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Thoracoscopic radical esophagectomy combined with left inferior pulmonary ligament lymphadenectomy for esophageal carcinoma via the right thoracic approach

A single-center retrospective study of 30 cases

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Abstract

To evaluate the necessity, safety, and feasibility of left inferior pulmonary ligament lymphadenectomy during video-assisted thoracic surgery (VATS) radical esophagectomy via the right thoracic approach.

Thirty patients (20 men, 10 women) with thoracic esophageal squamous cell carcinoma (ESCC) were recruited for this study. The patients' age ranged from 50 to 80 years, with an average age of 66.17 ± 7.47 years. After the patients underwent VATS radical esophagectomy and left inferior pulmonary ligament lymph node dissection (LIPLND) via the right thoracic approach, the operative outcomes included operative time, length of hospital stay, postoperative complications, number of lymph nodes removed, and postoperative pathologic results were evaluated.

There were no massive hemorrhages of the left inferior pulmonary vein during the operation. The operative time of LIPLND was 8.67 ± 2.04 minutes, and the length of postoperative hospital stay was 12.23 ± 2.36 days. The postoperative complications included 2 cases of left pneumothorax, 4 pulmonary infection cases, and no chylothorax. Moreover, 68 LIPLNs were dissected, 5 of which were positive, and the degree of metastasis was 7.4%. The postoperative pathologic results showed that 3 cases of LIPLNs were positive, with a metastasis rate of 10.0%. Among them, 2 cases were SCC of the lower thoracic esophagus, and 1 case was SCC of the middle thoracic esophagus, which involved the lower segment.

Thoracoscopic esophagectomy combined with left inferior pulmonary ligament lymphadenectomy for esophageal carcinoma via the right thoracic approach will not increase the difficulty of operation, increase the incidence of postoperative complications or prolong the postoperative hospital stay, and can theoretically reduce tumor recurrence. Therefore, we believe that LIPLND is necessary, safe, and feasible and is worthy of clinical popularization and application.

Abbreviations: AJCC = American Joint Committee on Cancer, CT = computed tomography, ESCC = esophageal squamous cell carcinoma, JES = Japan Esophageal Society, LIPLND = left inferior pulmonary ligament lymph node dissection, LIPLNs = left inferior pulmonary ligament lymph nodes, OS = overall survival, SCC = squamous cell carcinoma, UICC = Union for International Cancer Control, VATS = video-assisted thoracic surgery.

Keywords: esophageal squamous cell carcinoma, left inferior pulmonary ligament lymph nodes, right thoracic approach, video-assisted thoracic surgery

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was approved by the Ethics Committee of The Affiliated Hospital of Putian University (the number: 202020).

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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1. Introduction

Esophageal cancer is still one of the most common malignant tumors of the digestive tract.[1] It was estimated that in 2018, there were over 0.57 million (ranking seventh in incidence) new cancer cases and approximately 0.51 million (ranking sixth in mortality) deaths from esophageal cancer.[2] China has a high incidence of esophageal cancer, for which the morbidity and mortality rate is ranked third and fourth among malignant tumors in China,[3] respectively, with esophageal squamous cell carcinoma (ESCC) accounting for approximately >90% of all esophageal cancer.[4] At present, radical surgery is still the most effective method for the comprehensive treatment of esophageal cancer.[5,6] However, the prognosis of locally advanced tumors is not satisfactory, and the 5-year overall survival (OS) rate of patients with stage IIA-III ESCC is 20.6% to 34.0%.[7–9] Moreover, among the clinical and pathological features of esophageal cancer, the depth of invasion and lymph node metastasis was the most important prognostic factors in patients with ESCC.[10–12] Therefore, massive resection of esophageal cancer combined with standardized and systematic lymph node dissection is considered an essential part of radical resection of esophageal cancer and can prevent residual cancer, reduce tumor recurrence, and improve patient survival.[13,14]

In video-assisted thoracic surgery (VATS) radical esophagectomy via the right thoracic approach, the lower mediastinal lymph nodes are dissected, the paraesophageal and right lower pulmonary ligament lymph nodes are routinely removed. In contrast, for the left inferior pulmonary ligament lymph nodes (LIPLNs), the dissection is sometimes not thorough enough or even ignored. Among the patients we treated, an elderly female patient was clinically diagnosed with mid-thoracic ESCC (stage cT3N0M0 II) before the operation. No obvious surgical contraindications were found after examination, so she underwent VATS radical esophagectomy via the right thoracic approach, but the LIPLNs were not routinely removed during the operation. The patient recovered well during the perioperative period and received postoperative adjuvant chemotherapy. However, the enhanced chest computed tomography (CT) scan showed that the LIPLNs at the lower margin of the left inferior pulmonary vein was enlarged 7 months after the surgery, which is considered to indicate the possibility of lymph node metastasis (Fig. 1).

