivor-Lewis esophagectomy can be used safely with low mortality and long-time survival rates in esophageal cancer.

Keywords: Esophageal cancer, esophagectomy, Ivor-Lewis esophagectomy, laparoscopic thoracoscopic esophagectomy, minimally invasive esophagectomy, surgical techniques.

ÖZ

Amaç: Bu çalışmada minimal invaziv Ivor-Lewis özofajektomi tekniğimiz ve bu tekniğin sağkalım oranları sunuldu.

Çalışma planı: Eylül 2013 - Aralık 2020 tarihleri arasında özofagus kanseri nedeniyle minimal invaziv Ivor-Lewis özofajektomi yapılan toplam 140 hasta (56 erkek, 84 kadın; ort. yaş: 55.5±10.3 yıl; dağılım, 32-76 yıl) retrospektif olarak incelendi. Hastaların ameliyat öncesi verileri, onkolojik ve cerrahi sonuçları, patoloji sonuçları ve komplikasyonları kaydedildi.

Bulgular: Hastaların tümünde primer tanı özofagus kanseri idi. Çalışmaya dahil edilen hastaların tümüne minimal invaziv Ivor-Lewis özofajektomi yapıldı. Neoadjuvan kemoradyoterapi olguların 97'sine (%69.3) uygulandı. Ortalama ameliyat süresi 261.7±30.6 (dağılım, 195-330) dk. idi. Ortalama ameliyat sırası kan kaybı miktarı 115.1±190.7 (dağılım, 10-800) mL idi. Olguların 60'ında (%42.9) ameliyat sırası veya erken ya da geç ameliyat sonrası dönemlerde komplikasyonlar gelişti. Anastomoz kaçağı oranı %7.1 ve pulmoner komplikasyon oranı %22.1 idi. Ortalama hastanede kalış süresi 10.6±8.4 (dağılım, 5-59) gün ve hastane mortalite oranı %2.1 idi. Medyan takip süresi 37 (dağılım, 2-74) ay ve üç ve beş yıllık genel sağkalım oranları sırasıyla %61.8 ve %54.6 idi.

Sonuç: Minimal invaziv Ivor-Lewis özofajektomi düşük mortalite ve uzun süreli sağkalım sonuçlarıyla özofagus kanseri tedavisinde güvenle uygulanabilir.

Anahtar sözcükler: Özofagus kanseri, özofajektomi, Ivor-Lewis özofajektomi, laparoskopik torakoskopik özofajektomi, minimal invaziv özofajektomi, cerrahi teknikler.

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The incidence of esophageal cancer has been increasing worldwide.[1] The five-year overall survival chance has improved, although it is still announced less so than 30%. In limited nodal disease, the five-year survival expectance is still less than 50%.[1-3] Surgical procedures continue to be the cornerstone of multimodal approaches to esophageal cancer. Despite advances in technical and perioperative patient care, the mortality rate varies from 8 to 20%.[4,5] In any gastrointestinal anastomosis group, the anastomotic leak rate, reaching approximately 11% following esophagectomy, is the highest.[6] Surgeons devote their efforts to reduce surgical incisions and acquire better recovery. Minimally invasive surgical approaches have been increasingly used in the practice of oncology. Laparoscopic/thoracoscopic esophagectomy for esophageal cancer has become extremely widespread in recent years due to its low invasiveness. In a study of Worrell et al.,[7] 13,083 patients were revised: 8,906 (68%) open and 4,177 (32%) minimally invasive esophagectomy (MIE). They suggest that has MIE improved overall survival, as well as short-term outcomes (adequacy of resection margins, improved lymphadenectomy, and length of stay).

In the present study, we aimed to evaluate the effect of minimally invasive Ivor-Lewis esophagectomy (MILE) on perioperative and oncologic outcomes in esophageal cancer management and present our technique of MILE and discuss advantages and drawbacks in the light of literature data.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at the Department of Thoracic Surgery of Ataturk University, Faculty of Medicine between September 2013 and December 2020. A total of 140 consecutive patients (56 males, 84 females; mean age: 55.5±10.3 years; range, 32 to 76 years) were admitted to our clinic for esophageal cancer and underwent MILE. Eleven patients who were considered inoperable intraoperatively and who could not undergo resection, those who used a reconstruction organ other than the stomach, and those who underwent cervical anastomosis were excluded from the study.

