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ORIGINAL ARTICLE – THORACIC ONCOLOGY

Early Outcomes of Robot-Assisted Versus Thoracoscopic-Assisted Ivor Lewis Esophagectomy for Esophageal Cancer: A Propensity Score-Matched Study

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ABSTRACT

Background. Both robot-assisted Ivor Lewis esophagectomy (RAILE) and conventional thoracoscopic-assisted Ivor Lewis esophagectomy (TAILE) are minimally invasive surgical techniques for the treatment of middle and distal esophageal cancer. However, no research studies comparing early outcomes between RAILE and TAILE have been reported.

Methods. A retrospective analysis was made of 184 patients, 76 in the RAILE group and 108 in the TAILE group, who underwent minimally invasive Ivor Lewis esophagectomy between December 2014 and June 2018. Propensity score-matched analysis was performed between the two groups based on demographics, comorbidities, American Society of Anesthesiologists score, tumor location, tumor size, and pathological stage. Perioperative outcomes were compared.

Results. Two conversions to thoracotomy occurred in the RAILE group. There was no 30-day in either group. Sixty-six matched pairs were identified for each group. Within the propensity score-matched cohorts, the operative time in the RAILE group was significantly longer than that in the TAILE group (302.0 ± 62.9 vs. 274.7 ± 38.0 min, $P = 0.004$). There was no significant difference in the blood loss [200.0 ml (interquartile range [IQR], 100.0–262.5 ml) vs. 200.0 ml (150.0–245.0 ml), $P = 0.100$], rates of overall complications (28.8 vs. 24.2%, $P = 0.554$), length of stay [9.0 days (IQR 8.0–12.3 days) vs. 9.0 days (IQR 8.0–11.3 days), $P = 0.517$], the number of total dissected lymph nodes (19.2 ± 9.2 vs. 19.3 ± 9.5, $P = 0.955$), and detailed categories of lymph nodes.

Conclusions. RAILE demonstrated comparable early outcomes compared with TAILE and should be considered as an alternative minimally invasive option for treating esophageal cancer.

Esophageal cancer ranks the seventh in terms of incidence (572,000 new cases) and sixth in mortality overall (509,000 deaths) around the world in 2018.[1] In China, esophageal cancer is prominent, with an estimated 477,900 new cases and 375,000 deaths in 2015.[2] Despite improvements in neoadjuvant and adjuvant treatment regimens, surgical resection remains the main multimodality treatment for esophageal cancer.[3] Esophageal cancer is most likely to occur in the middle and distal esophagus.[4] Traditionally, an open Ivor Lewis esophagogastrectomy, which incorporates a laparotomy and a right thoracotomy, is one of the most commonly utilized approaches for allowing a subtotal esophagectomy as well as a thorough lymphadenectomy.[5,6] However, the mortality and morbidity associated with this procedure are high.[7] During the past two decades, the role of minimally invasive esophagectomy (MIE) has been well established. Thoracoscopic-assisted Ivor Lewis esophagectomy (TAILE) has become increasingly adopted.[8] Compared with open resections, TAILE results in shorter hospital stays and decreased postoperative morbidities, with comparable oncologic outcomes.[9] However, TAILE has some intrinsic limitations, including its two-dimensional view, reduced hand–eye coordination, and limited degree of freedom of

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movement, which make it difficult to perform key steps during the esophagectomy, including intrathoracic anastomosis and mediastinal lymph node dissection.

Recently, robot-assisted Ivor Lewis esophagectomy (RAILE) has been developed in some large thoracic centers. Robot systems were designed to provide some advantages over conventional minimally invasive surgery, including a magnified three-dimensional view and an improved dexterity, due to the surgical wrists and tremor filtration. Although we and other teams have demonstrated that RAILE is safe and feasible, the literature published in this area is still sparse.[10–13] More importantly, there are no studies comparing RAILE with TAILE to determine whether the RAILE technical advantages are reflected in surgical procedures. The purpose of this study was to compare the short-term outcomes and oncologic safety between RAILE and TAILE using a propensity score-matched (PSM) analysis.