The lymph node maps for esophageal cancer from the American Joint Committee on Cancer (AJCC)/Union for International Cancer Control (UICC) and the Japan Esophageal Society (JES) noted that the LIPLNs were the drainage area for thoracic esophageal cancer.[15–18] Additionally, the Chinese expert consensus on thoracic lymph node dissection in radical resection of esophageal cancer (2017 edition) strongly recommended that the thoracic lymph nodes be removed as thoroughly as possible in clinical practice, rather than just meeting the requirements of the number of lymph nodes removed. The C201–C209 lymph node group should be regarded as the target of thoracic lymph node dissection in radical esophagectomy[14] (Table 1). Therefore, we believe that in VATS radical esophagectomy via the right thoracic approach, when the lower mediastinal lymph nodes are dissected, the LIPLNs should be removed entirely to ensure a standardized and systematic dissection of the thoracic lymph nodes, improve the radical resection of esophageal cancer and define the N stage.

In this retrospective study, we report the clinical outcomes of 30 patients with thoracic ESCC who underwent VATS radical esophagectomy and analyze the clinical observations of LIPLN dissection (LIPLND) with VATS radical esophagectomy via the right thoracic approach.

2. Methods

2.1. Subjects

In this study, we retrospectively analyzed the clinical outcomes of 30 patients with ESCC who underwent VATS radical resection of esophageal cancer in our hospital from November 1, 2018 to December 31, 2019. Written informed consent was obtained from all patients before the surgical operation.

The inclusion criteria for the patients were as follows: thoracic ESCC confirmed by gastroscopy; stage cT1-3N0-1M0 (UICC TNM classification, eighth Edition); treatment with VATS left inferior pulmonary ligament lymph node dissection; no distant metastasis in the preoperative examination and tolerance of general anesthesia; no preoperative neoadjuvant radiotherapy and chemotherapy; and no prior malignancy.

The exclusion criteria for the patients were as follows: thoracotomy for radical esophagectomy; intraoperative explora-

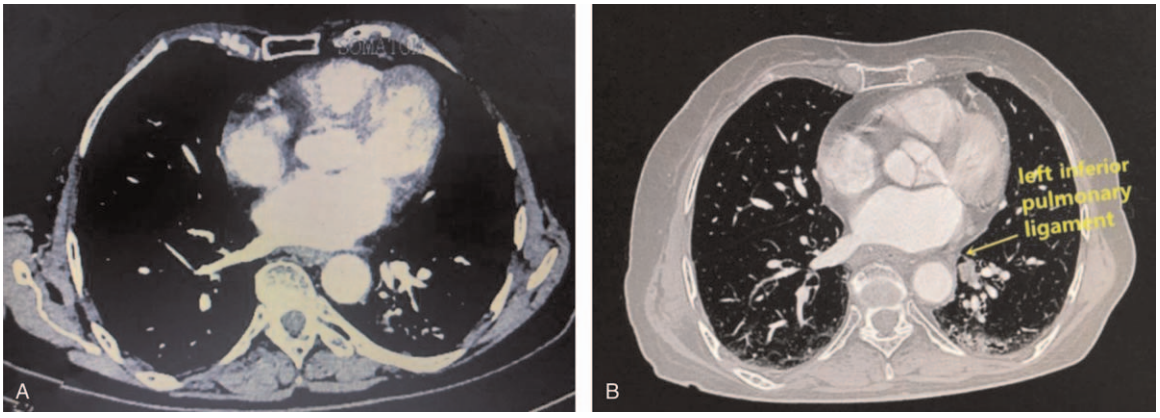

Figure 1. (A) Preoperative chest CT; (B) 7 months after the operation, chest CT showed left inferior pulmonary ligament lymph node enlargement. CT = computed tomography.

