Original Article

Comparison of clinical outcomes of robotic-assisted and video-assisted esophagectomy for esophageal cancer

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ABSTRACT

Introduction: Robotic-assisted minimally invasive esophagectomy (RAMIE) is a recently developed technique for the treatment of resectable esophageal cancer. The present study compares the outcomes of RAMIE and video-assisted thoracoscopic esophagectomy (VATE).

Method: Patients undergoing minimally invasive esophageal surgery between December 2020 and September 2022 were included in the study, while those undergoing conventional surgery were excluded. The patients were divided into two groups, as those undergoing RAMIE (Group 1) and those undergoing VATE (Group 2). The demographic and clinical characteristics, intraoperative parameters, pathological data, and postoperative parameters of the groups were compared.

Results: A total of 28 patients were included in the study, with 13 patients in Group 1 and 15 patients in Group 2. The gender distribution was similar ($P = 0.488$), and the mean age was 64.7 and 59.0 years in Groups 1 and 2, respectively ($P = 0.068$). The majority of the sample was in the ASA2 category (46.2% vs. 66.7%, $P = 0.341$); Ca19.9 levels were higher in Group 1 than in Group 2 (25.7 vs. 13.7, $P = 0.027$); preoperative Hb was lower in Group 1 than in Group 2 (10.9 g/dL vs. 12.2 g/dL, $P = 0.043$); the most commonly performed surgery was the McKeown procedure (69.2% vs. 66.7%, $P = 0.492$); an intraoperative feeding jejunostomy was placed only in Group 2; the operation time was similar between the groups (338.5 min vs. 340 min, $P = 0.916$); and the distribution of tumor localizations was similar between the groups ($P = 0.407$). In terms of tumor histology, squamous cell carcinoma (SCC) was the most common tumor type in the two groups (84.6% vs. 80%, $P = 0.636$); the tumor diameter was similar between the groups (14.9 vs. 18.1, $P = 0.652$); the number of removed lymph nodes was similar between the groups (24.9 vs. 22.5, $P = 0.419$); and the number of metastatic lymph nodes was higher in Group 2 (0.08 vs. 1.07, $P = 0.27$). One patient in Group 2 underwent repeat surgery due to suspected ischemic anastomosis; the distribution of postoperative complications according to the Clavien–Dindo classification system was similar in the two groups ($P = 0.650$); there was no early mortality within the first 30 days in either group; one patient in Group 2 was re-admitted within 90 days of discharge with decreased oral intake; the length of hospital stay was shorter in Group 1 (9 days vs. 16.5 days, $P = 0.006$); and the patients in Group 2 more often received neoadjuvant therapy in proportion to the disease stage (15.4% vs. 60%, $P = 0.016$).

Conclusion: Robotic procedures can be safely performed in esophageal cancers with complication rates and oncological radicality similar to those of other minimally invasive techniques.

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KEY WORDS: Clinical outcomes, esophageal cancer, lymph node dissection, robotic esophagectomy, thoracoscopic esophagectomy

INTRODUCTION

Esophageal cancer is the seventh most common form of cancer worldwide and the sixth leading cause of cancer-related death, placing a significant burden on the public health.[1] Significant advances have been achieved in the diagnosis and treatment of esophageal cancer, and survival has been improved by multimodal management. Nonetheless, 5-year overall survival is in the range of 15–25%, while morbidity associated with esophagectomy remains high, in the range of 30–60%.[2,3]

Although chemotherapy, radiotherapy, and immunotherapy are commonly used in clinical practice, esophagectomy is still the first-line treatment for patients with esophageal cancer.[4] The technical optimization of the esophagectomy procedure over the years has led to improvements

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in postoperative clinical and oncological outcomes in the long term, but despite these advances, esophagectomy is still an invasive procedure that is associated with significant morbidity and mortality.[5] The use of minimally invasive surgery (MIS) to reduce surgical trauma and associated morbidity and mortality may be considered beneficial, particularly over such complex and aggressive surgical techniques as esophagectomy. Accordingly, minimally invasive techniques have been used increasingly for the surgical treatment of esophageal cancer over the last two decades.[4,6]