PATIENTS AND METHODS

Patient Selection and Data Collection

We performed a retrospective study of patients who underwent curative MIE including both RAILE and TAILE by a single surgeon (Dr. H.C.L) between December 2014 and June 2018 at Ruijin Hospital affiliated to Shanghai Jiaotong University. TAILE was performed in our institution from December 2014 to May 2015. After that, our institution began the RAILE program. The inclusion criteria were: (a) endoscopically and pathologically diagnosed carcinoma of the mid-lower thoracic esophagus; (b) a tumor judged to be resectable based on a preoperative contrast-enhanced computed tomography of the neck, chest, and abdomen; and (c) patients without distant metastasis. The exclusion criteria were: (a) preoperative neoadjuvant therapy for the reason that the neoadjuvant chemoradiation was not fully realized in the course of this study in our institution; (b) potential surgical contraindications for MIE; and (c) previous history of gastrointestinal surgery or major right thoracic surgery. All patients chose the surgical approach according to their preference and signed informed consent forms. This study was approved by our institutional review board.

There was no difference in the preoperative preparation and postoperative treatment protocol between RAILE and TAILE. The basic demographics, pathological results, and short-term outcomes were retrospectively collected. The pathological stages were evaluated using the American Joint Committee on Cancer (AJCC) 7th edition TNM staging system.[14] To examine further details, the dissected lymph nodes were classified into the abdominal and thoracic categories as well as those along the bilateral recurrent laryngeal nerves (RLNs).

Surgical Technique

RAILE was performed using a da Vinci Surgical System (Model S; Intuitive Surgical, Inc., Sunnyvale, CA), and TAILE was completed using a laparoscopic-thoracoscopic system (Karl Storz, Tuttlingen, Germany). The patient was initially supine with a reverse Trendelenburg position for the abdominal phase. The port positions for the abdominal part of RAILE and TAILE were similar (Fig. 1a and c, respectively). Both the abdominal phases of the two surgical approaches included the liver suspension, gastric mobilization with abdominal lymphadenectomy, intracorporal gastric conduit formation, and laparoscopic feeding jejunostomy.

The patient was then placed in the left-lateral decubitus position for the thoracic phase with single-lung ventilation. For TAILE, four ports were positioned as shown in Fig. 1b. A 12-mm camera port was inserted in the 8th intercostal space (ICS) at the anterior axillary line. A 12-mm and a 5-mm port were inserted in the 10th ICS at the posterior axillary line and in the 5th ICS at the anterior axillary line, respectively, for the first and second working ports. Finally, a 5-mm assistant port was inserted at the triangle of auscultation. With regard to RAILE (Fig. 1d), a 12-mm camera port was inserted in the 5th ICS at the anterior axillary line. Three 8-mm robotic ports were inserted in the 3rd ICS at the anterior axillary line, the 8th ICS at the posterior axillary line, and the 10th ICS posterior to the posterior axillary line, respectively. Finally, a 12-mm assistant port was created in the 7th ICS near the costal margin. The robot was positioned on the dorsocranial side, with one assistant on the anterior side. CO_2 insufflation at a pressure of 8-10 mmHg was used for both RAILE and VAILE. The esophagus was mobilized en bloc from the thoracic inlet to the gastroesophageal junction, along with all periesophageal lymph nodes. The lymph nodes along the bilateral RLNs were dissected carefully. For TAILE, the conduit was pulled up through the hiatus, and an intrathoracic end to end anastomosis was performed with a circular stapler. For RAILE, both a circular stapled anastomosis and a double-layered, completely hand-sewn intrathoracic anastomosis were used as we previously described.[10]

Statistical Analysis

To minimize the bias caused by the nonrandomized selection of patients, we performed a PSM analysis to control the confounding factors using R Project Software (v.2.14.1; http://www.r-project.org). Each patient's