Table 1

Chinese criteria for the thoracic lymph node classification of esophageal cancer and their corresponding relations with the UICC/AJCC standards and JES standards.

Region	Chinese classification and anatomical position description	UICC/AJCC standards*	JES standards†
Upper mediastinum	C201: right recurrent laryngeal nerve lymph nodes (initial re-entry of right vagus nerves to the right terminal subclavian artery, peripheral lymph nodes, and adipose tissue of right recurrent laryngeal nerves)	2R: right upper paratracheal nodes	106recR: right recurrent laryngeal nerve lymph nodes
	C202: left recurrent laryngeal nerve lymph nodes (upper left 1/3 of the trachea, peripheral lymph nodes, and adipose tissue of left recurrent laryngeal nerves of the superior border of the aortic arch)	2L: left upper paratracheal nodes	106recL: left recurrent laryngeal nerve lymph nodes
	C203: upper thoracic paraesophageal lymph nodes (lymph nodes from apex pulmonis to inferior border of azygos vein)	8U: upper thoracic paraesophageal lymph nodes	105: upper thoracic paraesophageal lymph nodes
	C204: paratracheal lymph nodes (lymph nodes from right vagus nerves to esophagus, on the right side of tracheae)	4R: right lower paratracheal nodes	106: paratracheal lymph nodes (106pre: pretracheal lymph paratracheal: right paratracheal lymph nodes)
	–	4L: left lower paratracheal nodes	106tbL: left paratracheal lymph nodes
		5: subaortic nodes	113: lymph nodes of arterial ligament
		6: anterior mediastinal nodes	114: anterior mediastinal lymph nodes
	C205: subcarinal lymph nodes (caudal to the carina of the trachea)	7: subcarinal nodes	107: subcarinal lymph nodes
Lower mediastinum	C206: middle thoracic paraesophageal lymph nodes (from the tracheal bifurcation to the caudal margin of the inferior pulmonary vein)	8M: middle thoracic paraesophageal lymph nodes	108: middle thoracic paraesophageal lymph nodes
	C207: lower thoracic paraesophageal lymph nodes (paraesophageal lymph nodes from the inferior border of inferior pulmonary vein to gastroesophageal junction)	8Lo: lower thoracic paraesophageal lymph nodes	110: lower thoracic paraesophageal lymph nodes
	C208: inferior pulmonary ligament lymph nodes (close lymph nodes to the inferior border of the right lower inferior pulmonary vein and within inferior pulmonary ligament)	9L: left inferior pulmonary ligament nodes	112L: left posterior mediastinal lymph nodes
		9R: right inferior pulmonary ligament nodes	112R: right posterior mediastinal lymph nodes
	–	10L: left paratracheal bronchial nodes	109L: left paratracheal bronchial nodes
		10R: right bronchial paratracheal nodes	109R: right bronchial paratracheal nodes
	C209: diaphragmatic nodes (lymph nodes on the right side of cardiophrenic angle)	15: diaphragmatic nodes	111: superior phrenic lymph nodes

–, refers to lymph nodes that were not included in the Chinese Criteria; "C" in the Chinese classification stands for the Chinese Criteria; "2" indicates thoracic lymph nodes. AJCC = American Joint Committee on Cancer, JES = Japan Esophagus Society, UICC = Union for International Cancer Control,.

*It is based on literature.[18,20]

†It is based on literature.[19]

tion that revealed extensive pleural adhesions; and previous right thoracic surgery.

2.2. Surgical approaches

This study was approved by the Ethics Committee of The Affiliated Hospital of Putian University. All patients were informed of the method of VATS radical resection of esophageal cancer and signed the operative informed consent form. The right thoracic approach was selected, and the left prone position was adopted. Artificial pneumothorax was performed in the right chest of the patient.

For the LIPLND process, our team generally dissected the paraesophageal lymph nodes, left/right inferior pulmonary ligament lymph nodes, and other lower mediastinal lymph nodes while performing massive resection of the esophagus and its surrounding tissues. The specific steps are as follows:

After the posterior mediastinum was fully exposed, the mediastinal pleura was opened under the azygos venous arch with an electric hook. Then, the surgeon closed the thoracic aorta and dissociated the esophagus's posterior margin space from the azygos venous arch to the diaphragm. Simultaneously, the assistant pulled the esophagus forward with 5 leaves fan-shaped forceps, continued to dissociate the space between the esophagus and pericardia, and cleaned the paraesophageal lymph nodes. Then, the left inferior pulmonary vein, the left pleura, and the left lower lung lobe were exposed. The LIPLNs could be seen close to the lower edge of the left inferior pulmonary vein, thoroughly dissected (Fig. 2). Next, the assistant lifted the esophagus backward and exposed the field of vision between the esophagus and the lung's right hilum with gastric forceps. The surgeon dissociated the esophagus' anterior margin and dissected the paraesophageal lymph nodes and the right inferior pulmonary ligament lymph nodes.