The advantages of minimally invasive esophagectomy procedures have been determined in literature through comparisons of such approaches with open or hybrid techniques.[5,7,8] That said, there have been only a limited number of studies evaluating and comparing the outcomes of RAMIE and VATE. While some studies have reported similar outcomes between the two techniques, there are also those reporting reduced intraoperative blood loss, lower rates of postoperative pneumonia, lower overall morbidity, and higher R0 resection rates in patients undergoing robotic esophagectomy than those undergoing laparoscopic-thoracoscopic esophageal resection.[9] There is a lack of sufficient evidence in literature on the long-term effects of robotic esophageal surgery and the long-term results of the REVATE (robotic-assisted esophagectomy vs video-assisted thoracoscopic esophagectomy), while ROBOT-2 studies are awaited.[10,11] As such, there is a need for further studies to increase knowledge of the use of robotic surgery in esophageal cancer.

The present study compares the outcomes of RAMIE and VATE in patients with esophageal cancer.

METHOD

This single-center, retrospective study was launched after obtaining the approval of the local ethics committee. Patients undergoing minimally invasive esophageal surgery between December 2020 and September 2022 were included in the study, while those undergoing conventional surgery were excluded. The data sources included the hospital's automated archiving system and pathology records, which were reviewed retrospectively.

The patients were divided into two groups, being the RAMIE group (Group 1) and the VATE group (Group 2). All patients had undergone VATE in our clinic until the robotic-assisted surgery technique was introduced, and all patients since have undergone RAMIE.

Demographic data such as age and gender, American Society of Anesthesiologists (ASA) score, nutritional habits before surgery, preoperative hemoglobin, albumin and tumor marker levels, receipt of neoadjuvant therapy, operative parameters (including operation type, operation time, intraoperative complications, presence of a feeding jejunostomy, abdominal phase of the operation, tumor characteristics including tumor localization, histology, distal and proximal margins, tumor diameter, surgical margins, radial surgical margin, lymphovascular and perineural invasion status, the number of dissected total and metastatic lymph nodes, and T and N stages), and postoperative quality parameters (including the length of hospital stay, repeat surgery, 30-day mortality, 90-day readmission, complications according to the Clavien–Dindo classification, and receipt of adjuvant therapy) were compared between the groups.

For staging purposes, all patients underwent positron emission tomography (PET), abdominal and thoracic computed tomography (CT), and endoscopic evaluations of the tumor and upper gastrointestinal tract, while patients with proximal tumors additionally underwent a CT scan of the neck. The status of each patient was reviewed by a multidisciplinary committee before deciding on the treatment. Patients with a clinical disease stage of T2N0M0 or higher were offered neoadjuvant therapy. Resection materials were evaluated by specialist gastrointestinal pathologists using standard protocols. The patients were staged using the TNM classification system,[12] and the Clavien–Dindo classification system was used to define and grade postoperative complications.[13]

Surgical technique

Patients with proximal and middle esophageal tumors underwent McKeown esophagectomy, while those with distal esophageal tumors, Siewert type 1 tumors extending more than 4 cm to the proximal esophagus, and Siewert type 2 esophagogastric junction tumors underwent Ivor Lewis esophagectomy. Among the patients who underwent McKeown esophagectomy, those with suspected lymph node metastasis on PET-CT and neck CT scans underwent additional neck dissection.

The operation started in the thoracic area in patients undergoing McKeown esophagectomy with the patient placed in the left lateral decubitus position and proceeded with the abdominal and then cervical areas after switching to the supine position, with esophagogastrostomy anastomosis performed at the level of the cervical esophagus. In patients undergoing Ivor Lewis esophagectomy, the operation started from the abdominal area with the patient placed in a supine position and proceeded with the thoracic area after switching to the left lateral decubitus position, and intracorporeal esophagogastric anastomosis was performed. All patients undergoing right-sided surgery were placed in the left lateral decubitus position.