Data of the patients were obtained from the patient files, surgery records, endoscopy and pathology reports, positron emission tomography (PET)-computed tomography (CT) reports and images, and outpatient clinic records. Age, sex, symptoms, smoking habits, accompanying diseases, laboratory findings, endoscopic location of the tumor, pathological type and stage, type and duration of surgery, amount of intraoperative bleeding, hospital stay, morbidity, mortality, complications, and survival rates were noted. The determination of survival was made by querying the records of the Population Department using identification numbers and calling the phone numbers registered in the system.

Surgical technique

Our minimally invasive technique for Ivor-Lewis esophagectomy (ILE)

Abdominal Phase: Preferably in patients placed in a slight reverse Trendelenburg position, three or four trocars can be placed in the abdominal part of the surgery that contains a tubular gastric conduit creation, and lymphadenectomy. Diagnostic laparoscopy for staging is the first step. Controls should be made for peritoneal tumor spread, ascites, adjacent organ, and lymph node metastases before placing all ports. The celiac lymph node is checked by opening the gastrohepatic omentum. In case of suspected metastasis or lymph node enlargement, biopsy and histopathological examination with frozen-section are performed. Before starting gastric mobilization, the left triangular ligament can be cut and the left lobe of the liver can be gently retracted upwards and to the right. A nasogastric catheter is placed into the stomach, allowing it to move along the greater curvature and its tip to the pylorus. Ease of holding the stomach is achieved. The dissection begins at the pyloric antrum level by opening the gastrocolic omentum. Care is taken not to injure the right gastroepiploic artery. Exposing the second part of the duodenum is achieved by releasing the proximal transverse colon attachments from the retroperitoneum and the liver. A Kocher's maneuver is done routinely, making it easier for the pylorus to retreat into the diaphragmatic space. The greater curve is mobilized by dividing the short gastric vessels and the gastrocolic omentum moving toward the left crus. Difficulties in revelation can be reduced by adjusting the patient's position by adjusting the table. Getting the patient position left side up would facilitate the process and make a space between the spleen and stomach for clear visualization of the short gastric vessels and reduce possible stomach injury secondary to traction. Short gastric vessels are divided by cutting the gastrosplenic ligament with the energy device. A vascularized omental flap is formed to later act as a support for intrathoracic anastomosis. The left gastric artery and vein can be dissected with an energy device by placing a Hem-o-Lok clip at both ends, or vascular staplers can be used (Figure 1). Celiac lymphadenectomy is completed. The small curvature of the stomach is mobilized. The right gastric artery

is spared, if possible. The gastrohepatic ligament is released moving to the right crus. The esophagus is, then, lifted off its bed by sharp dissections and the gastroesophageal junction is circumferentially released. The hiatus is enlarged without dissecting the crus. If the hiatus is too small, the lateral part of the left crus is dissected with the energy device and the hiatus is enlarged (Figure 2). The gastric conduit preferably about 4 to 5-cm wide is created and 4-cm near to the pylorus by the laparoscopic linear stapler (Figure 3). We do not prefer pyloromyotomy or pyloroplasty, unless there is any indication.

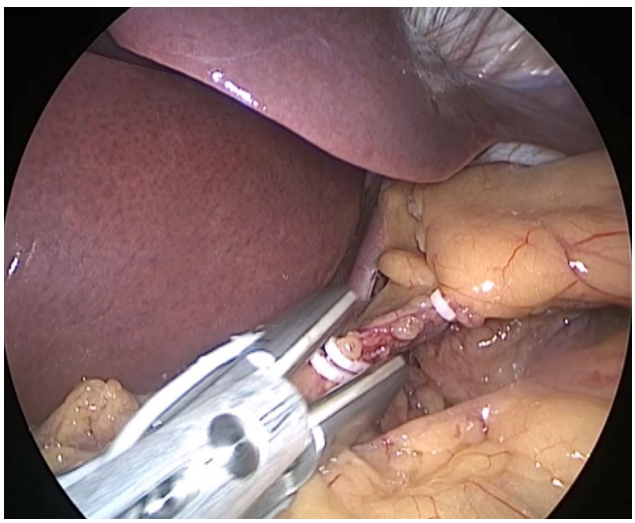

Figure 1. After clamping from the proximal and distal ends of the left gastric artery and vein by clips, its division is seen by an energy device.