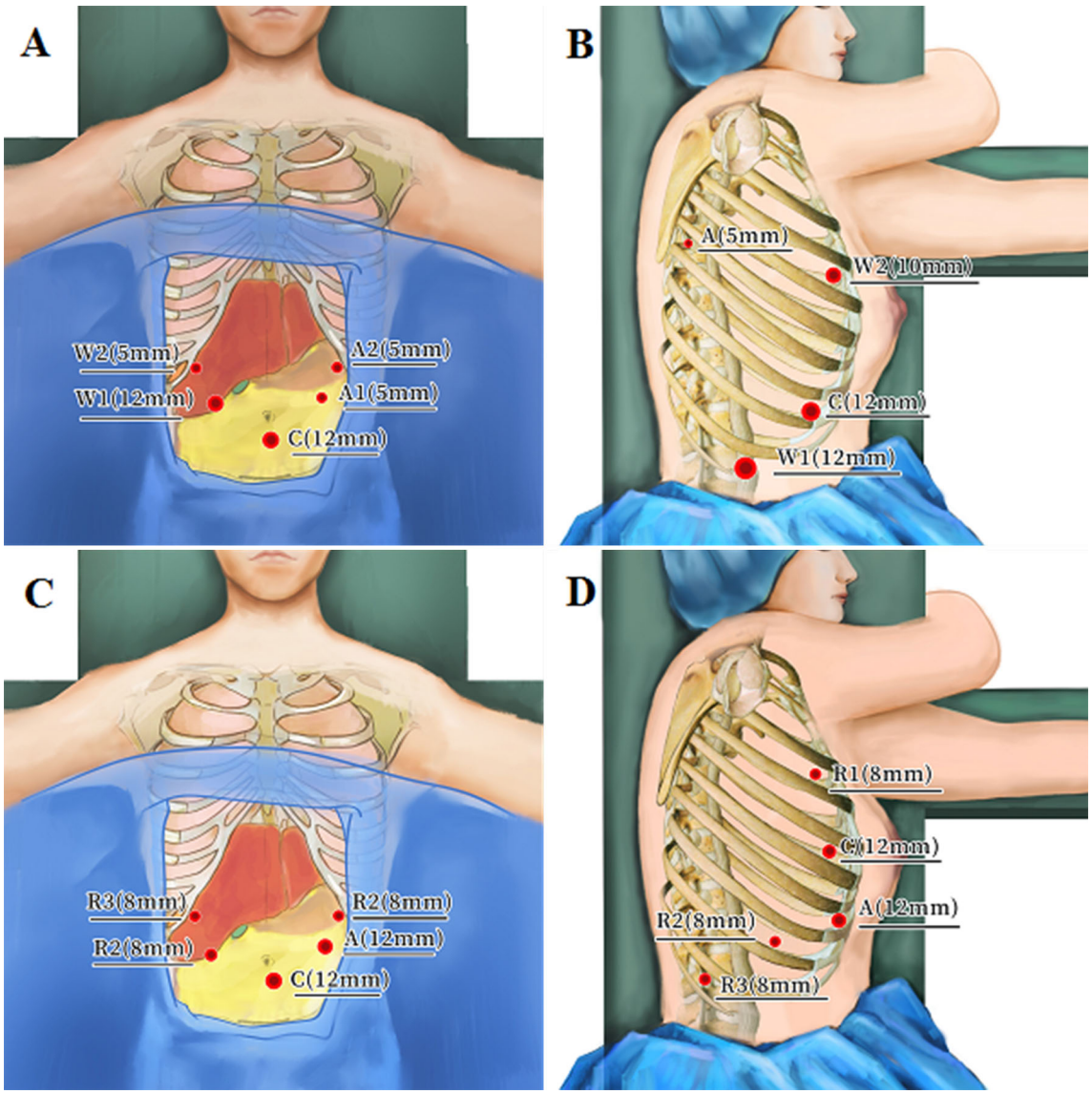

FIG. 1 Port positions for minimally invasive esophagectomy. (**A**) The abdominal phase in TAILE. (**B**) The thoracic phase in TAILE. C, camera port; W1 and W2, the first and second working ports; A1 and A2, the first and second assistant ports. (**C**) The abdominal phase in RAILE. (**D**) The thoracic phase in RAILE. C, camera port; R1, R2, and R3, the first, second, and third robotic ports; A, the assistant port