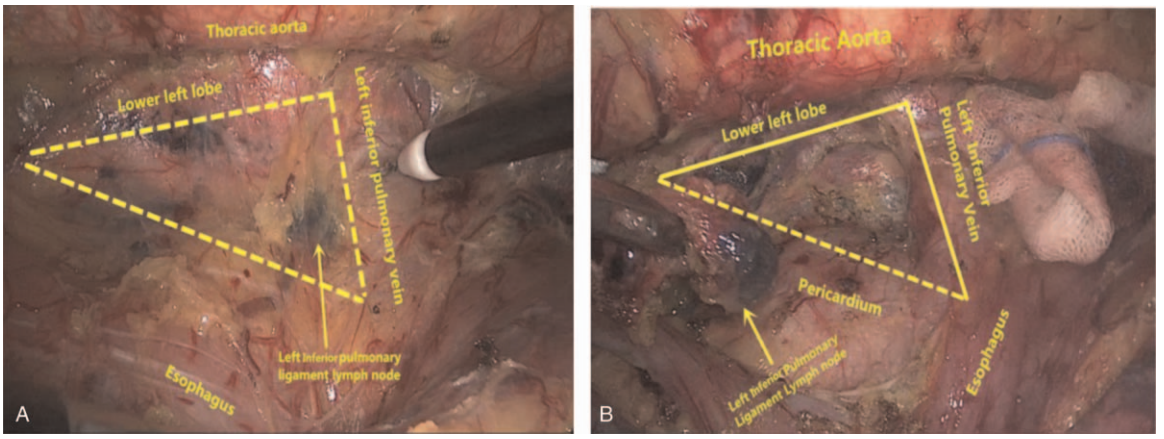

Figure 2. Left inferior pulmonary ligament lymph node dissection within the left inferior pulmonary ligament. (A) Preoperative anatomical structure; (B) postoperative anatomical structure.

2.3. Outcome measures

The outcome measures were as follows: age, sex, preoperative comorbidities, tumor location, postoperative pathologic data, total operative time, operative time of LIPLND, hospitalization days, postoperative complications, and number of LIPLNs dissected.

2.4. Statistics

All statistical analyses were performed using SPSS for Windows version 19.0 (IBM Inc., Chicago, IL).

3. Results

In this study, 30 patients with ESCC were enrolled, including 20 men and 10 women, with an average age of 66.17 ± 7.47 years. Before the operation, there were 5 cases of hypertension, 4 cases of diabetes, and 1 case of coronary heart disease. Preoperative gastroscopy showed 2 cases of SCC of the upper thoracic esophagus, 18 cases of SCC of the middle thoracic esophagus, and 10 cases of SCC of the lower thoracic esophagus; in total, 20 cases involved the lower esophagus. According to the 8th Edition AJCC/UICC TNM staging guidelines, the cases were divided into stages I (n = 8), II (n = 13), and III (n = 9) (Table 2).

There was were left inferior pulmonary vein injuries caused by LIPLND during the operation, no massive bleeding during the operation, and no perioperative deaths (Table 3). The postoperative complications included 2 cases of left pneumothorax caused by left mediastinal pleura rupture due to the LIPLND and 4 pulmonary infection cases. No postoperative chylothorax occurred.

A total of 68 LIPLNs were dissected, 5 of which were positive, and the degree of metastasis was 7.4%. Postoperative pathology showed that 3 cases of LIPLNs were positive, and the metastasis rate was 10.0%. Among them, 2 cases were lower thoracic ESCC, both were stage pT2N1M0 IIIa, and 1 case was middle thoracic ESCC (stage pT3N1M0 IIIb) but involved the lower segment. Figure 3A showed multiple polypoid lesions under endoscopy exam before surgery. Histopathologic examination showed the lesions were squamous cell carcinoma (Fig. 3B) with lymph node metastasis (Fig. 3C).

