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Lymph Node Dissection along the Recurrent Laryngeal Nerve in Video-Assisted Thoracoscopic Surgery (VATSE) for Esophageal Squamous Cell Carcinoma

Hiroshi Makino, Hiroshi Yoshida and Eiji Uchida

Additional information is available at the end of the chapter

Abstract

Esophageal carcinoma is the ninth most common cancer in the world, which is frequently seen in Asia and east Africa. Around 80% of all cases occurred in less-developed regions. Two major histological subtypes of esophageal carcinoma, adenocarcinoma and squamous cell carcinoma, are known to differ greatly in terms of risk factor, epidemiology, male to female ratios, and incidence. Lymph node metastasis is a crucial factor in staging and prognosis is associated with surgical treatment and a major lymphatic chain into the neck. Esophageal adenocarcinoma (EAC) is mainly detected at the lower third of the thoracic esophagus or esophago-gastric-junction (EGJ) and metastasizes mainly to lymph nodes of the lesser sac, celiac regions and lower mediastinal. Esophageal squamous cell carcinoma (ESCC) has a predilection for metastasis to the lymph nodes of the cervical region including recurrent laryngeal nerve (RLN) on both sides. Lymph node dissection is vital yet difficult, left-side lymph node dissection especially requires expertise. There are some reports on lymph node dissection in the prone position by video-assisted thoracoscopic surgery of the esophagus (VATS-E) along the left RLN in Japan and China. We also introduce a stripping method for lymph node dissection in this site.

Keywords: recurrent laryngeal nerve, lymph node dissection, video-assisted thoracoscopic surgery (VATS-E)

1. Introduction

Esophageal carcinoma is strongly invasive and is accompanied by numerous malignant tumors. It is mainly seen in Asia and East Africa. In the eastern countries, especially in Japan, extended lymph node dissection, including the abdominal, upper, middle, lower mediastinal,

and occasionally cervical lymph nodes, is suggested as a standard surgical method because systematic dissection of metastatic lymph nodes is thought to improve survival and lead to cure.

Consequently, recommending complete lymphadenectomy of the upper mediastinum is an essential component in radical esophagectomy for esophageal squamous cell carcinoma (ESCC). Three-field lymphadenectomy (3FL) is the ultimate surgical procedure in the pursuit of complete lymph node dissection for thoracic esophageal cancer. However, lymph node dissection along the recurrent laryngeal nerve (RLN) is difficult because severance of nerves by electrical devices can easily lead to paralysis [1, 2].

The prone position provides better visualization in the subaortic arch and subcarinal and supraphrenic regions, but the working space in the left upper mediastinum for dissecting the lymph nodes along the left recurrent laryngeal nerve is limited. Some investigators, including us, have shown how to obtain a good operative field in the upper mediastinum for lymph adenectomy. Osugi reported that tracheobronchus must be retracted ventrally to visualize the left side of the trachea and developed the retractor that provides exposure of the entire mediastinum and esophagus in left lateral position [3]. In eastern countries, surgeons also describe lymphadenectomy along the left recurrent laryngeal nerve, but few surgeons in western countries have discussed lymphadenectomy of esophageal adenocarcinoma (EAC). Here, we describe differences in lymph node metastasis between ESCC and EAC and procedures for lymph node dissection along the recurrent laryngeal nerve in ESCC.

2. Etiological differences between esophageal squamous cell carcinoma (ESCC) and esophageal adenocarcinoma (EAC)

Esophageal carcinoma is seen in two major histological subtypes: adenocarcinoma and squamous cell carcinoma (SCC). These subtypes are very different in terms of risk factors and epidemiology. According to GLOBOCAN 2012, there were an estimated 400,000 cases of ESCC and 50,000 cases of EAC of the esophagus in 2012 worldwide [4].

2.1. Global incidence of ESCC

In 2012, the global incidence of ESCC was 5.2 per 100,000 people. Most affected regions were located in Eastern and South-East Asia, followed by sub-Saharan Africa and Central Asia [4]. About 80% of global ESCC cases occur in Central and South-East Asian regions. China alone provided more than 50% of the global cases. Areas of high incidence of ESCC have been identified in Northern Iran, Central Asia, and China (together forming the so-called "esophageal cancer belt") as well as parts of Eastern Africa. ESCC is more common and the rate of ESCC is about 95% in Japan [3].

2.2. Risk factor of ESCC

Generally, chronic inflammation of the esophageal mucosa is postulated to increase the risk of ESCC. Two major risk factors are smoking and alcohol consumption, which have been found

to account for more than 75% of all SCC cases in high-income countries [5]. On the other hand, frequent consumption of extremely hot beverages is a common risk factor for ESCC in less-developed regions [4]. Consumption of hot mate drinks in Latin America and hot beverages in Southern China are associated with the risk of ESCC [4, 5].

In Iran, opium use has been found to increase mortality from esophageal cancer by 50%. High-incidence areas in Africa suggest that smoking, occupational exposures and nutritional deficiencies may be responsible for the high burden of ESCC [4].