propensity score was derived from a multivariable logistic model with covariates, including age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, comorbidity, tumor location, tumor size, and pTNM stage. Patients treated with RAILE were matched 1:1 with no replacement to patients treated with RAILE using the nearest-neighbor method with a caliper with of 0.01.

The statistical analysis was performed using SPSS version 20.0 (SPSS Inc., Chicago, IL). Student's *t* test or Wilcoxon rank-sum test was applied to compare the continuous variables between the groups, and the Chi squared test or Fisher's exact test was applied for comparing the categorical data. A two-sided P value < 0.05 was considered statistically significant.

RESULTS

Patient Characteristics

A total of 184 patients who underwent minimally invasive Ivor-Lewis esophagectomy met the inclusion criteria between December 2014 and June 2018 (Fig. 2). Of them, l08 patients underwent TAILE with stapled anastomosis, and 76 patients were treated with RAILE, including 40 cases of stapled anastomosis and 36 cases of hand-sewn

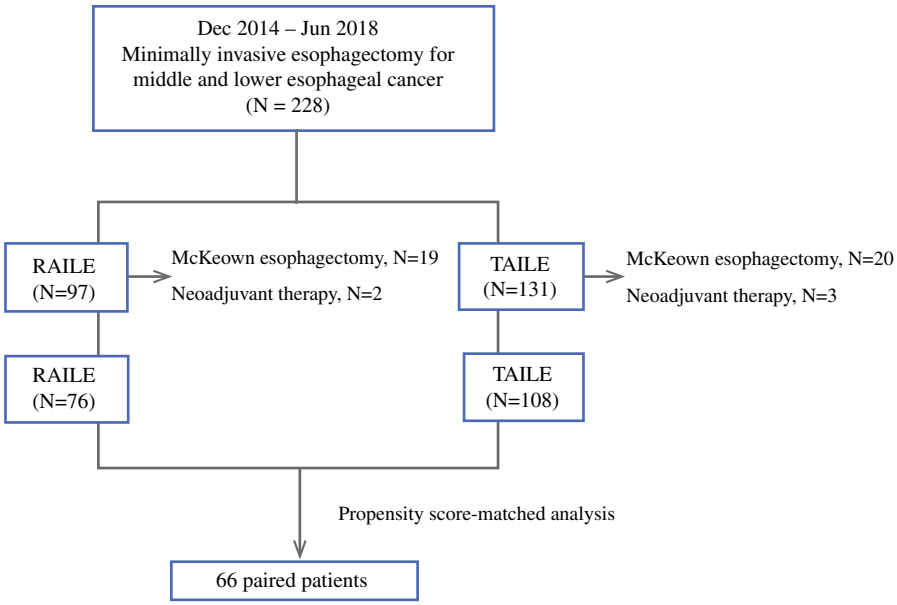

FIG. 2 Flow of the patients through the study. *RAILE* robot-assisted Ivor-Lewis esophagectomy; *TAILE* thoracoscopic-assisted Ivor-Lewis esophagectomy

anastomosis. After PSM, 66 paired patients were matched from the cohort. The baseline characteristics of the study population before and after PSM are summarized in Table 1. The two groups were comparable in patient characteristics, including age, sex, BMI, smoking history, comorbidity, ASA score, tumor location, tumor size, pTNM stage, or pathology.