Table 2

Clinical characteristics.

Characteristics	Patients (n = 30), mean ± SD or n (%)
Age, y	66.17 ± 7.47
Male/Female	20/10 (66.6/33.3)
Tumor location	
Upper/middle/lower	2/18/10 (6.6/60/33.3)
Lower involvement	20 (66.6)
Pathological T stage	
T1/2	7/7 (23.3/23.3)
T3/4	16/0 (53.3/0)
Pathological N stage	
0/1	21/7 (70/23.3)
2/3	2/0 (6.6/0)
Pathological TNM stage	
I/II	8/13 (26.6/43.3)
III/IV	9/0 (30/0)
Preoperative comorbidities	
HD, DM, CHD*	5/4/1 (16.6/13.3/3.3)

* CHD = coronary heart disease, DM = diabetes mellitus, HD = hypertension disease.

Table 3

Postoperative course.

Characteristics	Patients (n = 30), mean ± SD or n (%)
Operative time of LIPLND, min	8.67 ± 2.04
Total operative time, min	358.27 ± 42.26
Postoperative hospitalization days, d	12.23 ± 2.36
Left inferior pulmonary vein hemorrhage	0
Postoperative pulmonary infection	4
Chylothorax	0
Left pneumothorax	2
Perioperative death	0
LIPLND	
Positive number (pieces)	5
Total number (pieces)	68
Metastasis rate*	10%

* Lymph node metastasis rate = patients with positive lymph nodes/total patients.

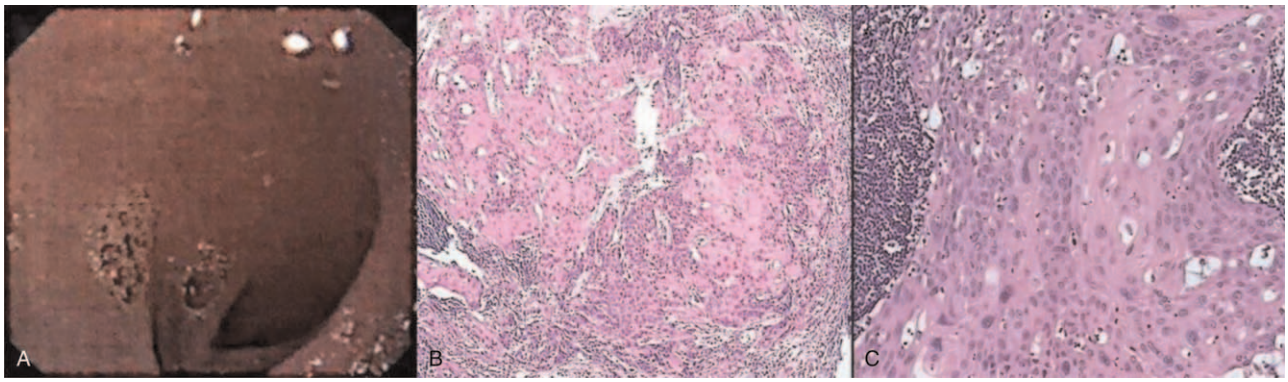

Figure 3. (A) An endoscopy was performed before surgery and showed multiple polypoid lesions. (B, C) Postoperative histopathologic examination showed the lesions were squamous cell carcinoma with lymph node metastasis.

4. Discussion

At present, although the multimodal therapy of esophageal cancer has been increasingly matured and perfected, radical surgery for esophageal cancer remains the first-choice treatment for resectable esophageal cancer.[5,6] Due to the longitudinal and horizontal lymphatic network communication between the esophagus and mediastinum, esophageal cancer has bidirectional and cervical-thoracic-abdominal jumping metastasis characteristics. Moreover, esophageal cancer's multipoint origin naturally leads to mediastinal lymph node metastasis in the early stage.[19,20] Thus, it is difficult to determine the extent of lymphatic metastasis before or during surgery. Therefore, many scholars believe that systemic, standardized, and thorough lymph node dissection plays an essential role in esophageal cancer's postoperative prognosis. Lymph node dissection can prevent residual cancer and reduce tumor recurrence and ensure a satisfactory postoperative pathological TNM stage and guide postoperative adjuvant therapy, which is of great significance for improving patient survival.[11,21]

In recent years, VATS radical resection of thoracic esophageal cancer via the right thoracic approach has gradually become the preferred surgical method for thoracic esophageal cancer because it can completely dissect the upper mediastinal lymph nodes, such as the left and right recurrent laryngeal nerve lymph nodes.[22–24] However, in clinical practice, we found that neglecting the existence of LIPLNs during the radical resection of esophageal cancer or performing incomplete dissection will increase the probability of residual cancer and the possibility of the recurrence of lymph node metastasis.