During thoracic dissection, the right lung was collapsed by the anesthesiology team after endotracheal intubation using a double-lumen endotracheal tube. In patients undergoing VATE, a 5-mm port was inserted into the seventh intercostal space below the right scapula, and pneumothorax was created

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to reach an intrathoracic pressure of 6 mmHg. This port was then used to introduce the instruments to be manipulated by the left hand of the surgeon. Inferior to the 5-mm port, a 10-mm port was placed in the ninth intercostal space for the insertion of a videoendoscopic camera, and a 10-mm port was placed in the ninth intercostal space at the anterior axillary line that was used to introduce the instruments to be manipulated by the right hand of the surgeon. A further 10-mm port was placed in the seventh intercostal space at the midclavicular line for the introduction of the instruments used to retract the right lung. In patients undergoing RAMIE, an 8-mm robotic port was placed in the eighth intercostal space at the midclavicular line to create pneumothorax. All robotic ports were placed 6 cm apart through the eighth intercostal space in a posterolateral direction, and a 12-mm assisting port was placed in the 10th intercostal space at the midaxillary line for clipping, aspiration, and the introduction of linear endostapler, gauze, and sutures. The azygos vein was blocked with a hemolock and ligated before the dissection. The pleura enveloping the esophagus was opened, and the esophagus and the surrounding adipose tissue containing the lymph nodes were dissected in a caudocranial direction from the hiatus up to the neck in patients undergoing McKeown esophagectomy, and from the hiatus up to the level of azygos vein in patients undergoing Ivor-Lewis esophagectomy, while preserving the aorta in the posterior and the trachea, bronchi, pericardium, and the pleura of the contralateral lung in the anterior. The subcarinal lymph nodes and bilateral bronchial lymph nodes were dissected off and removed in both McKeown and Ivor-Lewis procedures. In addition paratracheal, upper esophageal and thoracic part of the right recurrent laryngeal lymph nodes were removed in McKeown procedure. Left recurrent laryngeal lymph node dissection was not performed routinely. In patients undergoing Ivor-Lewis esophagectomy, a 5–10 cm 1/0 polypropylene curved needle suture knotted ancillary trocar attached to a 25-mm circular stapler anvil was introduced into the thoracic space via the 12-mm assisting port incision after being minimally enlarged by the assisting surgeon. Monopolar curved scissors (Intuitive da Vinci Robotic Surgical Systems) were placed in the proximal esophagus through an incision made on the anterior side of the esophagus at the level of azygos vein. The esophagus was cut using a 45-mm endostapler with a tissue thickness of 4.8 mm. The ancillary trocar and the needle were then detached from the anvil and removed.

For abdominal dissections, pneumoperitoneum was created by increasing the intraabdominal pressure to 10 mmHg through a puncture made with a Veress needle placed 1 cm above the umbilicus. An 8-mm robotic port or 10-mm videoendoscopic port was placed 1 cm above the umbilicus, and all quadrants of the intraabdominal cavity were inspected through a 30-degree optic to rule out peritoneal metastasis. All ports were aligned to create a horizontal line in patients undergoing RAMIE and a convex line in patients undergoing VATE and placed 6–10 cm apart. Three 8-mm robotic ports were placed in the right upper quadrant at the midclavicular line in patients undergoing RAMIE, and three 5-mm robotic ports were placed in the left upper quadrant at the midclavicular line in patients undergoing VATE. A 12-mm laparoscopic port was placed in the right upper quadrant at the anterior midaxillary line to be used for clipping, aspiration, and the introduction and exit of the linear endostapler, gauze, and sutures by the assisting surgeon. The patients were placed in a 15–30-degree reverse Trendelenburg position after the ports were placed. The greater omentum was cut from the origin at the gastroduodenal artery to the left diaphragmatic crus while preserving the right gastroepiploic vessels, and the lesser omentum was cut from the right paracardiac first lymph node station to the hepatic pedicle using a Vessel Sealer Extend (Intuitive da Vinci Robotic Surgical Systems) in patients undergoing RAMIE and using a bipolar sealing device in patients undergoing VATE. The left gastric artery and vein were clipped and cut. The right gastric artery was preserved in Ivor-Lewis procedure, but in McKeown procedure the artery was clipped to enhance the gastric mobilization if there was a suspicion of tension at the anastomosis or presence of short gastric conduit. 7-8-9-11-12. The lymph node stations were dissected, and an abdominal lymphadenectomy was performed. The Kocher maneuver was performed to mobilize the duodenum. A 4–5-cm gastric conduit was created from the entry of the right gastric artery to the lesser curvature to the gastric fundus using a 60-mm medium-thick reload with Tri-Staple™ technology (Medtronic, Minneapolis, MN, USA).