Perioperative Outcomes

Table 2 presents the perioperative outcomes between RAILE and TAILE. Before PSM, there was no conversion in TAILE, whereas two patients in RAILE were converted to thoracotomy due to severe intraoperative atrial fibrillation and severe chest adhesion, respectively. There was no 30-day mortality in either group. One patient in RAILE and two patients in TAILE died within 90 days after surgery ($P = 1.000$). Compared with the TAILE group, the RAILE group experienced a significantly longer operative time (303.5 ± 60.9 vs. 277.2 ± 42.2 min, $P = 0.001$). The intraoperative blood loss was similar between the two groups [200.0 ml (IQR 100.0–300.0 ml) vs. 200.0 ml (IQR 150.0–250.0 ml), $P = 0.059$]. The overall complication rate was comparable (31.6 vs. 33.3%, $P = 0.803$), and the detailed complications, including the anastomotic leakage, pneumonia, pleural effusion, chylothorax, vocal cord paralysis, cardiac complications, and wound infection, were all similar between the two groups. There was no significant in the length of stay (LOS) between the two groups [9.0 days (IQR 8.0–12.0 days) vs. 9.0 days (IQR 8.0–11.8 days), $P = 0.436$]. As for the pathological outcomes, the R0 resection was achieved in all but one patient in the TAILE group. There was no statistically significant difference in the number of total dissected lymph nodes (19.7 ± 9.8 vs. 20.3 ± 9.7, $P = 0.689$), as well as the number of thoracic (10.6 ± 7.0 vs. 12.5 ± 8.7, $P = 0.107$), abdominal (9.1 ± 6.8 vs. 7.8 ± 6.2, $P = 0.186$), right RLN (1.4 ± 1.6 vs. 1.3 ± 2.3, $P = 0.899$), and left RLN lymph nodes (1.6 ± 2.2 vs. 1.0 ± 2.0, $P = 0.081$).

Next, we analyzed the perioperative outcomes in well matched patients. After PSM, the operative time in RAILE was still longer than that in TAILE (302.0 ± 62.9 vs. 274.7 ± 38.0 min, $P = 0.004$). There was no significant difference between the two groups with respect to the blood loss [200.0 ml (IQR 100.0–262.5 ml) vs. 200.0 ml (150.0–245.0 ml), $P = 0.100$], 90-day mortality rates (1.5% vs. 1.5%, $P = 1.000$), rates of overall complications (28.8 vs. 24.2%, $P = 0.554$), LOS [9.0 days (IQR 8.0–12.3 days) vs. 9.0 days (IQR 8.0–11.3 days), $P = 0.517$], as well as the number of total dissected lymph nodes (19.2 ± 9.2 vs. 19.3 ± 9.5, $P = 0.955$) and detailed categories of lymph nodes.

DISCUSSION

To the best of our knowledge, this is the first study to focus on both RAILE and TAILE and compare the short-term outcomes between the two different surgical approaches. Notably, the present study includes a relatively large number of patients and applies a PSM study design to reduce the potential bias that could probably affect the perioperative outcomes. The results demonstrated that although RAILE experienced a significant longer operative time, the two surgical approaches were comparable in terms of the intraoperative blood loss, postoperative complication rate, LOS, and number of dissected lymph nodes.