Alcohol drinking is a well-established risk factor for esophageal cancer. International Agency for Research on Cancer (IARC) referred to acetaldehyde, an oxidative metabolite of ethanol, as a potential causative agent behind alcohol-induced carcinogenesis based on evidence of inter-action between alcohol consumption and acetaldehyde dehydrogenase (ALDH2) enzyme gene polymorphisms [6, 7]. Oze et al. showed that acetaldehyde dehydrogenase Glu504Lys polymor-phism had strong effect modification with alcohol drinking and concluded that there is con-vincing evidence that alcohol drinking increases the risk of esophageal cancer in the Japanese population [8]. Half of the Japanese population is heterozygous or homozygous for the *2 allele of ALDH2, showing respectively, peak blood acetaldehyde concentrations in post-alcohol consumption 6- and 19-fold higher than homozygous wide-type individuals [9]. As a result, ALDH2*2/*2 homozygous carriers show facial flushing and nausea after alcohol consumption that deters them from drinking, whereas heterozygotes exhibit less severe reactions [9]. Fang et al. indicated that individuals heterozygous for the *2 variant allele of aldehyde dehydrogenase 2 (ALDH2*1/*2) frequently detected in Asia had an increased risk of esophageal cancer, espe-cially among heavy drinkers, because inactive ALDH2 fails to metabolize acetaldehyde rapidly, leading to excessive accumulation of acetaldehyde in blood and repeated high exposure to acet-aldehyde after drinking. Drinking clearly modifies the effect of ALDH2 on esophageal cancer risk in Asians [6].

2.3. Global incidence of EAC

The global incidence of EAC is 0.7 per 100,000 people. Highest incidence rates by region were found in Northern and Western Europe, North America, and Oceania [4]. On the national level, the highest rates were seen in the UK, the Netherlands, Ireland, Iceland, and New Zealand. The burden of AC is the highest in Northern and Western Europe, North America, and Oceania, accounting for 46% of all global AC cases [4, 10, 11].

2.4. Risk factor of EAC

The strongest known risk factor for EAC is gastroesophageal reflux disease and its more severe manifestation, Barrett's esophagus (BE). Obesity promotes the development of gastro-esophageal reflux and also acts as an independent risk factor for EAC.

In North America and Northern and Western Europe, prevalence of *Helicobacter pylori* (H pylori) infection is among the lowest and incidence of EAC is higher [4, 10, 11].

Helicobacter pylori (H pylori) lowers gastric acid secretion and decreases gastric esophageal reflux [10, 11]. In more recent years, prevalence of the latter has leveled out in high-prevalence countries such as the Netherlands and the UK [4].

3. Clinical difference between EAC and ESCC

3.1. Location of ESCC and EAC

In 50–60% of cases, ESCC is located in the middle third thoracic esophagus in Thailand, Iran, and Japan [3, 12, 13, 14]. About 60% of SCCs is also located in the middle third of the esophagus in Iran. Several studies have found that ESCC was most commonly located in the lower third of the esophagus, such as studies conducted in Ghana [15].

In 80% of cases, EAC is located at the gastroesophageal junction (GEJ) and 20% in the lower third thoracic esophagus. This entity is capable of producing EAC directly or, more commonly, through an intermediate pre-neoplastic lesion or Barrett's esophagus (BE). BE is a pre-malignant lesion that develops in 6–14% of patients with Gastroesohageal reflux disease (GERD), of which approximately 0.5–1% will develop EAC [10, 11]. Increased incidence of BE in the past 30 years correlates with an increased incidence of EAC during the same period.

4. Clinical difference of lymph node metastasis between ESCC and EAC

4.1. Lymph node metastasis of ESCC

Udagawa et al. showed that it was necessary to dissect the cervical lymph nodes, particularly for tumors located in the upper and middle thoracic esophagus [2]. Bilateral cervical para-esophageal node dissection is predominantly effective and the inclusion of these stations in the regional lymph nodes is justified in the 7th TNM classification. The lower jugular or supraclavicular region lymph nodes are also important. Abdominal lymph node dissection is also effective, but the effectiveness is limited in upper esophageal cancer. The statistical efficacy index (EI) of individual lymph node stations according to the main tumor location, a more precise modification of the range of lymph node dissection is possible. Although mediastinal nodes are important in general, not all are located in the esophageal drainage area. Some specific stations such as pretracheal, left tracheobronchial, and supradiaphragmatic show least efficacy by dissection. The mediastinal node stations can be re-arranged such as recurrent laryngeal, paraesophageal, posterior mediastinal, subcarinal, and subbronchial in order, according to EI. The number of metastatic lymph nodes may be a better prognostic factor than Japanese N grading. The Japanese N-grouping seems to be more efficient for predicting of the radical and safe operation. It is difficult to detect lymph node metastasis clinically. Japanese N-grouping may be also more available in stage assessment because a single obvious distant lymph node metastasis in Japanese N-group can correctly identify a higher staging. Japanese Surgeons are afraid that discussion about lymph node dissection with precision is no longer possible if meticulous node grouping based on detailed data of lymph node stations is once discontinued.