Among the patients undergoing an Ivor-Lewis esophagectomy, the 12-mm assisting port site in patients undergoing RAMIE and the 10-mm port site in patients undergoing VATE were widened to allow the advancement of the circular stapler into the thoracic cavity. The gastric conduit and the specimen were pulled into the thoracic cavity through the hiatus by traction. Gastrotomy was performed on the gastric wall that remained on the specimen, and a circular staple was placed in the posterior wall of the proximal gastric corpus of the gastric conduit. Esophagogastric anastomosis was performed, and the specimen was cut to include the gastrotomy site using a 60-mm medium-thick reload with Tri-Staple™ technology (Medtronic, Minneapolis, MN, USA). The specimen was removed from the thoracic cavity through the widened port site.

In patients undergoing McKeown esophagectomy, the cervical esophagus was accessed through an oblique incision made on the anterior margin of the left sternocleidomastoid muscle. The esophagus was dissected off, and a 25-mm circular stapler anvil was placed in the proximal esophagus and fixed with purse-string sutures using 1/0 polypropylene and a curved needle. The gastric conduit and the specimen were pulled into the cervical area from the thoracic inlet through the hiatus by traction. Gastrotomy was performed on the gastric wall that remained on the specimen, and a circular stapler was placed in the posterior wall of the proximal gastric corpus of the gastric conduit. Esophagogastric anastomosis was performed, and the

specimen was cut to include the gastrotomy site using a 60-mm medium-thick reload with Tri-Staple™ technology (Medtronic, Minneapolis, MN, USA).

All operations were performed by the same surgeon (HB). The Da Vinci Xi Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) was used to perform all robotic procedures.

Statistical analysis

IBM SPSS Statistics (Version 23.0. Armonk, NY: IBM Corp.) was used for the statistical analysis of the study data. Categorical variables were expressed as numbers and percentages, and continuous variables as mean and standard deviation. A Shapiro–Wilk test was used to determine whether the study parameters were normally distributed; a Chi-square test or Fisher's exact test was used for the comparison of categorical variables; a Mann–Whitney U-test was used to examine the differences between the groups; and the level of statistical significance was set to an alpha of 0.05 in all analyses.

RESULTS

A total of 28 patients were included in the study, with 13 patients in Group 1 and 15 patients in Group 2. The gender distribution was similar ($P = 0.488$), and the mean age was 64.7 and 59.0 years in Groups 1 and 2, respectively ($P = 0.068$). The majority of the study population were in the ASA2 category (46.2% vs. 66.7%, $P = 0.341$). Carcinoembryonic antigen (CEA) levels were similar, while Ca19.9 levels were higher in Group 1 than in Group 2 (25.7 vs. 13.7, $P = 0.027$). Preoperative Hb was lower in Group 1 than in Group 2 (10.9 g/dL vs. 12.2 g/dL, $P = 0.043$). The preoperative feeding method and the receipt of neoadjuvant therapy were similar in the groups (92.3% and 86.7%, $P = 0.630$). Demographic characteristics and clinical data are presented in Table 1.