TABLE 1 Patient characteristics

Characteristics[a]	All patients			Matched patients		
	RAILE (n = 76)	TAILE (n = 108)	P value	RAILE (n = 66)	TAILE (n = 66)	P value
Age, yr	61.8 ± 7.7	61.3 ± 7.7	0.665	62.3 ± 7.8	62.0 ± 7.8	0.776
Gender			0.862			1.000
Male	59 (77.6)	85 (78.7)		50 (75.8)	50 (75.8)	
Female	17 (22.4)	23 (21.3)		16 (24.2)	16 (24.2)	
BMI, kg/m^2	22.8 ± 3.1	22.7 ± 3.9	0.850	22.9 ± 3.1	23.1 ± 4.5	0.782
ASA score			0.248			0.756
1	36 (47.4)	38 (35.2)		30 (45.5)	26 (39.4)	
2	37 (48.7)	64 (59.3)		33 (50.0)	36 (54.5)	
3	3 (3.9)	6 (5.6)		3 (4.5)	4 (6.1)	
History of smoking	39 (51.3)	70 (64.8)	0.067	33 (50.0)	42 (63.6)	0.175
Comorbidity	32 (42.1)	51 (47.2)	0.492	28 (42.4)	32 (48.5)	0.597
Tumor location			0.158			0.678
Middle thoracic	30 (39.5)	54 (50.0)		29 (43.9)	26 (39.4)	
Lower thoracic	46 (60.5)	54 (50.0)		37 (56.1)	40 (60.6)	
Tumor size, cm	3.1 ± 1.4	3.2 ± 1.4	0.835	3.1 ± 1.4	3.0 ± 1.4	0.438
pT stage			0.220			0.151
Tis	4 (5.3)	4 (3.7)		4 (6.1)	4 (6.1)	
T1	20 (26.3)	24 (22.2)		15 (22.7)	22 (33.3)	
T2	14 (18.4)	32 (29.6)		13 (19.7)	19 (16.0)	
T3	36 (47.4)	48 (44.4)		32 (48.5)	21 (31.8)	
T4a	2 (2.6)	0		2 (3.0)	0	
pN stage			0.294			0.066
N0	47 (64.8)	74 (68.5)		41 (62.1)	53 (80.3)	
N1	16 (21.1)	19 (17.6)		13 (19.7)	9 (13.6)	
N2	9 (11.8)	14 (13.0)		9 (13.6)	4 (6.1)	
N3	4 (5.3)	1 (0.9)		3 (4.5)	0	
TNM stage			0.215			0.164
0	4 (5.3)	4 (3.7)		4 (6.1)	4 (6.1)	
I	18 (23.7)	21 (19.4)		15 (22.7)	21 (31.8)	
II	29 (38.2)	58 (53.7)		24 (36.4)	33 (50.0)	
III	25 (32.9)	25 (23.1)		23 (34.8)	8 (12.1)	
Pathology			0.570			1.000
Squamous cell carcinoma	74 (97.4)	107 (99.1)		64 (97.0)	65 (98.5)	
Adenocarcinoma	0	0		0	0	
Adenosquamous carcinoma	2 (2.6)	1 (0.9)		2 (3.0)	1 (1.5)	

RAILE robot-assisted Ivor-Lewis esophagectomy, *TAILE* thoracoscopic-assisted Ivor-Lewis esophagectomy, *BMI* body mass index, *ASA* American Society of Anesthesiologists

[a]Categoric data are expressed as number (%) and continuous data as mean ± SD

Since the initial robot-assisted minimally invasive esophagectomy (RAMIE) was introduced in 2003 by Giulianotti et al., three main surgical approaches, namely, transhiatal esophagectomy, McKeown esophagectomy, and Ivor-Lewis esophagectomy, have been reported with robotic assistance.[15] van der Sluis et al. has recently published the results of the ROBOT trial, which is the first randomized trial of RAMIE to date, and demonstrated that compared to open esophageactomy, RAMIE resulted in a lower percentage of overall surgery-related and cardiopulmonary complications, lower postoperative pain, better short-term quality of life, and a better short-term postoperative functional recovery with comparable long-term oncological results.[16] However, so far, most of the