Ma et al. stated that 3FL improves overall survival rate but has more complications. Because of the high heterogeneity among outcomes, definite conclusions are difficult to draw [16].

4.2. Lymph node metastasis of EAC

Sepesi et al. reported 72% of patients presented with clinically involved lymph nodes showed metastasis in the lesser sac (perigastric/perihepatic) [17]. However, 11% of patients had metastatic lymph nodes located at the celiac artery, and 10% had nodal disease in the paratracheal region. Ninety-eight patients demonstrated clinical metastatic involvement in one or two nodal basins (example: perigastric and paratracheal); only about 2% of patients presented nodal disease in three nodal basins. Feith et al. reported the prevalence and number of lymph node metastases according to pT category in patients with primary resected Barrett's carcinoma. A strong correlation between the pT category and the presence and the number of lymph node metastases was detected [18]. Lymph node metastases in more than 95%of the patients was detected in the lower posterior mediastinum, in the bilateral paracardiac region, or in the region of lesser curvature and left gastric artery of the abdomen. Prevalence of lymph node metastases at the various topographic locations in relation to the T category of the underlying Barrett's carcinoma is shown. As T category increases, prevalence of regional lymph node metastases also markedly increases. Lymph node metastases to more distant locations, such as the tracheal bifurcation region, the proximal mediastinum, or celiac axis, lagged behind and were common only in patients with more advanced primary tumors. This suggests that lymphatic spread occurs in an orderly fashion. Patients who had many lymph nodes metastasis had distant lymph node metastasis in the upper mediastinum and tracheal bifurcation area that can be reached by a transthoracic approach [19]. According to an increasing number of lymph nodes metastasis, positive lymph node metastasis in the upper mediastinum and carinal region also increased. Prevalence of lymph node metastases at the celiac axis was also detected with increasing number of lymph nodes metastasis. There was significantly frequent lymph nodes metastasis in the upper mediastinal, carinal or celiac regions among patients with more than three positive regional nodes. Overall, skipping of regional lymph node stations, positive distant nodes in the absence of positive regional nodes, was seen in less than 5% of the patients.

Yamashita et al. reported clinical records of 2807 EGJ carcinoma patients without preoperative therapy in Japan [20]. There are obvious unbalances in terms of lymph node dissection rate according to histology and the main tumor location. Lymph nodes metastasis frequently involved abdominal lymph nodes. Lymph nodes at the right and left cardia, lesser curvature and along the left gastric artery were especially metastasized. Lymph nodes along the greater curvature of the stomach were not frequently metastatic, and advantage of dissection seemed unlikely. Lower mediastinal node dissection may contribute to improved survival for patients with esophagus-predominant EGJ carcinoma. However, due to low dissection rates for nodes of the middle and upper mediastinum, no conclusive results have been obtained regarding the optimal extent of nodal dissection in this region.

5. Lymph node metastasis along the recurrent laryngeal nerve

Extensive lymphadenectomy with esophagectomy for esophageal carcinoma improves the prognosis in Japan. In particular, lymph nodes along the RLN are considered as significantly important lymph nodes those are recommended to be completely dissected. However, lymph node along the RLN dissection complicates high morbidity and mortality. Udagawa et al. showed lymph node metastasis along the rt. RLN and cervical paraesophageal at a rate of 31.9, 22.2%, 19, 13.9%, and 14.7, 12.4% of upper, middle, and lower thoracic esophagus, respectively. Lymph node metastasis along the lt. RLN and cervical paraesophageal was found at a rate of 19.1, 20.1%, 14.1, 8.3%, and 8.1, 5% of upper, middle, and lower thoracic esophagus in Japan, respectively [2]. Ye et al. reported that the recurrent laryngeal nerve lymph node metastasis from esophageal carcinoma is detected at the rate of 34.2% in China [21]. Lymph node metastasis along the recurrent laryngeal nerve was detected, and the rate of lymph node metastasis was 23.4%. The rate of rt. RLN lymph node metastasis was 20.8%, which was slightly higher than the rate of lt. RLN lymph node metastasis which had a rate of 15.8%.

5.1. ESCC

In ESCC, lymph node metastasis is possible to occur in the neck, mediastinum, and abdomen. The location of RLN lymph node is from the upper mediastinum and to the cervical region, where lymph node metastasis is frequently detected in thoracic ESCC. Early, initial and micro metastasis of ESCC often occur and RLN lymph node metastasis has been regarded as an indication for three-field lymphadenectomy in the surgical treatment of ESCC. More importantly, RLN metastasis has been shown to be a strong predictor of poor prognosis in ESCC.

There are many reports about lymph node metastasis along the recurrent laryngeal nerve in Asia. In Japan, Igaki et al. reported that cervical or celiac lymph node metastasis in patients with carcinomas of the lower thoracic esophagus should be distinguished from pathologic M1 status in the UICC-TNM staging system [1].