The Chinese expert consensus on thoracic lymph node dissection in radical resection of esophageal cancer (2017 edition) noted that the LIPLNs were the lymph node drainage area of esophageal cancer and lymph node metastasis of thoracic esophageal cancer has the characteristics of cervical-thoracic-abdominal jumping and extensive metastasis. Therefore, esophageal cancer is prone to metastasize to the LIPLNs.[14,19,20]

Studies[25–27] have shown that the lymph node metastasis rate of LIPLNs is 6.2% to 13.9%. The metastasis degree was 4.5% to 6% in radical resection of esophageal cancer via a left thoracic approach, which was consistent with our study. According to the 8th Edition AJCC/UICC TNM classification of esophageal cancer, N staging is based on the number of positive lymph nodes, so the greater the number of lymph nodes dissected, the less likely it is to miss positive lymph nodes, making N staging more accurate.[14,28,29] Thus, it can be seen that in VATS radical resection of thoracic esophageal cancer via the right thoracic approach, the LIPLNs should be removed as thoroughly as possible to achieve radical resection of the lymph nodes in the mediastinal drainage area.

This study included 30 cases of thoracic ESCC, and 20 cases involved the lower thoracic segment. Three cases were positive, including 2 cases in the lower thoracic segment and 1 case in the esophagus's middle thoracic segment, but the lower segment was involved. Many studies show that according to the rule of lymph node metastasis of esophageal cancer, the lymph node metastasis of lower thoracic ESCC is mainly to the inferior mediastinal and abdominal lymph nodes, and the lymph node metastasis of esophageal cancer also follows the principle of the nearest metastasis.[30,31]

Based on the esophagus's anatomic position, the lower thoracic esophagus is closer to the left lower pulmonary ligament. When esophageal cancer transversely penetrates the esophageal wall, it is more likely to invade the LIPLNs. Therefore, we believe that for patients with ESCC involving the lower thoracic segment of the esophagus, it is necessary to carefully and thoroughly dissect the LIPLNs in a standardized manner. Additionally, in the process of performing thorough LIPLND, the posterior margin space of the lower thoracic esophagus and its surrounding adipose and connective tissue can be freed to ensure radical resection of the lower thoracic segment esophagus. Reducing the residual cancer tissue is helpful, mainly when the tumor focus is located in the lower thoracic segment of the esophagus, reducing the possibility of local recurrence after the operation.

The results showed that the average operative time of LIPLND was 8.67 ± 2.04 minutes, which did not significantly increase the total operation time. Additionally, there were no left inferior pulmonary vein injuries caused by LIPLND, no massive bleeding during the operation, and no significant complications related to LIPLND, such as thoracic duct injury. The postoperative hospital stay was not prolonged. LIPLND does not increase the operation's difficulty, increase the incidence of postoperative complications, or prolong the postoperative hospital stay. Therefore, we believe that during VATS radical resection of esophageal cancer via the right thoracic approach, LIPLND is safe and feasible.

There are several limitations in this study. As an observational cases serial study, there is a limited sample size in the current study. It is necessary to continue to increase the sample size of future studies, clarify the correlation between metastasis of the LIPLNs and the location and depth of invasion of esophageal cancer, and further follow-up evaluates the long-term effects of this approach.

5. Conclusion

In VATS radical esophagectomy via the right thoracic approach, the LIPLNs should be completely removed, especially for patients with ESCC involving the lower thoracic segment; this approach can ensure the extent of resection of the lower segment of the esophagus, reduce the recurrence of tumors, and improve the 5-year survival rate. LIPLND will not increase the operation's difficulty, increase the incidence of postoperative complications, or prolong the postoperative hospital stay. Therefore, we believe that LIPLND is necessary, safe, and feasible and is worthy of clinical popularization and application in VATS radical resection of esophageal cancer via the right thoracic approach.

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