Thoracic phase: Esophageal resection, mediastinal lymphadenectomy, and esophagogastrostomy are performed in the thoracic part of the case. The patient is placed in a well-supported and padded left lateral decubitus position on the table. Single lung ventilation is performed through a double-lumen endotracheal tube. For the right-side video-assisted thoracoscopic surgery (VATS), despite the commonly used five ports, a 5-cm utility incision is opened in the lateral fifth intercostal space. Two 10-mm trocars are placed in the eighth and ninth intercostal space. The inferior pulmonary ligament is divided up the inferior pulmonary vein level and the lung is moved on the anterior side. The mediastinal pleura is opened and the esophagus is mobilized circumferentially. The azygous vein is tied and divided using XL Hemoclips. Care is taken against recurrent laryngeal nerve damage at the upper level. The subcarinal lymph node should also be removed, taking care not to damage the tracheobronchial wall. The proximal esophagus is divided with a linear stapler at least 5 cm from the tumor (Figure 4). The stomach is pulled through the dilated hiatus into the thorax with gentle traction, taking care not to undergo torsion. The specimen is extracted and forwarded for a pathological negative margin confirmation. The 25-mm OrVil™ (Covidien, Minneapolis, MN, USA) is sent orally and crossed through the esophageal stump by a small opening that is formed at the staple line or next to it, leaving the anvil in place. A gastrotomy is made at the proximal end of the gastric conduit. The stapler line at the tip of the gastric conduit is removed by Ligasure® Vascular Sealing System (Medtronic, Minneapolis, MN, USA). The head of the circular stapler 25 mm DST XL EEA (Covidien, Minneapolis, MN, USA) is

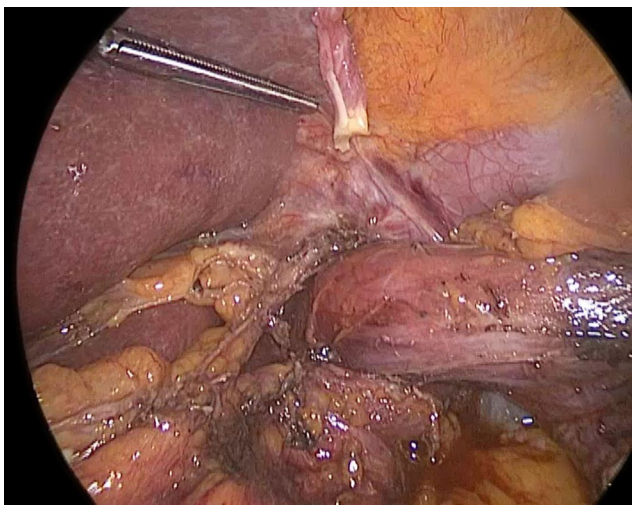

Figure 2. Circumferential hiatal dissection is shown.

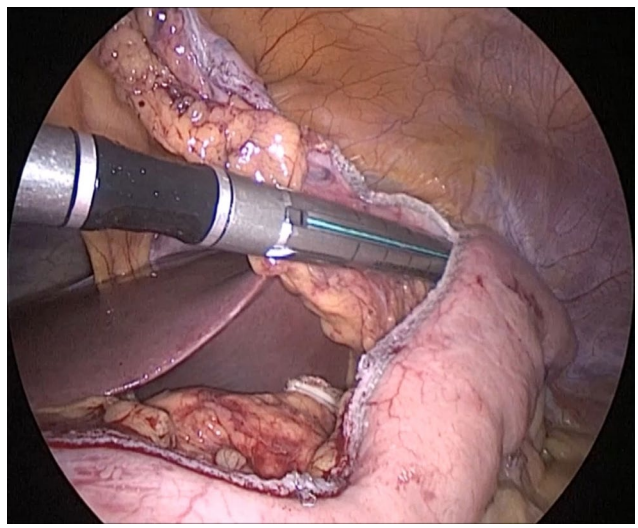

Figure 3. The tubing of the stomach is seen by linear staplers.

inserted along the thoracic incision into the proximal gastrotomy. Esophagogastric anastomosis is provided with the help of an anvil placed transorally (Figure 5). Before closing the gastrotomy, a nasogastric tube is moved through anastomosis in direct sight. Gastrotomy is closed by linear staplers (Figure 6). By placing physiological saline in the mediastinum, compressed air is given through the nasogastric catheter and, thus, the anastomosis is controlled. After confirming that there is no leak, the anastomosis area and the gastric stapler line are supported by covering the previously mentioned omental flap on them. To prevent the conduit torsion, two sutures are placed from the conduit to the mediastinal pleura.