5.2. EAC

Giacopuzzi et al. reported that in Siewert type I tumors, when standard mediastinal lymphadenectomy is performed, about half of the node-positive patients show positive nodes in mediastinal stations [22]. Specifically, upper and mid mediastinal lymph node metastases (right paratracheal, subcarinal, aortopulmonary window) were reported in up to 25% of patients. When the few studies in which cervical nodes are also removed are considered, a non-negligible incidence of metastases is detectable, but, due to the scarcity of available data and the higher complication rate of three-field dissection, this is not currently thought to be relevant in clinical practice. Mediastinal nodes are involved in about 30% of Siewert type II cases. Although most of the positive nodes occur at lower stations, the rate of metastasis detected in the upper-mid mediastinum after transthoracic esophagectomy ranges between 8 and 22% [22].

6. Lymph node dissection along the recurrent laryngeal nerve

6.1. ESCC

Surgeons in Asia, where the rate of ESCC is higher, perform lymphadenectomy along the recurrent laryngeal nerve. Udagawa et al. reported that cervical lymph node dissection had high efficacy index (EI) in upper and middle thoracic esophageal cancer but a low EI in lower esophageal cancer. Cervical lymphadenectomy for lower esophageal cancer showed some but limited efficacy only in cervical paraesophageal stations [2]. Three-field lymph node dissection may be indicated even for patients with clinical Stage I ESCC requiring surgical intervention because this surgical procedure offers possible cure by removing unsuspected lymph node metastasis. Altorki et al. also mentioned that three-field lymph node dissection with esophagectomy can involve with a low mortality and reasonable morbidity. Unsuspected metastases to the lymph nodes along the RLN and cervical region are present in 36% of patients in spite of histological tumor type or tumor location of the esophagus [23].

Osugi et al. reported that video-assisted thoracoscopic surgery (VATS), a less invasive method that preserves curability, provides comparable results to open radical esophagectomy. Palanivelu et al. demonstrated the lymph node dissection along the recurrent laryngeal nerve in prone position to be effective [24].

6.2. EAC

Lagergren et al. indicated that the extent of lymphadenectomy during surgery for esophageal carcinomas which include 83.5% adenocarcinoma may not influence 5-year all-cause or disease-specific survival [25]. These results challenge current clinical guidelines.

Feith et al. showed that a transthoracic approach followed by an extended lymph node dissection in the upper mediastinum is not recommended in patients with adenocarcinoma of the distal esophagus. Conservative surgical resection due to the virtual absence of lymph node metastasis in the upper mediastinum can cure patients with high-grade dysplasia and pT1a carcinoma. In addition systematic lymph node dissection of the lower posterior mediastinum and upper abdominal compartment can improve the prognosis in patients with more advanced tumors and a limited number of regional lymph node metastases. A transmediastinal approach with a wide splitting of the esophageal hiatus can achieve this radical lymph node dissection in the lower posterior mediastinum and upper abdominal compartment. Multimodal treatment protocols including chemotherapy and irradiation on systemic therapy are considered to be more appropriate for patients with more extensive lymph node metastases [25].

Cuscheri et al. recommended placing the patient prone to clear the posterior mediastinum, thus avoiding lung compression, but did not demonstrate lymph node dissection along the recurrent laryngeal nerve in EAC patients [26].

6.3. Lymph node dissection along the rt. recurrent laryngeal nerve

Thoracoscopic lymph node dissection along the right (rt.) recurrent laryngeal nerve has been more readily demonstrated by various authors. The rt. recurrent laryngeal nerve LN is removed as follows: the location of the right vagal nerve and the right inferior subclavian artery are confirmed. The airway behind the mediastinal pleura is opened to expose the right subclavian artery. The rt. recurrent laryngeal nerve is separated from the right vagal nerve followed by blunt dissection of the right recurrent laryngeal nerve through the vagus nerve trunk at the level of the right subclavian artery. We performed VATS-E in prone position (**Figure 1**). The surrounding LNs and fatty tissues are subsequently removed from the right recurrent laryngeal nerve [27] (**Figure 2**).

To reduce the risk of paralysis, an electric device is used to separate the nodes from the recurrent laryngeal nerve within 2 s [27].

