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Challenges in total minimally invasive esophagectomy procedures; Our single center initial experiences

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ABSTRACT

Introduction: We aimed to retrospectively evaluate the first period patient portfolio and surgical outcomes, difficulties in operations, morbidity, and early mortality rates in minimally invasive esophagectomy procedures in a clinic with high experience in gastrointestinal minimally invasive surgery.

Materials and Methods: The records of fifteen esophageal cancer patients who underwent minimally invasive laparoscopic/robotic-thoracoscopic esophagectomy between November 2019 and July 2024 in our Gastroenterology Surgery Clinic were retrospectively reviewed.

Results: The mean age of the patients was 61.2 (42-74) years. Ten patients (66.6%) were male, and five patients (33.3%) were female. The tumor locations were 1 (6%) in the upper esophagus, 5(36%) in the middle esophagus, and 9 (60%) in the lower esophagus. Eleven (73.4%) patients were operated on laparoscopically-thoracoscopically, and four (16.6%) patients were operated on robotic-thoracoscopically. Total esophagectomy - cervical anastomosis (McKeown) was performed in 13 (86.6%) patients. Subtotal esophagectomy - intrathoracic anastomosis (Ivor Lewis) was performed in 2 (13.4%) patients. Two patients with intrathoracic anastomosis were in the laparoscopy group.

The mean operation time was 280.53(180-464) minutes. The mean intraoperative bleeding was 200.33 (50-550) ml. The mean intensive care unit (ICU) stay was 3.26(1-27) days, and the mean ward stay was 7.26 (0-11) days. One (6%) of our patients followed up in the ICU in the early postoperative period resulted in mortality.

Conclusion: We believe that in clinics experienced in gastrointestinal system (GIS) and minimally invasive surgery, sufficient experience can be achieved with smaller patient series in the transition to minimally invasive esophagectomy.

Keywords: Esophageal cancer, laparoscopic-robotic-thoracoscopic surgery, minimally invasive esophagectomy

Introduction

Esophageal cancer is an overwhelming disease, ranking 7th in cancer incidence worldwide and 6th in overall cancer-related mortality, and its incidence is increasing.[1] Although squamous cell carcinoma (SCC) of the esophagus is the most common histologic type worldwide, there has been an increase in the incidence of adenocarcinoma (AC) of the esophagus in Western countries in recent decades (partly due to the increasing prevalence of obesity).[2] In addition, in the United States, the in-

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cidence of adenocarcinoma (AC) arising from Barrett's esophagus (BE) has been increasing dramatically over the past few years.[3]

Multimodal therapies (chemotherapy, radiotherapy, immunotherapy, surgery) are often required to treat esophageal cancer patients. However, surgical resection remains the cornerstone in the management of early and locally advanced esophageal cancer.[4] Esophagectomy is a challenging operation that requires specific surgical techniques and extensive anatomical knowledge of the various surgical fields (abdomen, chest, and neck). Since its introduction in the early 1990s, minimally invasive esophagectomy (MIE) has been adopted by many centers due to its lower postoperative complication rates and better quality of life compared to the traditional open approach.[5] However, MIE is still technically complex (two-dimensional vision, flat non-articulating instruments, limited mediastinal surgical field, limited intracorporeal movements) and is associated with high morbidity rates.[6] Robotic surgery has well-known advantages over open and conventional MIE (laparoscopic and thoracoscopic surgery), facilitating more precise surgical dissection.

The choice of the type of surgery to be performed is decided by determining the extent of tumor resection and planned lymph node dissection depending on the location of the tumor. In addition, the performance of the patient and especially the experience of the surgeon are very important for esophageal tumor surgery. However, the randomized, controlled TIME study revealed that thoraco-laparoscopic total minimally invasive esophagectomy causes fewer pulmonary and cardiovascular complications than open surgery.[7]

Laparoscopic or robotic preparation of the gastric tube and thoracoscopic (laparoscopic-robotic) total or near-total esophagectomies are becoming increasingly common. In total esophagectomies, cervical anastomosis was performed through a cervical incision, while intrathoracic anastomosis was performed in near-total esophagectomies.