The most commonly performed surgery was the McKeown procedure (69.2% vs. 66.7%, $P = 0.492$); an intraoperative feeding jejunostomy was placed only in Group 2; and the operation time was similar between the groups (338.5 min vs. 340 min, $P = 0.916$). The abdominal phase was also proceeded using the robotic technique in patients undergoing robotic procedure and using conventional methods in five patients undergoing thoracoscopic procedure. The distribution of the tumor localization was similar between the groups ($P = 0.407$). In terms of tumor histology, squamous cell carcinoma (SCC) was the most common tumor type in the two groups (84.6% vs. 80%, $P = 0.636$); the tumor diameter was similar between the groups (14.9 vs. 18.1, $P = 0.652$); the number of removed lymph nodes was similar between the groups (24.9 vs. 22.5, $P = 0.419$); and the number of metastatic lymph nodes was higher in Group 2 (0.08 vs. 1.07, $P = 0.27$). The distance to the surgical margins was similar, and surgical margin positivity was observed in one patient in Group 1. Radial surgical margin positivity was similar between the groups (7.7% vs. 20%, $P = 0.353$); the presence of lymphovascular invasion (7.7% vs. 13.3%, $P = 0.63$) and perineural invasion (15.4% vs. 13.3%, $P = 0.877$) was similar between the groups; T0 tumors were the most common in the two groups (46.2% vs. 53.3%, $P = 0.270$); and the lymph node stage was 0 in all patients in Group 1 (100% vs. 53.3%, $P = 0.018$). Intraoperative details and pathological data are presented in Table 2.

Table 1: Demographic and clinical data

	n (%)			*P*
	Group: 1 Robotic	Group: 2 Thoracoscopic	Total	
Gender				
Male	6 (46.2)	5 (33.3)	11 (39,3)	0.488
Female	7 (53.8)	10 (66.7)	17 (60.7)	
Age	64.7±8.4	59.0±7.8	61.6±8.5	0.068
ASA				
1	1 (7.7)	2 (13.3)	3 (10.7)	0.341
2	6 (46.2)	10 (66.7)	16 (57.1)	
3	4 (30.8)	3 (20)	7 (25)	
4	2 (15.4)	-	2 (7.1)	
CEA	2.70±2.6	2.90±1.9	2.84±2.0	0.522
CA19.9	25.7±9.6	13.7±7.3	17.0±9.5	0.027*
Preoperative hemoglobin gr/dL	10.9±1.1	12.2±1.4	11.7±1.4	0.043*
Preoperative albumin gr/L	38.2±5.1	38.3±4.8	38.3±4.9	0.922
Preoperative feeding				
Oral	11 (84.6)	11 (73.3)	22 (78.6)	0.468
PEG	2 (15.4)	4 (26.7)	6 (21.4)	
Neoadjuvant therapy	12 (92.3)	13 (86.7)	25 (89.3)	0.630

* P <0.05, **P <0.001, a: Chi-square and Fisher's exact test, b: Mann-Whitney *U*-test

One patient in Group 2 underwent repeat surgery due to suspected ischemic anastomosis. The distribution of postoperative complications according to the Clavien–Dindo classification system was similar between the groups ($P = 0.650$). One patient in Group 2 was re-admitted within 90 days of discharge due to decreased oral intake; the length of hospital stay was shorter in Group 1 than in Group 2 (9 days vs. 16.5 days, $P = 0.006$), and the patients in Group 2 more often received neoadjuvant therapy in proportion to the disease stage (15.4% vs. 60%, $P = 0.016$). Postoperative data is presented in Table 3.

DISCUSSION

The present study comparing minimally invasive techniques in patients with esophageal cancer found that robotic surgery provided sufficient oncological dissection and similar intraoperative and postoperative outcomes in curative resections to those achieved with thoracoscopic surgery. There was no difference in postoperative complications or radical resection.

Esophagectomy, which is an extremely invasive procedure that is associated with significant morbidity and mortality, is still performed frequently in many international centers for the treatment of resectable esophageal cancer. Robotic-assisted, laparoscopic, and thoracoscopic approaches have been put

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Table 2: Operative details and pathological data