6.4. Lymph node dissection along the lt. recurrent laryngeal nerve

Lymph nodes along RLNs are thought to be significantly involved by carcinoma cells as well as a main lymphatic chain to the neck, and complete dissection of these nodes is recommended. However, a lymphadenectomy, especially along the left RLN by thoracoscopic esophagectomy, is considered to be a burdensome step due to difficult operative exploration at the left upper mediastinum. To achieve a precise dissection of this portion, stable operative views and technical feasibility are necessary. Noshiro et al. mentioned that in their lymphadenectomy procedure along the left RLN, performing a thoracoscopic esophagectomy in the prone position had advantages compared to surgery in the left lateral decubitus position [27]. They introduced such details, during the procedure, the trachea is rolled back carefully and firmly to the right and ventrally by a grasper holding small gauze to explore the left aspect of the trachea and the left bronchus. The tissue, including the left RLN and lymph nodes, is
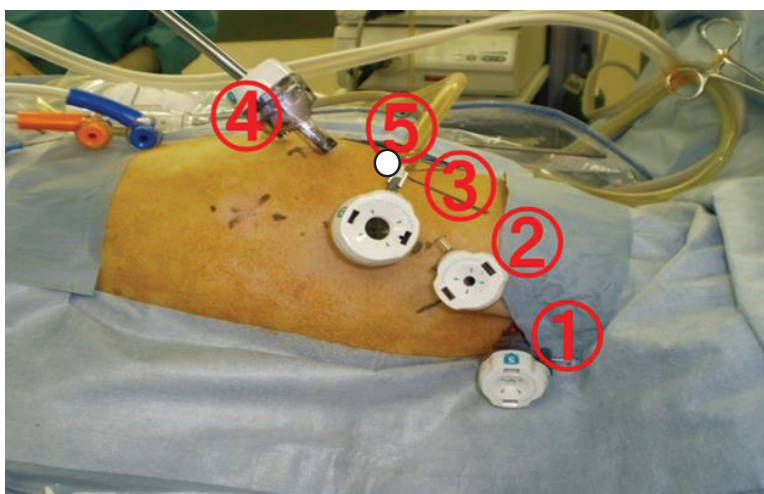

Figure 1. Port site in prone position. 3rd ICS, middle A.L.(1), 5th ICS, posterior A.L.(2), 7th ICS, posterior A.L.(3), 9th ICS, SSCL(4), 7th ICS, SSCL(5). ICS: inter costal space, AL: axillary line, SSCL: subscapular line.
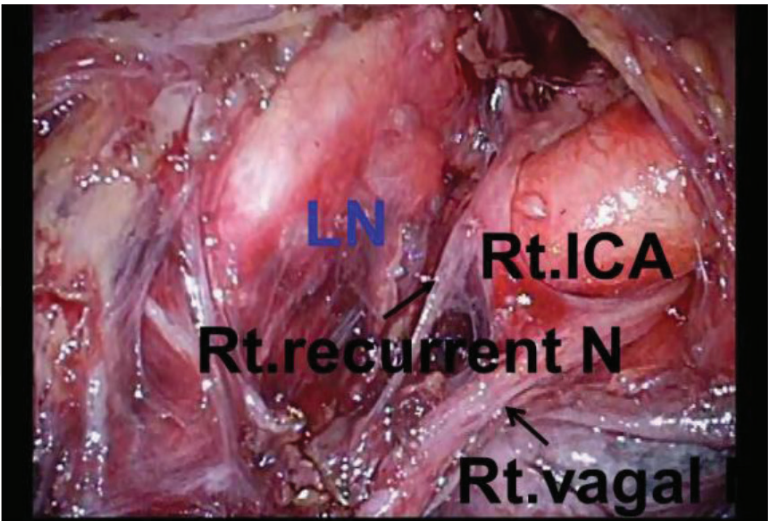
Figure 2. Lymph node dissection along the rt. RLN.

dissected sharply just along the trachea and the left bronchus to make a ventral border of dissection. Finally, the left RLN is sharply isolated from the explored tissue without using an electric device to avoid injury by electricity or heat, and the lymph nodes were consequently dissected in an en-bloc fashion accompanied with the divided thoracic duct.

However, dissecting the lymph nodes along the left RLN during VATS is challenging and requires significant technical skill, and there is limited working space in the left upper mediastinum for dissecting the lymph nodes along the left RLN and expertise in dissection is required. The technique of lymph node dissection along the lt. RLN in VATS-E has been demonstrated by some authors (**Table 1**).

We have previously reported a "Stripping method" to overcome this disadvantage in prone position [28]. Therefore, we considered stripping the esophagus toward the neck to remove the esophagus. Both the esophagus and stomach tube in the upper mediastinum are cut apart from the tumor by a linear stapler after isolating the esophagus (**Figure 3A**). The residual esophagus is stripped in the reverse direction and retracted toward the neck when the stomach

Method		Position
Stripping method	Makino et al. [28, 29]	Prone position
Bascule method	Oshikiri et al. [30]	Prone position
Suspension method	Xi et al. [31]	Prone position
Suspension method	Zheng et al. [32]	Prone position
LN dissection of hybrid position	Kaburagi et al. [33]	Hybrid position
Looping method	Lin et al. [34]	Prone position
Mediastinoscopic LN dissection	Fujiwara et al. [35]	Spine position