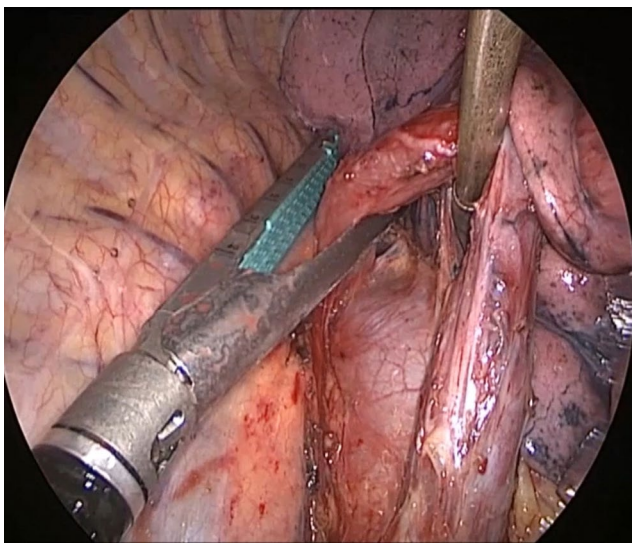

Figure 4. The division of the esophagus from the proximal to the linear stapler is shown.

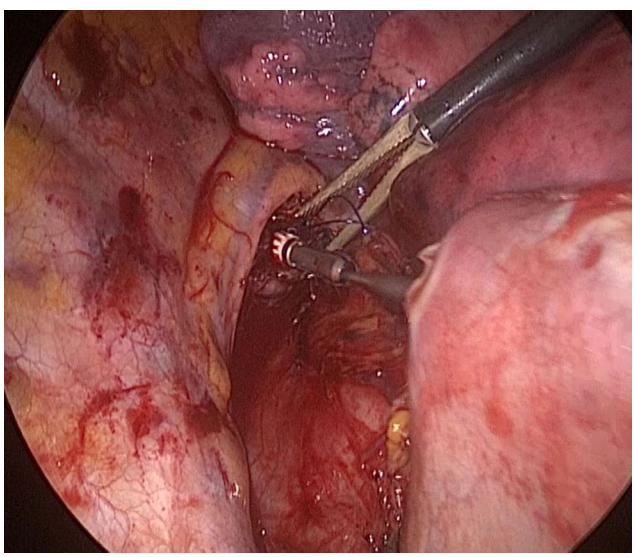

Figure 5. It is shown that the pointed end of the stapler, which is taken out from a point above the gastroepiploic arch, is carefully seated inside the anvil.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD), median (interquartile range [IQR]) or number and frequency. The normal distribution of continuous variables was analyzed using the Shapiro-Wilk test. The survival of the patients according to the stages was performed by the Kaplan-Meier method for survival analysis. A p value of <0.05 was considered statistically significant.

RESULTS

Total MILE was used in all of the patients included in the study. In our study, tumors with one-third lower thoracic and esophagogastric junction involvement were frequent (75%). Localization in the mid-thoracic esophagus was detected in 35 (25%) patients. In 113 (80.7%) patients, a preoperative epidural catheter was inserted and intramuscular analgesia was performed, 27 (19.3%) of them were used patient-controlled analgesia devices and intramuscular anesthesia was performed in the postoperative period. The LigaSure® Vascular Sealing System was used in each patient. The mean operation time was 261.7±30.6 (range, 195 to 330) min. The mean intraoperative bleeding amount of the patients was 115.1±190.7 (range, 10 to 800) mL.

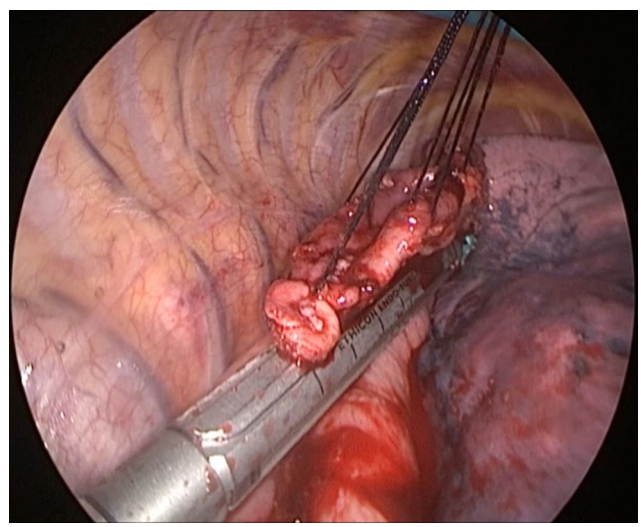

Figure 6. After esophagogastric anastomosis, the closure of the gastrotomy line by a linear stapler is shown.