	n (%)			*P*
	Group: 1 Robotic	Group: 2 Thoracoscopic	Total	
Operation type				
Ivor-Lewis	3 (23.1)	5 (33.3)	8 (28.6)	0.492
McKeown	9 (69.2)	10 (66.7)	19 (67.9)	
Transhiatal	1 (7.7)	-	1 (3.6)	
Intraoperative feeding jejunostomy	-	9 (60)	9 (32.1)	0.001**
Operation time (min)	338.5±118.9	340.9±83.6	339.8±99.3	0.916
Intraoperative complications	-	1 (6.7)	1 (3.6)	0.343
Tumor localization				
Distal	6 (46.2)	9 (60)	15 (53.6)	0.407
Middle	7 (53.8)	5 (33.3)	12 (42.9)	
Proximal	-	1 (6.7)	1 (3.6)	
Tumor type				
Adenocarcinoma	2 (15.4)	2 (13.3)	4 (14.3)	0.636
Neuroendocrine	-	1 (6.7)	1 (3.6)	
SCC	11 (84.6)	12 (80)	23 (82.1)	
The largest tumor diameter (mm)	14.9±20.0	18.1±21.2	16.7±20.4	0.652
Total number of removed lymph nodes	24.9±8.7	22.5±7.7	23.6±8.1	0.419
Number of metastatic lymph nodes	0.08±0.3	1.07±1.6	0.63±1.3	0.027*
The closest margin, distal (mm)	38±32	49±15	45±23	0.200
The closest margin, proximal (mm)	45.7±1.7	29±21	36.6±21	0.080
Tumor perforation	1 (7.7)	-	1 (3.6)	0.274
Surgical margin positivity	1 (7.7)	-	1 (3.6)	0.274
Radial surgical margin positivity	1 (7.7)	3 (20)	4 (14.3)	0.353
Presence of lymphovascular invasion	1 (7.7)	2 (13.3)	3 (10.7)	0.630
Presence of perineural invasion	2 (15.4)	2 (13.3)	4 (14.3)	0.877
Pathological T stage				
0	6 (46.2)	8 (53.3)	14 (50)	0.270
1a	1 (7.7)	-	1 (3.6)	
1b	3 (23.1)	1 (6.7)	4 (14.3)	
2	1 (7.7)	-	1 (3.6)	
3	2 (15.4)	6 (40.0)	8 (28.6)	
Pathological N stage				
0	13 (100)	8 (53.3)	21 (75)	0.018*
1	-	5 (33.3)	5 (17.9)	
2	-	2 (13.4)	2 (7.1)	

P <0.05, ***P* <0.001, a: Chi-square and Fisher's exact test, b: Mann-Whitney *U*-test

Table 3: Postoperative period

	n (%)			*P*[a]
	Group: 1 Robotic	Group: 2 Thoracoscopic	Total	
Reoperation	-	1 (6.7)	1 (3.6)	0.343
Clavien–Dindo				
1	10 (76.9)	10 (66.7)	20 (71.4)	0.650
2	1 (7.7)	3 (20)	4 (14.3)	
3	2 (15.4)	2 (13.3)	4 (14.3)	
90-day re-admission	-	1 (6.7)	1 (3.6)	0.34
Length of hospital stay	9.0±3.0	16.5±8.5	13.0±7.5	0.006**
Adjuvant therapy status	2 (15.4)	9 (60.0)	11 (39,3)	0.016*

P <0.05, ***P* <0.001, a: Chi-square and Fisher's exact test, b: Mann-Whitney *U*-test

forward as a potential solution to significant morbidity and mortality, being associated with low rates of cardiopulmonary complications, less postoperative pain, shorter length of hospital stay, and improved quality of life.[9,14-16]

Lymphadenectomy brings about technical challenges in esophageal cancer and is an important step in radical esophagectomies performed for esophageal cancer. In previous studies in literature, Tagkalos *et al*.[17] reported a higher number of dissected lymph nodes in the robotic group in their large series than in those undergoing conventional minimally invasive surgery (23 vs. 27, $P = 0.043$). In a study comparing 62 patients undergoing RAMIE and 43 patients undergoing VAMIE, Park *et al*.[18] reported a higher number of dissected lymph nodes in the robotic group. Similarly, Deng *et al*.[19] reported a significantly higher number of dissected lymph nodes in the robotic group (21.9 and 17.8, $P = 0.042$), while Suda *et al*.[20] showed decreased incidence of laryngeal nerve palsy, but no significant increase in the number of dissected lymph nodes. The different results derived from these series may be attributed to different experience levels. In the present study, there was no significant difference in the number of dissected lymph nodes between the groups. Thoracoscopic instruments have limitations in dissection in short and narrow spaces, and thus, deep thoracoscopic dissections in the thoracic inlet are technically challenging. Robotic-assisted surgery procedures have the ability to overcome the limitations associated with laparoscopic and thoracoscopic esophagectomy. Specifically, robotic-assisted surgery provides a larger and three-dimensional view of the operation site in the mediastinum and allows broader instrument mobility and articulation.