Table 1. Methods of lymph node dissection along the RLN.
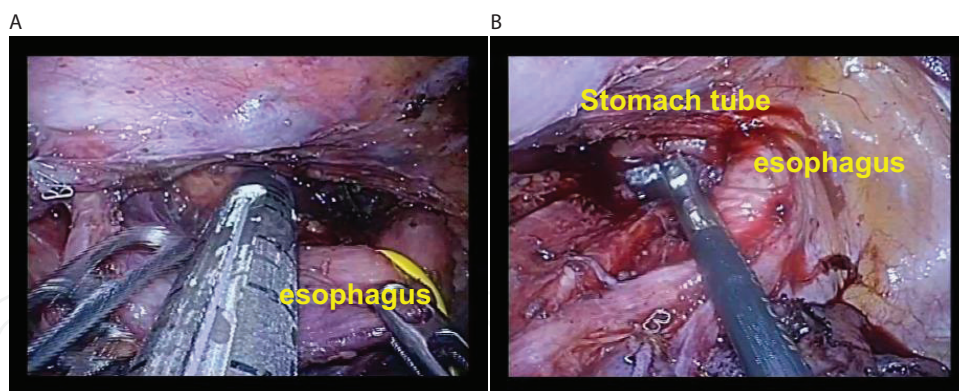
Figure 3. (A) Cutting both the esophagus and stomach tube. (B) Stripping by pulling the stomach tube.
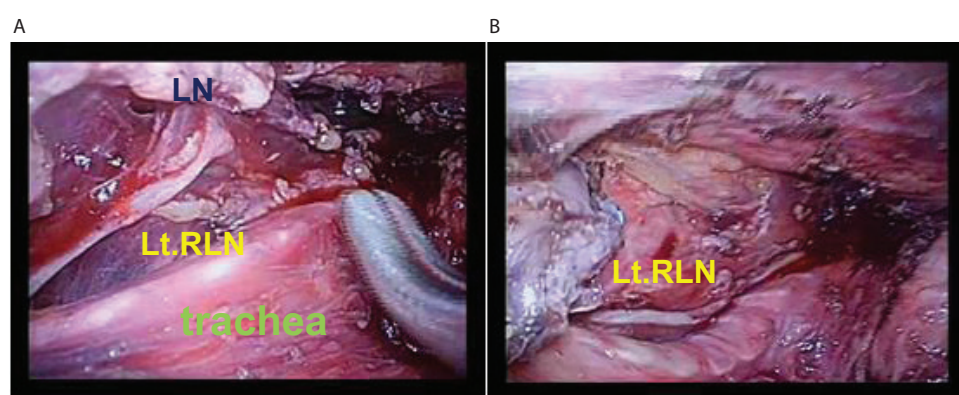

Figure 4. (A) Lymph node dissection along the lt. RLN. (B) After LN dissection along the lt. RLN.

tube is removed through the nose by anesthesiologist (**Figure 3B**). The wide operative field of left upper mediastinum is possible using this stripping technique. Lymph node dissection is performed after stripping the residual esophagus [28, 29] (**Figure 4A**). Moreover, working space is created by compressing the right main bronchus or retracting the trachea using a retractor. Lymph node and fat tissue are ablated from the left edge of the trachea, after which lymph node along the left RLN is dissected (**Figure 4B**). An electrical device is used to separate the node from the nerve, and endoscopic scissors and forceps are used during sharp dissection along the nerve. One hundred patients with esophageal carcinomas underwent VATS-E (27 in left lateral position and 73 in prone position). This original technique of lymphadenectomy along the left RLN has been performed in 54 patients in the prone position VATS-E. The rate of transient recurrent laryngeal nerve palsy is 17.2%, but permanent palsy is only 1.2% [29].

Oshikiri et al. developed the "Bascule method" where the proximal portion of the divided esophagus and tissue that includes the left RLN and lymph nodes are drawn through a gap between the vertebral body and the right scapula [30]. The membranous portion between the esophagus and the trachea like the esophageal mesenteriolum is ablated by traction of the tissue including the left RLN and lymph nodes along the left RLN by the proximal esophagus. The lymph node along the left RLN is distinguished from the left RLN and the tracheoesophageal artery on the posterior side of the left RLN can be detected and easily cut by this traction

technique. The esophageal mesenteriolum is possibly drawn by taping of the entire length of the undivided esophagus. However, there is a limit to the amount of retraction. Division of the esophagus increases the amount of retraction possible, allowing for further drawing and development of the operative field.

Xi et al. and Zheng et al. showed an esophageal suspension method in scavenging peripheral lymph nodes of the lt. RLN. In this method, a traction line is used to suspend the incompletely stripped esophagus [31, 32]. Tissues including the left RLN and lymph nodes were extended, which improved operative exposure. Tissue is released in the area close to the trachea and left main bronchus in order to dissect the ventral and cranial borders. The left RLN and LNs are easily recognizable. The lt. RLN to the thyroid gland and the lymph nodes along the left RLN are separated using endoscopic scissors, keeping the remaining lymph nodes attached to the esophagus.

Kaburagi et al. demonstrated hybrid position method that radical lymphadenectomy along the bilateral recurrent laryngeal nerves was performed in the left lateral decubitus position because this approach was superior for lymphadenectomy in the region. Thoracoscopic esophagectomy and other lymphadenectomy were provided in the middle to lower mediastinum in prone position [33].