TABLE 2 Perioperative outcomes

Characteristics[a]	All patients			Matched patients		
	RAILE (n = 76)	TAILE (n = 108)	P value	RAILE (n = 66)	TAILE (n = 66)	P value
Operative time, min	303.5 ± 60.9	277.2 ± 42.2	0.001	302.0 ± 62.9	274.7 ± 38.0	0.004
Blood loss, ml	200.0 (100.0–300.0)	200.0 (150.0–250.0)	0.059	200.0 (100.0–262.5)	200.0 (150.0–245.0)	0.100
Conversion to open	2 (2.6)	0	0.169	1 (1.5)	0	1.000
Overall complications	24 (31.6)	36 (33.3)	0.803	19 (28.8)	16 (24.2)	0.554
Leakage	7 (9.2)	6 (5.6)	0.410	5 (7.6)	3 (4.5)	0.727
Pneumonia	5 (6.6)	10 (9.3)	0.513	4 (6.1)	5 (7.6)	1.000
Pleural effusion	0	5 (4.6)	0.078	0	2 (3.0)	0.476
Chylothorax	1 (1.3)	3 (2.8)	0.503	0	1 (1.5)	1.000
Vocal cord paralysis	5 (6.6)	7 (6.5)	0.979	4 (6.1)	3 (4.5)	1.000
Cardiac complications	5 (6.6)	4 (3.7)	0.587	5 (7.6)	2 (3.0)	0.375
Wound infection	1 (1.3)	1 (0.9)	1.000	1 (1.5)	0	1.000
In-hospital mortality	0	0		0	0	
30-day mortality	0	0		0	0	
90-day mortality	1 (1.3)	2 (1.9)	1.000	1 (1.5)	1 (1.5)	1.000
LOS, day	9.0 (8.0–12.0)	9.0 (8.0–11.8)	0.436	9.0 (8.0–12.3)	9.0 (8.0–11.3)	0.517
R0 Surgery	76 (100)	107 (99.1)	1.000	66 (100)	66 (100)	
Number of dissected LN	19.7 ± 9.8	20.3 ± 9.7	0.689	19.2 ± 9.2	19.3 ± 9.5	0.955
Abdominal phase	9.1 ± 6.8	7.8 ± 6.2	0.186	8.9 ± 6.7	7.3 ± 5.9	0.198
Thoracic phase	10.6 ± 7.0	12.5 ± 8.7	0.107	10.3 ± 5.8	11.9 ± 8.3	0.137
Right RLN	1.4 ± 1.6	1.3 ± 2.3	0.899	1.4 ± 1.6	1.6 ± 2.8	0.597
Left RLN	1.6 ± 2.2	1.0 ± 2.0	0.081	1.3 ± 1.9	0.9 ± 1.9	0.235

RAILE robot-assisted Ivor Lewis esophagectomy, *TAILE* thoracoscopic-assisted Ivor-Lewis esophagectomy, *LOS* length of stay

[a]Categoric data are expressed as number (%) and continuous data as mean ± SD or median (interquartile range)

published literature focused on the robot-assisted transhiatal esophagectomy and McKeown esophagectomy.[17–19] Only a few centers have reported on RAILE, mostly with relatively small number of patients and different manner of intrathoracic anastomosis.[11, 20–22] In addition, the literature directly comparing RAILE with conventional TAILE is still scarce. One such study, which was conducted by Park et al. in 2016, compared the short-term outcomes of 62 robot-assisted and 43 thoracoscopic-assisted esophagectomy.[23] However, this study cohort involved two different surgical approaches, specifically the Ivor-Lewis and McKeown procedures.

In this comparative study, despite the mean operative time in RAILE was similar to the published studies, the only difference we observed between the two surgical approaches was that RAILE took longer operative time, which is consistent with the most other studies comparing the operative time of robot-assisted and thoracoscopic esophagectomy.[11,12,24] We analyzed the reasons for this longer operative time. First, although the apparent advantages of robotic system over conventional minimally invasive surgery, including high-definition, three-dimensional view, wristed instrumentation with seven degrees of freedom and tremor-filtering facilitate meticulous dissection and thereby can theoretically decrease the operative time, the potential drawbacks of robotic system also inevitably affect the operative time. For example, during RAILE, the robot must be docked twice and moved from the head side to the dorsocranial side when turning from the abdominal phase to the thoracic phase. In addition, the first, second, and third robotic arms need to be exchanged frequently according to the approach angle, which all contribute to the prolonged operation time. However, these shortcomings have been greatly overcome with the application of the most advanced Da Vinci Xi Surgical system, which has revolutionary improvements in its docking, targeting, and operating procedures. Second, although we did not compare the operative time of the adominal phase and thoracic phase separately between the two surgical approaches, we have an impression that robotic surgery has no clear advantages in the abdominal phase due to the need of excessive visceral manipulation and mutiple applications of mechanical devices by assistants. Moreover, even in robotic surgery, the final stage of abdominal surgery, known as a feeding jejunostomy, must be performed laparoscopically.

