

# A novel method for lymphadenectomy along the left laryngeal recurrent nerve during thoracoscopic esophagectomy for esophageal carcinoma

Yong Xi<sup>1\*</sup>, Zhenkai Ma<sup>2\*</sup>, Yaxing Shen<sup>1</sup>, Hao Wang<sup>1</sup>, Mingxiang Feng<sup>1</sup>, Lijie Tan<sup>1</sup>, Qun Wang<sup>1</sup>

<sup>1</sup>Department of Thoracic Surgery, Zhongshan Hospital of Fudan University, Shanghai 200032, China; <sup>2</sup>Department of Thoracic Surgery, People's Hospital of Yangzhong, Yangzhong 212200, China

*Contributions:* (I) Conception and design: All authors; (II) Administrative support: Zhongshan Hospital; (III) Provision of study materials or patients: L Tan; (IV) Collection and assembly of data: Y Xi; (V) Data analysis and interpretation: Y Xi, Z Ma; (VI) Manuscript writing: Y Xi; (VII) Final approval of manuscript: All authors.

\*These authors contributed equally to this work.

*Correspondence to:* Lijie Tan, MD. Department of Thoracic Surgery, Zhongshan Hospital of Fudan University, 180 Fenglin Road, Shanghai 200032, China. Email: tan.lijie@zs-hospital.sh.cn.

**Background:** Due to limited space in the left upper mediastinum, complete dissection of lymph nodes (LN) along left recurrent laryngeal nerve (RLN) is difficult. We herein present a novel method for lymphadenectomy along the left RLN during thoracoscopic esophagectomy in the semi-prone position for esophageal carcinoma. The method, suspension the esophagus and push aside trachea, allows en bloc lymphadenectomy along the left RLN from the below aortic arch to the thoracic inlet.

**Methods:** Between September 2014 and September 2015, a total of 110 consecutive patients with esophageal carcinoma were treated with thoraco-laparoscopic esophagectomy with cervical anastomosis in the semi-prone position. Outcomes between those who received surgery with the novel method and conventional surgery were compared.

**Results:** Fifty patients underwent the novel method and sixty received conventional surgery. The operative field around the left RLN was easier to explore with the novel method. The estimated blood loss was less ( $23.7 \pm 8.2$  vs.  $34.2 \pm 10.3$  g,  $P=0.001$ ), and the number of harvested LNs along the left RLN was greater ( $6.4 \pm 3.2$  vs.  $4.1 \pm 2.8$  min,  $P=0.028$ ) in the novel method group, while the duration of lymphadenectomy along left RLN was longer in the novel method group ( $28.2 \pm 3.9$  vs.  $20.3 \pm 2.8$  min,  $P=0.005$ ). The rate of hoarseness in the novel and conventional groups was 10% and 16.7%, respectively. No significant difference in postoperative morbidity related to the left RLN was noted between the groups.

**Conclusions:** The novel method during semi-prone esophagectomy for esophageal carcinoma is associated with better surgeon ergonomics and operative exposure.

**Keywords:** Semi-prone esophagectomy; lymphadenectomy; left recurrent laryngeal nerve (RLN); esophageal carcinoma; novel method

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## Introduction

Esophageal cancers are strongly invasive and malignant tumors, and lymph node (LN) dissection is crucial for staging and determining the prognosis associated with

surgical treatment (1-3). In esophageal carcinoma, LN metastasis mostly likely occurs to the neck, mediastinum, and abdomen (4). LNs along the recurrent laryngeal nerves (RLNs) are located at the cervical base continuous to

the upper mediastinum. As a major lymphatic chain into the neck, LNs along the RLNs are thought to be highly involved in metastasis (4,5). In addition, the left RLN can be easily injured during surgery because of its long course from the aortic arch to the neck.