In addition, MIE intrathoracic anastomosis was performed in all 140 patients. Four ports were used in almost all patients in our study during the laparoscopy stage. Three ports were used in the laparoscopy stage in only seven patients. The tubing of the stomach was performed with an average of four 60-mm thick tissue endo GIA™ staplers, depending on the patient. Although circular esophageal staplers of 25 mm or 28 mm were generally used in esophagogastric anastomoses, linear staplers were used in 14 patients. The stomach was used for reconstruction in all patients who underwent esophagectomy. A 28-mm circular stapler was used in 76 patients, and a 25-mm oral anvil was used in 50 patients. In 14 patients, a side-to-side anastomosis technique was conducted using a linear stapler.

In histopathological classification, 110 (81.4%) patients had squamous cell carcinoma, 15 (10.7%) patients had adenocarcinoma, eight (5.7%) patients had adenosquamous cell carcinoma, five (3.6%) patients had neuroendocrine carcinoma, one patient Signet ring cell carcinoma and one patient had poorly cohesive adenocarcinoma. Tumor segment length in the resection material varied between 1 and 7 cm. Tumor segment length was shorter than 5 cm in 125 (89.3%) patients and 5 cm or more in 15 (10.7%) patients. While lymph node metastasis was seen in 19.13% in cases with tumor segment length less than 5 cm, lymph node involvement rate was 45.45% in patients with a tumor segment length of 5 cm and above. In our cases with tumor segment length over 5 cm, lymph node metastasis was approximately two times higher than in cases with segment length below 5 cm. In our study, the mean removed lymph node number was 19.8±8.1 (range, 10 to 58) in our patients who were operated for esophageal cancer.

The staging was done according to the 8th edition of the American Joint Committee on Cancer (AJCC) and Union for International Cancer Control Cancer (UICC) Staging Book, using postoperative pathology reports. In 31 (21.1%) of the cases, lymph node involvement was positive. In the pathological staging of our patients who underwent MIE, 26 (18.6%) patients were evaluated as Stage 0, 33 (23.6%) patients as Stage 1, 45 (32.1%) patients as Stage 2, and 36 (25.7%) patients as Stage 3. The R0 resection rate was 97.1% (136/140), with negative margins on the final pathological review. Adjuvant radiotherapy and chemotherapy were given to patients found to be R1.

Complications developed in 60 (42.9%) patients in the intraoperative, early postoperative, and late postoperative periods (Table 1). The pulmonary complication rate was 22.1% in postoperative complications. The most common complications in the early postoperative period were anastomotic leakage in 10 (7.1%) patients, empyema in eight (5.7%) patients, wound infection in eight (5.7%) patients, contralateral hydrothorax in 10 (7.1%) patients, a cardiac complication in five (3.6%) patients and gastric dilatation was observed in nine (6.4%) patients. Since pneumothorax developed due to the opening of the left pleura in four (2.9%) patients, a chest tube was applied to the left hemithorax intraoperatively.

The most mortal complication was anastomotic leaks that occurred in the early postoperative period. Broad-spectrum antibiotics were initiated in all patients who developed an anastomotic leak. Irrigation with saline was applied orally. Total parenteral nutrition was started. In two of our patients, the fistula was closed thoracoscopically in the early period. The fistula in the stomach line in one and the anastomosis in the other were closed thoracoscopically. One patient

Table 1. Complications

	n	%
Intraoperative complications		
Colon perforation	1	0.71
Vena azygos injury	1	0.71
Left main bronchus perforation	1	0.71
Thoracic duct damage	1	0.71
Liver injury	1	0.71
Early postoperative complications		
Anastomotic leak	10	7.14
Empyema	8	5.71
Wound infection	8	5.71
Contralateral hydrothorax	10	7.14
Cardiac complications	5	3.57
Stomach dilation	9	6.43
Respiratory failure	3	2.14
Sepsis	2	1.42
Bleeding	2	1.42
Pneumothorax (left parietal pleura opening)	4	2.86
Renal dysfunction (acute renal failure)	1	0.71
Neurological disorder (delirium)	1	0.71
Cytomegalovirus retinitis	1	0.71
Late postoperative complications		
Anastomotic stricture	9	6.43
Hiatal hernia	10	7.14
Ileus	1	0.71

with anastomotic leak were repaired by thoracotomy. An esophageal stent was placed in four patients. In one patient, an esophageal stent was placed and a jejunostomy was performed in the same session. The other two patients who developed anastomotic leakage were followed. At the end of the observations, the anastomotic leak was closed in seven patients. Three of 10 patients who developed anastomotic leak died on Days 11, 44, and 59, respectively.