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Zheng *et al*.[21] reported significantly longer operation times with robotic surgery than with conventional minimally invasive surgery and attributed this finding to the repositioning of the robotic cart twice in each operation and the lack of surgical experience. Comparative studies in literature have reported similar operation times, although there are also studies reporting longer operation times for robotic surgery.[6] The operation time in robotic procedures decreases with increasing surgical experience, and docking times and other technical arrangements are faster in centers that use only robotic surgical procedures, achieving operation times comparable to those of other minimally invasive methods. The results of the present study show that the operation time does not pose a disadvantage in robotic surgery.

In a meta-analysis conducted by Banks *et al*.,[22] the reported anastomotic leakage rates for MIE, RAMIE, and open esophagectomy were 2.1–13.2%, 3.0–24.1%, and 7.0–25.3%, respectively. It has been well-established that the type and site of the anastomosis also play a role in anastomotic leakage, although the heterogeneous nature of studies in literature may affect these rates, and there are a limited number of randomized and controlled studies in this regard. It is difficult to determine an operative approach that minimizes anastomotic leakage, although the lower range of leakage rates reported for MIE and RAMIE is promising and suggests that these approaches may help surgeons limit the rate of anastomotic leakage.[9,11] No anastomotic leakage was encountered in our series, while there were patients with lymphatic fistula in both groups.

In their meta-analysis evaluating overall morbidity rates, Angeramo *et al*.[9] reported a rate of 40% (95% CI, 34–47%) after conventional minimally invasive esophagectomy, and 30% (95% CI, 24–38%) after robotic procedures, revealing the overall morbidity rate to be significantly lower after robotic surgery (OR 0.67, 95% CI 0.58–0.79, $P < .0001$). The primary characteristics of the study sample also influence the overall morbidity rate. The present study found a lower overall morbidity rate than reported in literature, and this rate did not differ between surgical techniques. The authors of the present study believe this finding may be associated with the younger study sample, or attributable to low ASA scores or surgical experience.

Hospital quality indicators have been defined for the evaluation of postoperative periods, such as re-operation, unplanned admission, and length of hospital stay. Robotic surgery had a positive effect only on the length of hospital stay in the present study.

There are ongoing studies evaluating the long-term oncological outcomes of robotic surgery in esophageal cancer, although none have demonstrated the superiority of one over another.[10,11] Long-term outcome data were lacking in our series, although the conventional group received more adjuvant therapies, and this was associated with a relatively more advanced disease stage.

The most important limitation of the present study is the limited number of study patients and the retrospective study design. Furthermore, the robotic esophagectomies were the first carried out by the surgeon in his career.

When we searched the literature, we saw that the design of studies on esophageal cancer surgical technique was generally in the form of a comparison of minimally invasive methods with conventional methods.[2,5,8,23] In these studies, patients in the minimally invasive group included robotic and or thoracoscopic approaches. Due to this heterogeneous patient population, it is wrong to associate the good results in the minimally invasive group with patients who only underwent robotic surgery. In these studies, we see that the advantages of minimally invasive surgery are reflected in the results. Essentially, in order to reveal the results of robotic surgery, it is necessary to compare with other minimally invasive techniques. In addition, complex surgeries such as esophageal surgery are affected by individual factors. In studies involving different surgeons, the results may vary depending on the surgeon. The contribution of our study to the literature was that our patient population consisted of only minimally invasive techniques. The sample in the present study was made up of consecutive patients who were operated by the same surgeon with an experienced learning curve in the same center, ensuring the use of a similar anastomotic technique and facilitating patient management. For this reason, we believe that we have presented clear information about the use of robots in esophageal surgery to the literature.

CONCLUSION

Robotic procedures can be safely performed in esophageal cancers, with complication rates and oncological radicality similar to other minimally invasive techniques. There is a need for further randomized and prospective studies in Western countries before this approach can be recommended more extensively, and to contribute to the knowledge of the potential benefits of robotic platforms.

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Conflicts of interest
There are no conflicts of interest.

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