Lin et al. reported that after looping the esophagus and fixation with a clip, the exposed thorax part of the thread is pulled up by the assistant to lift esophagus [34]. The left RLN is then exposed and separated in the space between lifted esophagus and the trachea. Scissor and isolating forceps are preferred during separation due to safety concerns. During subsequent mobilization of the esophagus and dissection of left RLN lymph nodes, the assistant uses the grasping forceps to compress the trachea so as to better expose the space between esophagus and trachea.

Fujiwara et al. reported that the lymph nodes along the left RLN could be separated from the left RLN trunk using endoscopic scissors under a mediastinoscope, with the nodes remaining attached to the esophagus [35]. First, the nerve trunk is exposed along the anterior plane, then, the lymph nodes are retracted to the left, through beneath the nerve trunk, and separated by dividing the attachment to the nerve trunk. Finally, the subaortic arch lymph nodes are dissected by dividing the attachment to the nerve trunk.

To avoid injury to the lt. RLN by electricity or heat, an electric device should not be used. Wong et al. demonstrated that a more aggressive and thorough nodal dissection may be possible with less concern of RLN injury by the availability of intermittent nerve mapping and continuous intraoperative nerve monitoring (CIONM) [36].

7. Conclusion

In eastern countries ESCC is common and lymph node metastasis along the RLN is frequently seen. Many surgeons in Japan, China and India perform thoracoscopic lymph node dissection along the RLN. The prone position allows for visualization of a dry and wide surgical space without the need for special assistants, but there is difficulty in lymph node dissection along

the left RLN. To obtain a good and wide operating field for lymph node dissection along the left RLN, only retraction or rotation of the trachea toward the right is insufficient. With our technique, the residual esophagus can easily be pulled up to the neck after sufficient ablation. In this technique, it is not necessary to retract the esophagus with more holes or to fix the esophagus. Esophageal stripping in lymph node dissection is easier and more effective than other methods.

Lymph node dissection along the left RLN after esophageal stripping is possible in the prone position during VATS-E.

Acknowledgements

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References

[1] Igaki H, Tachimori Y, Kato H. Improved survival for patients with upper and/or middle mediastinal lymph node metastasis of squamous cell carcinoma of the lower thoracic esophagus treated with 3-field dissection. Annals of Surgery. 2004;**239**(4):483-490

[2] Udagawa H, Ueno M, Shinohara H, Haruta S, Kaida S, Nakagawa M, Tsurumaru M. The importance of grouping of lymph node stations and rationale of three-field lymphoadenectomy for thoracic esophageal cancer. Journal of Surgical Oncology. 2012;**6**:742-747

[3] Osugi H, Takemura M, Higashino N, Takada S, Lee M, Ueno Y, Tanaka Y, Fukuhara K, Hashimoto Y, Fujiwara Y, Kinoshita H. Video-assisted thoracoscopic esophagectomy and radical lymph node dissection for esophageal cancer. Surgical Endoscopy. 2002;**16**:1588-1593

[4] Arnold M, Soerjomataram I, Ferlay J, Forman D. Global incidence of oesophageal cancer by histological subtype in 2012. Gut. 2015;**64**:381-387

[5] José M, Arnal D, Arenas ÁF, Arbeloa ÁL. Esophageal cancer: Risk factors, screening and endoscopic treatment in Western and Eastern countries. World Journal of Gastroenterology. 2015;**21**(26):7933-7943

[6] Fang P, Jiao S, Zhang X, Liu Z, Wang H, Gao Y, Luo H, Chen T, Shi L. Meta-analysis of ALDH2 variants and esophageal cancer in Asians. Asian Pacific Journal of Cancer Prevention. 2011;**12**:2623-2627

[7] Kagemoto K, Urabe Y, Miwata T, Oka S, Ochi H, Kitadai Y, Tanaka S, Chayama K. ADH1B and ALDH2 are associated with metachronous SCC after endoscopic submucosal dissection of esophageal squamous cell carcinoma. Cancer Medicine. 2016;**5**(7):1397-1404

[8] Oze I, Matsuo K, Wakai K, Nagata C, Mizoue T, Tanaka K, Tsuji I, Sasazuki S, Inoue M, Tsugane S. Alcohol drinking and esophageal cancer risk: An evaluation based on a systematic review of epidemiologic evidence among the Japanese population. Japanese Journal of Clinical Oncology. 2011;**41**(5):677-692

[9] Mizoi Y, Yamamoto K, Ueno Y, Fukunaga T, Harada S. Involvement of genetic polymorphism of alcohol and aldehyde dehydrogenases in individual variation of alcohol metabolism. Alcohol and Alcoholism. 1994;**29**(6):707-710

[10] Thrift AP, Whiteman DC. The incidence of esophageal adenocarcinoma continues to rise: Analysis of period and birth cohort effects on recent trends. Annals of Oncology. 2012;**23**:3155-3162