The mean hospital stay was 10.6±8.4 days (range, 5 to 59). There was no intraoperative mortality. The overall hospital mortality rate was 2.1% (3/140). The cause of mortality was anastomotic leakage in all three patients, and two of the cases were males and the other was female. All three patients had diabetes and hypertension. Two patients who died were in Stage 3A and the other one was in Stage 1A. Thirty-three (23.6%) patients received adjuvant chemotherapy after esophagectomy. Adjuvant chemotherapy was given to the following patient groups: patients with Stage 2 and above who did not receive neoadjuvant therapy, those with reported pathological lymph nodes after surgery, and patients with R1.

The most common complication in the late postoperative period was anastomotic stenosis. Three of nine patients who developed anastomotic stricture were males and six were females. All patients were successfully treated with dilatation. A temporary metallic stent was applied to one patient.

The second most common complication in the late postoperative period was hiatal hernia. A hiatal hernia was observed in 10 patients who underwent MIE. Surgery was planned for patients with hiatal hernia. One of the patients did not accept the surgical procedure to be performed. Laparoscopic primary repair of the diaphragm was performed in five patients. In two, primary repair of the diaphragm was achieved by laparotomy. Laparotomy + primary diaphragm repair + partial colectomy procedures were performed in one. In another, laparotomy + left utility thoracotomy + primary diaphragm repair + jejunum resection + ascending colon and transverse colon resection procedures were applied.

Follow-up

The patients were evaluated by our clinic after discharge. Follow-up consisted of evaluations every three months in the first year. In the second and third year, it was done every six months. During the fourth and fifth years, annual visits were held. The median follow-up was found as 37 (range, 2 to 74) months. In survival analysis, 10 patients were excluded. Seven of them were excluded, as they were out of follow-up. Three of them were excluded for perioperative mortalities. A total of 130 cases were analyzed for overall survival using the Kaplan Meier method. The mean three- and five-year overall survival rates were 61.8±5.0% (95% confidence interval [CI]: 51.2-71.8%) and 54.6±5.1% (95% CI: 45.1-69.9%). The mean survival time was 31.5±2.0 (range, 1 to 74) months.

DISCUSSION

Epidemiological studies have shown that esophageal cancer is seen in the eight place among all cancers in the world and it is in the sixth place in the causes of death from cancer.[8] It constitutes 1.5 to 2% of all cancers and 5 to 7% of gastrointestinal system cancers.[9,10] Esophagus and stomach cancer are most commonly seen in the Eastern Anatolia region in Türkiye and cause a high rate of death.[11,12]

The main treatment of esophageal cancer is surgical treatment. The surgical method to be chosen gains importance in terms of postoperative morbidity and mortality. Minimally invasive techniques have evolved significantly in the last decade. Similar to the explanations of DePaula et al.,[13] Swanstrom and Hansen,[14] laparoscopic approaches were used in all of the first cases. They recently switched to the laparoscopic-thoracoscopic McKeown technique (thoracoscopic esophageal mobilization, laparoscopic gastric tubing, and cervical anastomosis). A few technical lacks of the laparoscopic transhiatal technique have been resolved with this approach, including a more complete mediastinal lymphadenectomy and better visualization of perioesophageal tissues. The authors conducted more than 500 esophagectomies by the modified McKeown and it was shown to reduce perioperative mortality and morbidity compared to many open series.[15] The major technical issue with the modified McKeown MIE may be recurrent laryngeal nerve damage associated with cervical dissection. Postoperative dysfunction in swallowing can be seen after cervical dissection, even if there is no recurrent nerve damage. Anastomotic stenosis and anastomotic leak occur more frequently in open series using cervical anastomosis.[16]

These concerns have led the authors to a new experience with a purely thoracoscopic-laparoscopic ILE. Avoiding cervical dissection has increased the interest in MILE, as it minimizes the rate of recurrent laryngeal nerve injury to almost zero. Swallowing dysfunction and pharyngeal passage can also be improved by intrathoracic anastomosis.[17]

Luketich et al.[18] published their experience by performing more than 1,000 MIEs over 15 years. Elective, modified McKeown MIE was conducted in 481 cases and MILE was performed in 530 patients. Until 2006, the approach preferred by the authors was MILE. Therefore, MILE was performed in the majority of patients in the last five years of the study period. The median length of hospital stay (eight days) and median length of stay in the intensive care unit (two days) were similar between the two techniques. The median number of lymph nodes resected was 21. Operative mortality rate was 1.7%. Mortality, morbidity, lymph node removal, and cancer outcomes were better or comparable than most announced series of open esophagectomy. The MILE group had both a significantly lower operative mortality rate (0.9% at 30 days) and a lower incidence of recurrent nerve injury (1%) than the modified McKeown MIE group.