In this study, we aimed to share the first-term results of minimally invasive esophagectomy surgery performed in patients with esophageal tumors in our clinic, which is experienced in gastrointestinal surgery, the difficulties we encountered, and the management of complications in light of current literature.

Materials and Methods

We retrospectively analyzed the data of fifteen esophageal cancer patients operated on using the minimally invasive esophagectomy technique between November 2019 and July 2024 in our Gastroenterology Surgery Clinic.

Demographic and clinical characteristics were recorded for all patients (Table 1).

Patients were evaluated for treatment options by a multidisciplinary tumor board. The American Joint Committee on Cancer (AJCC) 8th edition TNM staging system by Amin et al.[8] was used for clinical staging. Patients with T2-4 and/or node-positive, M0 esophageal cancer were included in the study. Siewert type two patients and patients with previous esophageal surgery were excluded. The Group Performance Status Scale (ECOG PS) was used to evaluate the performance status of the patients,[9] and patients with ECOG PS 0, 1, or 2 were included. All patients received preoperative chemotherapy (CT) and/or radiotherapy (RT) treatment (patients with adenocarcinoma received CT, and patients with SCC received chemoradiotherapy (CRT). Thoracoabdominal triphasic

Table 1. Demographic parameters

	N	%
Age		
61.2 (42-74) mean	15	
Gender		
Male	10	66.6
Female	5	33.4
BMI		
28.26 (21-45) mean		
ASA score		
1	4	26.6
2	9	60
3	2	13
ECOG-PS		
0	6	40
1	7	46.6
2	2	13
Oncologic treatment protocol		
Definitive CRT	6	40
Neoadjuvant CRT	9	60

BMI: Body Mass Index; ASA: American Society of Anesthesiologists; ECOG-PS: Eastern Cooperative Oncology Group- Performance Status; CRT: Chemoradiotherapy.

computed tomography (CT), positron emission tomography (PET-CT), and endoscopic examination were performed before and after oncologic treatment to evaluate both localization and treatment response. Demographic characteristics, clinical and pathologic data, operative data, postoperative complications, and pathological data were retrospectively recorded. Six patients with partial tumor regression response who received definitive treatment and nine patients who received neoadjuvant treatment were operated on after waiting at least six weeks after treatment. Pathologic staging was performed using the American Joint Committee on Cancer (AJCC) 8th edition TNM staging system. All patients received anti-embolic stockings and prophylactic low molecular weight heparin and 2 grams of sulfamethoxazole for prophylaxis in preparation for surgery.

Surgical Technique

The operation was performed in three fields and in the following sequence:

Laparoscopy

The patient was placed in a supine position. After pneumoperitoneum was established, the abdomen was entered with a 12 mm trocar through a 1 cm vertical incision above the umbilicus. A thirty-degree scope was used. A 12 mm trocar was inserted from the left anterior axillary line, two 5 mm ports from the right and left pararectal region, a 5 mm port from below the xiphoid, and five ports in total were used. A Nathanson retractor was used for liver excision.

In all cases, the stomach was prepared for pull-up with an endoscopic stapler (Endo GIA 60-blue cartridge), celiac lymphadenectomy, and wide Kocher maneuver were performed. Pyloroplasty was not performed in any case. The right gastric artery and vein and the vascular arch with the right gastroepiploic artery and vein were preserved. A wide gastric tube was created using a linear tube with an endostapler through the greater curvature. No jejunostomy was opened in any patient for feeding.

Thoracoscopy

In the left lateral decubitus position, the right lung was collapsed with a double-lumen intubation tube, and three trocars were inserted from the right hemithorax. The first 10 mm trocar was inserted through the inferior right scapula with the open technique, one 10 mm trocar was inserted through the 7th intercostal space, and one 12 mm trocar was inserted through the 9th intercostal space under camera-guided direct vision. CO_2 insufflation was not performed during thoracoscopy. A 30-degree camera was used. The thoracic esophagus was exposed by opening the mediastinal pleura over the esophagus. The esophagus was mobilized from the hiatus to the thoracic inlet and dissected together with the paraesophageal lymph nodes. The azygos vein was dissected and cut with (Endo GIA 45-white cartridge). A 32F thoracic drain was placed in the thoracic cavity for postoperative drainage.