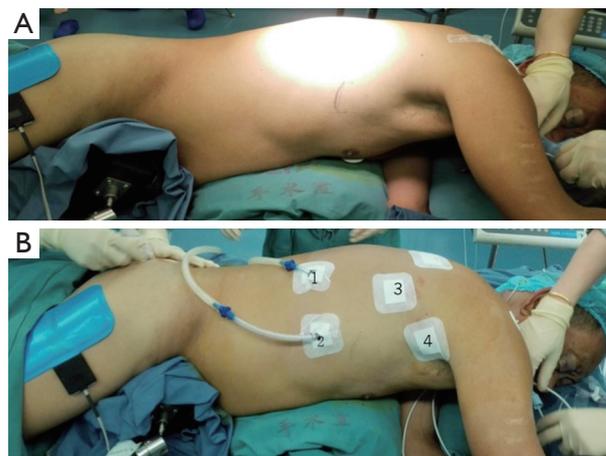
Minimally invasive esophagectomy has been widely acceptable for the advantages of a magnified operative view and less invasiveness since the 1990s (6-9). Compared to the lateral decubitus position, better operative exposure has been demonstrated in the prone position due to the working field formed by gravity and pneumothorax (10-12). Noshiro *et al.* (12) showed thoracoscopic esophagectomy in the prone position provides better surgeon ergonomics and better operative exposure around the left RLN during an aggressive esophagectomy (12). Oshikiri *et al.* (13) reported a method that draws the proximal portion of the divided esophagus and tissue that includes the left RLN and LNs through a gap between the vertebral body and the right scapula to improve lymphadenectomy along left RLN. However, lymphadenectomy along left RLN still thought to be a burdensome step because of limited operative exposure. To achieve a complete dissection of this portion, stable operative views and advanced surgical skill are required.

We herein present a novel method for en bloc dissection of the LNs along the left RLN during thoracoscopic esophagectomy, and retrospectively review the outcomes of this method in the semi-prone position.

## Methods

We retrospectively reviewed the records of 110 consecutive patients with potentially curable thoracic esophageal cancer who received thoracoscopic esophagectomy in the semi-prone position between September 2014 and September 2015. All patients had squamous cell carcinoma located at the esophagus, histologically proven by esophagogastroduodenoscopy. Clinical stage was assessed by thoraco-abdominal enhanced computed tomography (CT), cervical ultrasonography, and endoscopic ultrasonography. Cancer was staged according to seventh edition of the American Joint Committee on Cancer (AJCC) Staging Manual (14). From September 2014 to April 2015, 60 patients received conventional surgery, and from April 2015 to September 2015, 50 patients received surgery with the novel method.

Under a combination of epidural and general anesthesia, a single-lumen endotracheal tube was inserted for ventilation. The patient was initially placed in the semi-



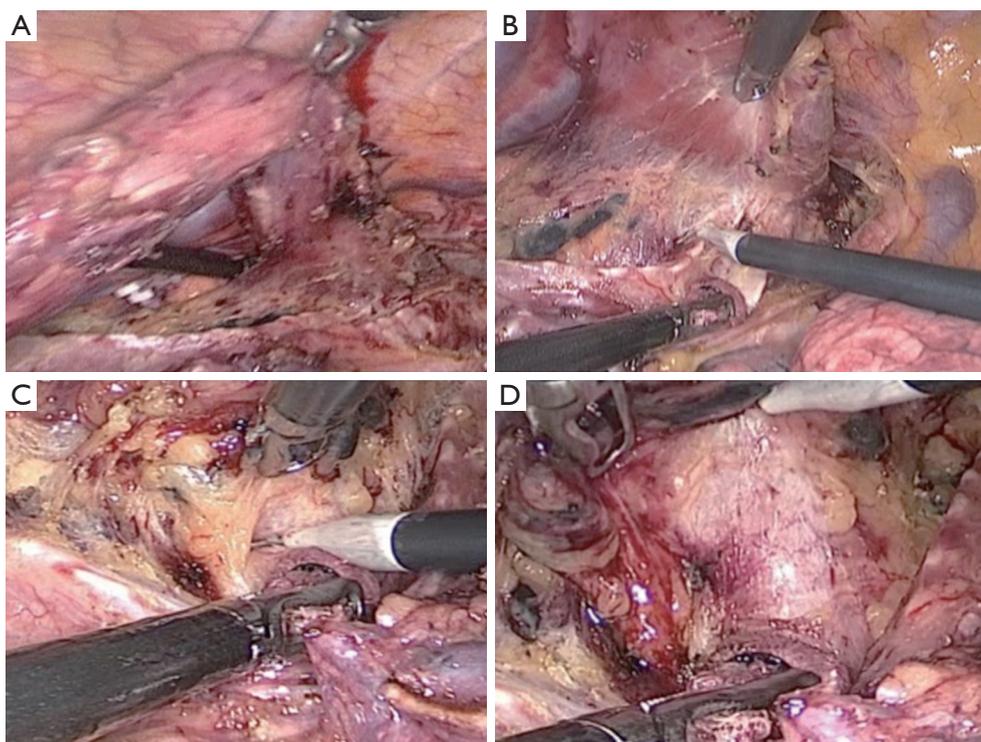
**Figure 1** Semi-prone position. (A) The patient was initially placed in the semi-prone position; (B) the observation port was placed at the seventh intercostal space (ICS) along the mid-axillary line [1], and another 10-mm port was placed at the ninth ICS in the scapular line [2]. Two 5-mm ports were placed at the third ICS along the mid-axillary line [4], and just inferior to the tip of scapula [3].

prone position (*Figure 1A*). To introduce the thoracoscope (30°), an observation port was placed at the seventh intercostal space (ICS) along the mid-axillary line, and another 10-mm port was placed at the ninth ICS in the scapular line. Two 5-mm ports were placed at the third ICS along the mid-axillary line and just inferior to the tip of scapula, respectively (*Figure 1B*).