Colon perforation (0.71%), vena azygos injury (0.71%), left main bronchus perforation (0.71%), thoracic duct injury (1.42%), and liver injury (0.71%) mediastinal hematoma (0.71%) were unexpected intraoperative complications seen in our study. Complications seen in the study of Luketich et al.[18] were myocardial infarction (1%), bleeding (1%), and splenectomy (0.2%).

The advantages of cervical anastomosis are mainly proximal resection margin and lower morbidity related to a potential cervical anastomotic leak. The intrathoracic anastomosis has lower tension, the chance of removal of the ischemic end in potential gastric ischemia, lower anastomotic leak rates, and a lower incidence of recurrent laryngeal nerve injury.[19] In one of the large series, Schröder et al.[20] performed open esophagectomy in 181 patients and hybrid MIE (laparoscopy + thoracotomy) in 238 patients in their study of 419 cases. The rate of anastomotic leakage was found to be 9.4% in patients who underwent open esophagectomy and 7.6% in patients who underwent hybrid MIE. Lee et al.[21] applied open esophagectomy to 64 patients, hybrid MIE (laparotomy + thoracoscopy) to 44 patients, and cervical anastomosis MIE to 30 patients in their study. The cervical anastomosis of the MIE group was made similar to the one performed in open surgery. In this study, they reported anastomotic leak rates as 28% in open esophagectomy, 18% in hybrid MIE, and 6.7% in neck anastomosis MIE. The explanation for the difference in anastomotic leakage rate between the total MIE group and the hybrid MIE group or open group is not fully known. However, these rates show that MIE is preferable to open esophagectomy. In our study, the anastomotic leak rate was found to be 7.1% in patients who underwent MILE with thoracic anastomosis.

The feasibility and safety of MIE have been shown by many studies and meta-analyses. In the comparative analysis of open esophagectomy with MIE published by Nafteux et al.,[22] the rate of pulmonary complications was reported as 26.2% in patients who underwent MIE with cervical anastomosis, while this rate was 46.5% in patients who underwent open esophagectomy. In a prospective study of Lee et al.,[21] the pulmonary complication rate was 30% in patients who underwent open esophagectomy, 20% in patients who underwent hybrid MIE (laparotomy + thoracoscopy), and 6.7% in patients who underwent neck anastomotic MIE. In our study, the rate of pulmonary complications was 22.1% in patients who underwent MILE.

In the comparative analysis of open esophagectomy with MIE by Nafteux et al.,[22] the cardiac complication rate was reported as 12.9% in patients who underwent open esophagectomy and 16.9% in patients who underwent MIE with cervical anastomosis, and there was no significant difference between the two applications (p=0.47). However, Luketich et al.,[18] in their study conducted at the University of Pittsburgh for 15 years, investigating more than 1,000 MIE, reported the rate of cardiac complications as 6% in the MIE group with cervical anastomosis and 4% in the MIE group with thoracic anastomosis. In our study, cardiac complications developed in five (3.6%) patients, four of which were atrial fibrillation and one was pericardial effusion.

Dantoc et al.[23] conducted a meta-analysis investigating oncological outcomes and five-year mortality in open esophagectomy group against MIE. This review includes 17 case-control studies with 1,586 patients. The number of lymph nodes removed was significantly higher in the MIE group (median 16 nodes in MIE, median 10 nodes in open group; p=0.03). Five-year survival rates were similar (p=0.33), 12.5 to 63% in the MIE group and 16 to 57% in the open esophagectomy group. The authors concluded that the oncological results provided by the MIE were identical to those undergoing open esophagectomy. Berger et al.,[24] in their study consisting of 118 patients, showed that the oncological efficacy could be improved by increasing lymph node removal in MIE by comparing the number of lymph nodes removed in MIE with open esophagectomy. In this study, the median number of lymph nodes removed in patients who underwent open esophagectomy was nine,

while it was 20 in patients who underwent MIE, indicating a statistically significantly higher number ($p<0.0001$). In our study, the mean number of lymph nodes removed was 19.8±8.1.

In the Luketich et al.'s[18] large-scale MIE series consisting of 1,011 patients, the median length of hospital stay was reported as eight days in patients who underwent MIE with cervical anastomosis and seven days in patients with thoracic anastomosis. In our study, the mean length of hospitalization was 10.6±8.4 (range, 5 to 59) days in patients who underwent MIE. Based on these results, shorter hospital stay was observed in the MIE group compared to the open esophagectomy group. The morbidity of MIE appears to be similar to or better than open esophagectomy in published series.