Robotic

In the cases where we performed robotic surgery, four 8 mm device-specific trocars and one 12 mm assistant port were used both in the abdomen and thorax, and esophagectomy was completed by preparing the gastric pull-up and dissecting the esophagus thoracoscopically. McKeown esophagectomy and cervical anastomosis were performed in all robotic cases.

Cervical

An oblique incision was made at the anterior border of the left sternocleidomastoid muscle. The left recurrent laryngeal nerve was exposed following medial retraction of the thyroid. The prevertebral region was then entered. From here, the esophagus was dissected, suspended, and then continued dissection towards the mediastinum. In thirteen cases, the esophagus was removed through a cervical incision. The gastric tube was transected, and a 25 mm unvill was placed. Esophagogastric anastomosis was performed with a 25 mm circular stapler. The remaining gastric line was cut with Endo GIA 60 (blue cartridge). A closed absorbent drain was placed under the cervical incision, and the incision was closed.

In the early postoperative period, the lungs were evaluated by direct radiography. Patients with fully expanded lungs and no tube oscillation had a thoracic drain removed on the 2nd or 3rd day. On the 2nd day, patients were started on oral fluids. A routine leak test was not performed for patients with a normal course in terms of clinical and laboratory tests. Patients who did not develop problems in oral intake were discharged without complications by gradually increasing their feeding regimen.

Results

The mean age of the fifteen patients was 61.2 (42-74) years. Ten patients (71%) were male, and five patients (29%) were female. The female/male ratio was 0.50. The mean body mass index (BMI) was 28.26 (21-45). Tumor locations were in the lower esophagus in nine patients, the middle esophagus in five patients, and the upper esophagus in one patient. Tumor types were AC in eight cases and SCC in seven cases. Six SCC patients received definitive chemoradiotherapy (CRT), and one patient received neoadjuvant CRT. All of the AC patients received neoadjuvant CT. Cervical anastomosis (McKeown) or intrathoracic anastomosis (Ivor Lewis) was performed laparoscopically/robotically thoracoscopically in all operations (Table 2).

Gastric pull-up and cervical anastomosis were performed in thirteen cases of total esophagectomy. In two cases, subtotal esophagectomy and intrathoracic anastomosis were performed. Pyloromyotomy and feeding jejunostomy were not performed in any patient.

The mean operative time was 280.53 (180-464) minutes. The mean intraoperative bleeding was 200.33 (50-550) ml. The mean intensive care unit (ICU) stay was 3.26 (1-27) days; however, when the patient who resulted in mortality and was followed up in the ICU was excluded, our mean ICU stay was 1.57 (1-3) days. The mean ward stay was 7.26 (0-11) days. The mean hospital stay was 10.5 (ICU + ward) days. In the early postoperative period (<30 days), one case (0.06%) resulted in mortality. Histopathologic examination revealed ypTNM stage 1 in nine patients. Complete pathologic response was observed in five of these cases (T0N0M0). Of these five cases, two were AC and three were SCC. Two patients had ypTNM stage 2 disease, and four patients had ypTNM stage 3B disease (Table 3).

Table 2. Tumor type-location and type of surgery

	N	%
Tumor location		
Upper	1	6
Middle	5	33.3
Lower	9	60
Tumor type		
Adenocarcinoma	8	53.3
Squamous cell carcinoma	7	46.7
Operation type		
Laparoscopic-thoracoscopic		
Mc Keown	9	60
Ivor-Lewis	2	13
Robotic-thoracoscopic		
Mc Keown	4	26.6
Ivor-Lewis	0	0

Two patients with esophageal cancer with tumor localization in the distal esophagus underwent near-total esophagectomy and intrathoracic anastomosis (Ivor Lewis). Among these patients, the morbidly obese patient (BMI: 45) developed fever on the 10th postoperative day. Neck-thorax CT was performed, and anastomotic leakage was detected. Antibiotic revision was performed. A thoracic tube was available. A feeding jejunostomy was opened, and this leak was endoscopically verified. An intraluminal esophageal stent was then placed in the esophagus. The stent was replaced five days after stent placement due to stent migration. However, after clinical septicemia, the patient ended up with exitus on postoperative day twenty-seven due to sepsis.