The chest cavity was inflated with a CO<sub>2</sub> insufflation pressure of 8 to 10 mmHg. All procedures were performed by a surgeon who had performed more than 1,000 minimally invasive esophagectomies with patients in the semi-prone position with conventional extended lymphadenectomy.

## Thoracic surgery procedures

In both conventional and novel method, the upper thoracic esophagus was mobilized from both sides of the mediastinal pleura. The LNs along the RLN were dissected, and the azygous vein was doubly ligated and transected. Circumferential mobilization of the thoracic middle and lower esophagus, with all surrounding mediastinal pleura, peri-esophageal tissues, and LNs was performed. The thoracic duct was carefully preserved. The tissues, including the left RLN and LNs, between the upper esophagus and trachea or bronchus were not released.



**Figure 2** Surgery procedures. (A) Using a traction line, the esophagus was suspended and drawn away from trachea; (B,C) the tissue was released in the area close to the trachea and left main bronchus dissected to the ventral and cranial borders, with the trachea pushed aside by assistant; (D) the left recurrent laryngeal nerve (RLN) and lymph nodes (LN) were easily recognizable.

In the novel method, using a traction line to suspension the incompletely stripping esophagus (*Figure 2A*). Tissues including the left RLN and LNs were extended, which improved the operative exposure. The tissue is released in the area close to the trachea and left main bronchus to dissect the ventral and cranial borders. The trachea was pushed aside by an assistant to exposed surgical field (*Figure 2B,C*). The left RLN and LNs were easily recognizable (*Figure 2D*). First, the LNs below the aortic arch was dissected (*Figure 3A*). The left RLN to the thyroid gland and the LNs along the left RLN were separated using endoscopic scissors, keeping the remaining LNs attached to the esophagus (*Figure 3B*). The tracheoesophageal arteries were identified and ligated. Consequently, en bloc lymphadenectomy along the left RLN was performed (*Figure 3C,D*). Finally, circumferential mobilization of the esophagus was completely performed to cervical region.

In conventional surgery, the tissue surrounding the left RLN and LNs was released from the undivided esophagus proximally, toward the neck. The esophagus needs to be continuously held by the surgeon's left hand to expose the

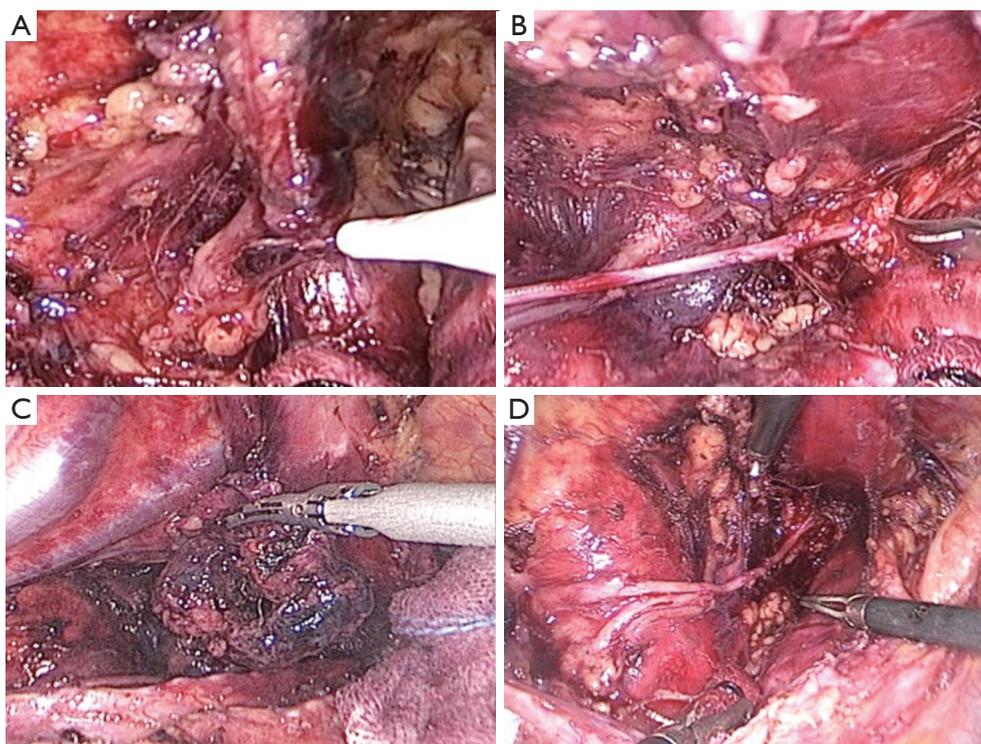
surgical field. Finally, the left RLN is sharply isolated from the explored tissue.