Zingg et al.[25] reported that the hospital mortality rate was 6.1% in patients who underwent open esophagectomy, and 3.6% in patients who underwent hybrid MIE (laparotomy + thoracoscopy) and MIE with thoracic anastomosis in their study comparing open esophagectomy and MIE. In the large series of 419 cases by Schröder et al.,[20] the hospital mortality rate was 6.1% in patients who underwent open esophagectomy, while hospital mortality was 2.9% in patients who underwent hybrid MIE (laparoscopy + thoracotomy). Baker et al.[26] performed hybrid MIE (laparoscopy + thoracoscopy) to all 109 patients in their study. In this study, 30-day mortality rate was reported as 1.8% and hospital mortality rate as 2.7%. In our study, 30-day mortality rate was 1.43% and hospital mortality rate was 2.14%. These studies suggest that MIE is reliable and applicable.

Zingg et al.,[25] in their study comparing open esophagectomy and MIE, reported the mean survival time as 29 months in patients who underwent open esophagectomy and 35 months in patients who underwent MIE. In a prospective study of Lee et al.,[21] the median survival time was reported as 32.2 months in patients who underwent open esophagectomy, while the median survival time in patients undergoing MIE was reported as 33.0 months. In a recent study working on trends in the use and outcomes of open esophagectomy and MIE, Lazzarino et al.[27] showed an exponential increase in MIE performance in England and better one-year survival in patients who underwent MIE. In our study, the mean survival time was 31.5±2.0 months.

Our experience has shown that LTE can be performed with acceptable mortality and morbidity, compared to the most recently published series.[18,20,22,23] The three- and five-year overall survival rates in our study were 61.8% and 54.6%, respectively. The three- and five-year overall survival rates found in our study are similar to or better than the results of the most recent minimally invasive or open esophagectomy series.[18,22,26-29]

In our practice, we prefer MILE whenever possible, particularly in middle and lower esophageal cancers. We believe that we can obtain adequate proximal and distal margins without anastomotic tension. In the MILE approach, we can directly dissect the esophagus, provide safe hemostasis, perform sensitive lymph node dissection, and wrap the omental flap around the anastomosis. By avoiding the cervical approach with this method, we reduce the laryngeal nerve injury risk and the postoperative aspiration risk.

It is necessary to pay attention to the following important technical points about MILE. Although the risk of bleeding is less than open surgery, there may also be severe bleeding that can be converted to open surgery. There may be bronchial injury during lymph node dissection. Chylothorax can be seen with injury to the ductus thoracicus during the mobilization of the esophagus. To preserve the vitality of the gastric tube, protection of the epiploic arch, not widening the hiatus too much to prevent hernias, and not rotating the stomach before anastomosis are the conditions that should be considered. Care should be taken against anastomotic leakage that may occur postoperatively. Close follow-up should be continued in terms of cardiopulmonary complications. Postoperative early gastric dilatation indicates that the nasogastric tube is not working. In this case, the nasogastric tube should be activated. It is important to prevent malnutrition. On postoperative Day 3, feeding is started through the nasogastric tube to gain intestinal functions. The delayed gastric emptying process should be managed well, and the dilatation option should be considered in cases of stricture. Reflux symptoms should be relieved by appropriate medical treatment and regulation of dietary habits.

The limitation of this study is its retrospective nature without a control open esophagectomy group or randomization. The strength of this study is the length of follow-up, excellent three- and five-year overall survival, and technical details related to the procedure.

In conclusion, esophageal cancer is an endemic disease in our region. Esophageal cancer surgery is difficult and progresses with serious complications. Many techniques have been applied to minimize these complications. Appropriate patient selection

and the experience of the surgical team are critical to optimizing results, while applying these techniques. It is important to apply new techniques such as minimally invasive esophagectomy systematically and carefully. In this study, we presented the effectiveness of MILE in esophageal cancer in the light of the literature and showed that it was safe and preferable with low mortality, low morbidity, short operation time, and a short stay in hospital. Minimally invasive Ivor-Lewis esophagectomy can be safely achieved by experienced surgeons in high-volume centers. Multicenter studies to be done soon would further support in defining the advantages of minimally invasive Ivor-Lewis esophagectomy.

Ethics Committee Approval: The study protocol was approved by the Ataturk University Faculty of Medicine Ethics Committee. IRB approval number is 02.25.2016/15. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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