Discussion

In the last two decades, a significant increase in surgical innovations aimed at improving patients' health care has been seen. Concerns about different complications that may occur in multiple anatomical sites have resulted in the use of different combinations in esophageal surgery to optimize technique. The use of some of these innovations requires a learning curve, and this has led to the creation of combinations such as minimally invasive esophagectomy (MIE) and robotic-assisted minimally invasive esophagectomy (RAMIE). The learning curve for MIE is largely determined by the technical challenges associated with the thoracoscopic approach. Technical complexity is reflected in a long learning curve.[10] The length of the learning curve for MIE ranges from 40 to 54 cases depending on the operative time.[11] It's been found that surgeons noticed a reduction in operative time in both thoracic and abdominal phases after twenty-three cases, reaching a plateau at case seventy. Pointer et al.[12] confirmed an improvement in surgery times with increasing experience, but this occurred after eighty cases.[13] It can be assumed that operative times decrease with more experience, which again emphasizes the importance of a learning curve.[14] As a clinic that actively uses minimally invasive surgical procedures in the upper GIS and actively performs open esophageal surgery, we aimed to share our first fifteen cases of total minimally invasive esophageal surgery and the difficulties we encountered in light of the literature.

Table 3. Introperative - postoperative data and complications

Operation time (min.)	280.53 (180-464) min. (mean)		
Intraoperative bleeding amount (ml)	200.33 (50-550) ml (mean)		
Duration of hospitalization (days)			
ICU	3.26 (1-27) (mean)	10.52 (overall average)	
Service	7.26 (0-11) (mean)		
		n	**%**
Pathological stage			
ypTNM stage1		9	60
ypTNM stage 2		2	13
ypTNM stage 3B		4	26.6
Postoperative complications			
Anastomotic leakage		1	6
Pulmonary complications (atelectasis)		2	13
Other		0	0
Early mortality (<30 days)		1	6

ICU: Intensive Care Unit; yp: post neoadjuvant (radiation or systemic) therapy—pathological; TNM: Tumour, Node, Metastasis.

It is very difficult to perform both MIE and RAMIE operations and to manage their complications (McKeown or Ivor Lewis operations). In this respect, especially laparoscopic and thoracoscopic Ivor Lewis esophagectomy and intrathoracic anastomosis have technical difficulties. Mini-thoracotomies have been added in some series to facilitate the anastomosis technique, but the difficulties increase even more, especially in obese patients.[15] A potentially fatal complication following esophageal surgery is anastomotic leakage. The incidence of this complication ranges from 0% to 12% and is similar between MIE and OE.[16] In cancer diagnosed as SCC, the surgical margin should be a minimum of 10-12 cm,[17] and therefore, neck anastomoses after total esophagectomy are often preferred in these patients.[18] However, anastomotic leakage in anastomoses performed into the thoracic cavity causes more frightening outcomes.[19] In our series, 7 (46.7%) of fifteen patients were diagnosed with SCC, and 9 (60%) of these fifteen patients were localized in the lower esophagus. However, in our surgical procedures, only 2 (13.3%) of fifteen patients underwent the Ivor Lewis procedure, whereas the number of Ivor Lewis esophagectomies should have been higher. Thirteen (86.7%) patients underwent McKeown esophagectomy. One of these two patients was discharged after uneventful recovery, while the other patient had anastomotic leakage, and mortality could not be prevented despite subsequent stenting. We believe that this patient's mortality due to the complication of the first minimally invasive esophagectomy and thoracic anastomosis performed with the Ivor Lewis procedure in our clinic has increased our tendency to perform McKeown esophagectomy in other cases. Another problem we encountered in these two patients was the difficulty in removing the pathological specimen from the 12 mm trocar area that we placed to use the endostapler. This area was enlarged during pathological specimen extraction, and we encountered the difficulty of suturing this area. Pulmonary complications in this patient group are among the most important concerns of us surgeons. In the TIME study, the reported incidence of pulmonary complications associated with MIE was 29%.[20] In our case series, postoperative atelectasis was detected in two of our patients (13%) and resolved with clinical medication. The mean duration of hospitalization after MIE was 10.53 days, which is consistent with the literature.