Lymphadenectomy of the entire subcarinal LNs was performed. All thoracic procedures were completed by placement of an intercostal drain and closure of the thoracic incisions.

#### *Data collection and statistical analysis*

Data collected included patient demographic information, the operative time for the lymphadenectomy along the left RLN and for the entire thoracic procedure, estimated blood loss, the number of harvested LNs during the entire thoracic procedure and along the left RLN, perioperative morbidity related to the left RLN, and the duration of postoperative hospital stay. Data were compared between the two groups.

Data collected were recorded in Microsoft Excel for further processing. All statistical analyses were performed using SPSS version 22.0. Student's *t*-test and chi-square test were used to compare categorical variables, as appropriate



**Figure 3** Surgery procedures. (A) The inferior lymph nodes (LN) of the aortic arch were dissected; (B) exposure of the left recurrent laryngeal nerve (RLN) to the thyroid gland and the LNs along the left RLN were separated using endoscopic scissors, with the LNs remaining attached to the esophagus; (C) en bloc lymphadenectomy along the left RLN was performed; (D) preservation of the left RLN was confirmed.

**Table 1** Clinicopathological characteristics of the two groups

Groups	Novel method	Conventional method	P
Number	50	60	
Age (years)	63.2±6.6	62.9±8	0.795
Sex (male/female)	42/8	47/13	0.451
Location of primary tumor (upper/middle/lower)	15/23/12	16/30/14	0.903
Depth of tumor invasion (T1/T2/T3/T4)	20/13/16/1	21/16/23/0	0.69
AJCC stage (0-I/II-IV)	21/29	28/32	0.701
Preoperative therapy	5	7	1

AJCC, American Joint Committee on Cancer.

The Mann-Whitney test was used to compare continuous variables. A two-sided P value <0.05 was considered to be statistically significant.

## Results

Patient and tumor characteristics are shown in *Table 1*. No significant differences were found between the two

groups in age, sex, tumor location and depth, stage, and preoperative therapy (*Table 1*). Conversion to open surgery and intraoperative morbidity related to the left RLN did not occur in either group. During the thoracic procedure, there was no significant difference between the groups in the total operative time (chest) (61.5±7.8 vs. 53.5±6.7 min, P=0.13), while the operative time for lymphadenectomy along the left RLN was significantly longer in the novel

**Table 2** Surgical outcomes of the two groups

Groups	Novel method [%]	Conventional method [%]	P
Number	50	60	
Operative time (min)			
Chest	61.5±7.8	53.6±6.7	0.130
Dissection along the left RLN	28.2±3.9	20.3±2.8	0.005
Blood loss during the thoracic procedure (g)	23.7±8.2	34.2±10.3	0.001
Conversion to open surgery	0	0	
Number of harvested LNs			
Chest	27.6±7.2	25.7±10.8	0.300
Along the left RLN	6.4±3.2	4.1±2.8	0.028
Metastasis of LN s along the left RLN	11 [22]	8 [13.3]	0.231
Postoperative morbidity related to the left RLN			
Hoarseness	5 [10]	10 [16.7]	0.310
Aspiration	1 [2]	1 [1.7]	0.896
Postoperative hospital stay (d)	15.4	16.8	0.875

RLN, recurrent laryngeal nerve; LN, lymph node.

method group than in the conventional method group (28.2±3.9 vs. 20.3±2.8 min, P=0.005). The number of harvested LNs along the left RLN in the novel method group was significantly less than in the conventional surgery group (6.4±3.2 vs. 4.1±2.8 min, P=0.028). Blood loss during thoracic procedures in the novel method group was significantly less than in the conventional surgery group (23.7±8.2 vs. 34.2±10.3 g, P=0.001). There was no significant difference of postoperative morbidity related to the left RLN and duration of the thoracic procedure between the groups. Hoarseness occurred in 10% of patients in the novel method group, and in 16.7% of patients in the conventional method group (P=0.31). None of the other operative results were significantly different between the two groups (Table 2).