Lymph node dissection plays a crucial role in ensuring patient survival after a radical esophagectomy.[25] Mediastinal lymph node dissection, especially along the bilateral RLNs, requires a meticulous technique to achieve the complete removal of lymphatic chains and intact preservation of nerves. Compared with conventional thoracoscopy, the robot system has a better exposure of the upper mediastinum due to its ability to offer a three-dimensional, self-controlled magnified view and readily adjustable tractions on esophagus and trachea by the full use of the third robotic arm, which would otherwise be the work of an experienced assistant in TAILE.[26] In the abovementioned study comparing the short-term outcomes between RAILE and TAILE conducted by Park et al., they found that the robot system enabled a more radical lymphadenectomy, especially in the upper mediastinum.[23] The early experience of RAILE from the University of Pittsburgh suggested increased lymph node counts compared with the large cohort of conventional TAILE.[27] Chao et al. also showed that compared with thoracoscopic-assisted esophagectomy, robotic surgery resulted in a higher lymph node yield along the left RLN without increasing morbidity.[28] However, some other comparative studies together with our study demonstrated that the number of total dissected lymph nodes as well as the lymph nodes along the bilateral RLNs was comparable between the two surgical approaches.[29,30] These controversial results may be related to the surgeon's personal experience and the number of patients enrolled, which deserve further comparative analysis.

Although no significant advantages were shown in our study for the use of robotics during Ivor-Lewis esophagectomy, questions remain whether robotic surgery has brought some contributions to MIE. In TAILE, the intrathoracic anastomosis is the most challenging and difficult step during the thoracic phase due to the limited flexibility of the instrument tip and the two-dimensional visualization. Stapled intrathoracic anastomosis was mostly employed including transthoracic or transoral placement of the anvil and introduction of the circular stapler through a small thoracotomy.[31] This process requires close coordination within the surgical team, including the surgeon, assistant, and camera holder within the crowded surgical area. Even in RAILE, this process is sometimes difficult due to the rigid stapler in limited thoracic space and the placement of multiple robotic arms. As for hand-sewn anastomosis, few cases have been published to date with this technique during TAILE due to its high technical requirements of suturing ability.[32,33] However, we found this technique simple and reliable with robotic assistance, which has become our dominant anastomotic technique in RAILE. The magnified three-dimensional view and the angulation given to the needle holder by the robotic system make it feasible to perform a two-layer continuous or interrupted suture without technical difficulties. In our recent study, we have demonstrated that the robotic hand-sewn anastomosis was feasible and safe with no increase of the operative time compared with stapled anastomosis.[10] Some other reports also indicated the feasibility and safety of this technique during RAILE.[34–36] The application of the hand-sewn anastomosis may be an example to demonstrate the clinical benefit of robot system in the future.

This study has some limitations. First, it was conducted in a nonrandomized, retrospective manner. The use of robot system was based on patients' economic levels and their own preferences, which may cause selection bias. Even with the PSM analysis, this selection bias could not be ruled out. Second, this is still an early experience for comparisons between RAILE and TAILE, which included 76 cases of RAMIE and 108 cases of MIE, respectively. Previous studies demonstrated that the learning curve of RAMIE takes approximately 24–70 cases, and approximately 35–40 procedures are needed to reach proficiency for conventional MIE cases.[37,38] The current results of this early comparative study were definitely partly influenced by the learning curve. Moreover, the goal of the study was to gain short-term perioperative outcomes, and a longer follow-up is necessary to compare the oncology results between these two approaches.

In conclusion, we reported the comparative perioperative outcomes between RAILE and TAILE. As such, RAILE should be considered as an alternative minimally invasive method to TAILE for treating esophageal cancer.

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DISCLOSURE The authors declare no conflicts of interest.

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