Robotic surgery has well-known advantages over MIE (laparoscopy and thoracoscopy) that facilitate more precise surgical dissection: improved visualization through high-resolution and magnified three-dimensional (3D) imaging, stable surgical field, tremor filtration, fingertip control of EndoWrist instruments, and better ergonomics/reduced fatigue, among others. The potential benefits of these technical advantages in esophageal cancer surgery have been explored in previous studies. A randomized trial comparing robot-assisted minimally invasive esophagectomy (RAMIE) with open transthoracic esophagectomy found that RAMIE had lower rates of complications associated with surgery (59% vs. 80%, P=0.02), lower pulmonary complications (32% vs. 58%, P=0.005), lower cardiac complications (22% vs. 47%, P=0.006), lower postoperative pain, and better short-term quality of life. In oncologic outcomes, there was no difference between both approaches.[21] Another study showed that RAMIE was associated with less intraoperative blood loss, fewer pulmonary complications, and less overall morbidity.[22] Our high experience in robotic abdominal surgery and laparoscopic thoracic surgery has been a facilitating factor in our robotic thoracic interventions. We performed 4 (26.6%) of fifteen minimally invasive esophagectomy patients with the fully robotic McKeown procedure. In these patients, trocar placement difficulties, especially configuration according to tumor location, were the most important challenges we faced. In this first experience, none of the patients had complications and all were discharged in the usual course.

In the TIME study, mean operative times were 319 minutes: 299 minutes for MIE and 329 minutes for open esophagectomy.[23] In our current series, the mean operative time was 280.53 (180-464) minutes, which was shorter than the literature. The mean intraoperative blood loss was 200 ml in MIE in the TIME study.[23] In our current series, it was 200.33 (50-550) ml, which is consistent with the literature. We attribute this improvement to the current technological change and development (laparoscopy and robotic technological devices and equipment), specialization, and the fact that we have a lot of clinical experience in laparoscopy and robotic gastrointestinal cancer surgery.

When our first minimally invasive series of fifteen cases was evaluated, lower esophageal cancer surgical intervention was more common (60%) in line with our experience in minimally invasive total gastrectomy. As it is known, the rate of adenocarcinoma is higher in lower esophageal cancer,[24] and this was in parallel with our results (53-47%). In this first series, we used laparoscopic interventions more in the first cases because of our concern about controllability, and we included robotic thoracic surgery interventions more after laparoscopic experience (laparoscopic 73.3% - robotic 26.6%). The first selected group of patients had early-stage tumors, and the pathology results confirmed this (yp stage-1 60%).

When our case series is evaluated, we think that the ability of a team experienced in open esophageal surgery and minimally invasive abdominal surgery to perform minimally invasive esophagectomy while adhering to oncological principles in the treatment of robotic or laparoscopic esophageal cancer surgery can be achieved with a little experience. The small number of patients in this series, the preference for more McKeown esophagectomy surgery in patients, and the insufficient number of patients to separately evaluate the difficulties in differentiating between definitive and neoadjuvant therapy before esophagectomy are the most important shortcomings of our study. Studies with a higher number of cases are needed to evaluate the results of the study.

Conclusion

The widespread use of laparoscopic-thoracoscopic surgery in esophageal cancer surgery, the addition of the gains of robotic surgery technology to minimally invasive surgery, and increased experience have led to better early postoperative outcomes. In clinics experienced in gastrointestinal system and minimally invasive surgery, the thoracic surgery stage is considered to be the most worrisome step in minimally invasive esophagectomy procedures. We believe that adequate experience can be achieved with smaller patient series in the transition to minimally invasive esophagectomy, especially in clinics experienced with the open method in thoracic surgery. With the increase in laparoscopic-robotic thoracoscopic applications in esophageal cancer surgery, we think that neoadjuvant treatment may be preferred to definitive treatment in selected cases with a higher number of case results and sharing of experiences. However, more studies with larger series and long-term results are needed for this.

Disclosures

Ethichs Committee Approval: The study was approved by the Antalya Training and Research Hospital Ethics Committee. (No: 2024-320, Date: 10/10/2024).

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Conflict of Interest: None declared.

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