## Discussion

In this study, the novel method significantly increased the number of harvested LNs along the left RLN, and was associated with decreased blood loss compared to the conventional method. The survival rate has been shown to be significantly better in extensive three-field dissection than two-field dissection for patients with esophageal carcinoma (4,15,16). The rationale for the aggressive procedure is based on high involvement of LNs along the RLN, and survival is significantly improved by radical dissection of

these nodes (17,18). Completely lymphadenectomy of these nodes is recommended; however, significant postoperative morbidity and mortality are associated with this procedure (15,19). When the operative field is sufficiently exposed, lymphadenectomy in this area can be performed precisely and accurately through strictly defined and traced.

Minimally invasive esophagectomy via a thoracoscopic procedure is associated with less operative blood loss, fewer respiratory complications, and preserved respiratory vital capacity (11,20,21). However, complete dissection of the LNs along the left RLN during thoracoscopy is challenging and requires substantial technical skill. In the left upper mediastinum there are three important anatomical structures: the left RLN, which should be preserved; LNs, which should be dissected; and the left tracheoesophageal artery, which should be cut. These structures intermingle in limited working space, which complicates lymphadenectomy along the left RLN. The left RLN can easily injured during this procedure because of its long course from the aortic arch to the neck. Therefore, it is necessary to understand the interrelationship of these three anatomical structures, and their logical separation (13). In addition, the layer including the thoracic duct should be preserved.

In thoracoscopic procedures, the magnified operative view can enhance meticulous dissection of LNs, thereby preserving mediastinal structures. It is difficult to achieve satisfactory operative exposure with a patient in

the left lateral decubitus position during thoracoscopic esophagectomy because mediastinal organs and structures are shifted to the left, the right lung is collapsed by single lung anesthesia and overlies the esophagus, and exudates collect in the posterior mediastinum of the operative field. The surgeon's hand-eye coordination hard to obtain smoothly if the assistant exposes the operative views not quickly and correctly. In the prone position with an artificial pneumothorax, mediastinal structures are exposed spontaneously and exudates accumulate in the right anterior thorax, not in the operative field (10-12). Nevertheless, disadvantages of the prone position include the need of an assistant help to expose the operative field, emergent or elective conversion to open surgery, and endotracheal tube displacement. Some have suggested that the prone position is unsuitable for patients who received neoadjuvant chemoradiotherapy and for those with large tumors adjacent to neighboring organs (12,22,23). The semi-prone position not only maintains the advantages of the prone position, but also overcomes some of the disadvantages. The collapsed lung and structures are exposed spontaneously and exudates accumulate in the right anterior thorax. In addition, it is easier to manage displacement of the endotracheal tube.

The left RLN, LNs along the left RLN, and the tracheo-esophageal and primary esophageal arteries are integrated in a two-dimensional membrane in the left upper mediastinum (13). During conventional surgery, the esophagus needs to be continuously held by the surgeon's left hand. The operative exposure is unsatisfactory, and distinguishing the left RLN and lymphadenectomy are difficult. However, with the novel method the esophagus is simply drawn away from trachea, the working space and operative field between esophagus and trachea is extended, the left RLN is easier to distinguish from the LNs, and the trachea-esophageal artery can be reliably ligated. In addition, the surgeon's left hand is freed and lymphadenectomy along the left RLN easier and safer.

During lymphadenectomy along the left RLN, the operative time in the novel method group was significantly longer than in the conventional group. Better operative exposure was not associated with shortened operative time in this series. The initial learning curve does not appear to prolong the operative time. The chief surgeon in this study had performed over 1,000 cases of thoracoscopic esophagectomy in the semi-prone position (24). The main reason for the prolonged operative time was that it took more time to dissect the LNs completely and remove them en bloc. Furthermore, we should assess specific measurements of task performance or surgeon fatigue in

future studies to advocate improved surgeon ergonomics.

## Conclusions

In conclusion, the novel method for en bloc dissection of LNs along the left RLN with the patient in the semi-prone position is technically safe and feasible, and provides good surgeon ergonomics and excellent operative exposure. During lymphadenectomy along the left RLN, blood loss was less and the number of harvested LNs along the left RLN was greater in the novel method group. We believe complete en bloc dissection of the LNs along the RLN by thoracoscopy in the semi-prone position may possibly improve long-term outcomes.

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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