[11] CastroC, Bosetti C, Malvezzi M, BertuccioP, Levi F, Negri E, LaVecchia C, Lunet N. Patterns and trends in esophageal cancer mortality and incidence in Europe (1980-2011) and predictions to 2015. Annals of Oncology. 2014;**25**:283-290

[12] Nun-anan P, Vilaichone R. Late stage and grave prognosis of esophageal cancer in Thailand. Asian Pacific Journal of Cancer Prevention. 2015;**16**:1747-1749

[13] Mansour-Ghanaei F, Heidarzadeh A, Naghipour MR, Joukar F, Valeshabad AK, Fallah MS, Rezvani SM, Sedigh-Rahimabadi M, Rokhshad H, Dadashi A. A 10-year study of esophageal cancer in Guilan province, Iran: The Guilan cancer registry study (GCRS). Asian Pacific Journal of Cancer Prevention. 2012;**13**:6277-6283

[14] Gasmelseed N, Abudris D, Elhaj A, Eltayeb EA, Elmadani A, Elhassan MM, Mohammed K, Elgaili EM, Elbalal M, Schuz J, Leon ME. Patterns of esophageal cancer in the national cancer institute at the University of Gezira, in Gezira State, Sudan, in 1999-2012. Asian Pacific Journal of Cancer Prevention. 2015;**16**:6481-6490

[15] Tettey M, Edwin F, Aniteye E, Sereboe L, Tamatey M, Ofosu-Appiah E, Adzamli I. The changing epidemiology of esophageal cancer in sub-Saharan Africa—The case of Ghana. Pan African Medical Journal. 2012;**13**(6):1-7

[16] Ma GW, Situ DR, Ma QL, Long H, Zhang LJ, Lin P, Rong TH. Three-field vs two-field lymph node dissection for esophageal cancer: A meta-analysis. World Journal of Gastroenterology. 2014;**20**(47):18022-18030

[17] Sepesi B, Schmidt HE, Lada M, Correa AM, Walsh GL, Mehran RJ, Rice DC, Roth JA, Swisher SG, Low DE, Hofstetter WL. Survival in patients with esophageal adenocarcinoma undergoing trimodality therapy is independent regional lymph node location. The Annals of Thoracic Surgery. 2016;**101**:1075-1081

[18] Feith M, Stein HJ, Siewert JR. Pattern of lymphatic spread of Barrett's cancer. World Journal of Surgery. 2003;**27**:1052-1057

[19] Siewert JR, Feith M, Werner M, Stein HJ. Adenocarcinoma of the esophagogastric junction results of surgical therapy based on anatomical/topographic classification in 1,002 consecutive patient. Annals of Surgery. 2000;**232**(3):353-361

[20] Yamashita H, Seto Y, Sano T, Makuuchi H, Ando N, Sasako M, Japanese Gastric Cancer Association and the Japan Esophageal Society. Results of a nation-wide retrospective study of lymphadenectomy for esophagogastric junction carcinoma. Gastric Cancer. 2017;**20**:69-83

[21] Ye K, Xu JH, Sun YF, Lin JA, Zheng ZG. Characteristics and clinical significance of lymph node metastases near the recurrent laryngeal nerve from thoracic esophageal carcinoma. Genetics and Molecular Research. 2014;**13**(3):6411-6419

[22] Giacopuzzi S, Bencivenga M, Weindelmaye J, Verlato G, de Manzoni G. Western strategy for EGJ carcinoma. Gastric Cancer. 2017;(Suppl 1):60-68

[23] Altorki N, Kent M, Ferrara C, Port J.Three-field lymph node dissection for squamous cell and adenocarcinoma of the esophagus. Annals of Surgery. 2002;**236**(2):177-83

[24] Palanivelu C, Prakash A, Senthilkumar R, Senthilnathan P, Parthasarathi R, Rajan PS, Venkatachlam S. Minimally invasive esophagectomy: Thoracoscopic mobilization of the esophagus and mediastinal lymphadenectomy in prone position—Experience of 130 patients. Journal of the American College of Surgeons. 2006;**203**(1):7-16

[25] Lagergren J, Mattsson F,Zylstra J, Chang F, Gossage J, Mason R, Lagergren P, Davies A. Extent of lymphadenectomy and prognosis after esophageal cancer surgery. JAMA Surgery. 2016;**151**(1):32-39

[26] Cuschieri A. Endoscopic subtotal oesophagectomy for cancer using the right thoracoscopic approach. Surgical Oncology. 1993;**2**(Suppl 1):3-11

[27] Noshiro H, Iwasaki H, Kobayashi K, Uchiyama A, Miyasaka Y, Masatsugu T, Koike K, Miyazaki K. Lymphadenectomy along the left recurrent laryngeal nerve by a minimally invasive esophagectomy in the prone position for thoracic esophageal cancer. Surgical Endoscopy. 2010;**24**:2965-2973

[28] Makino H, Nomura T, Miyashita M, Okawa K, Hagiwara N, Uchida E. Esophageal stripping creates a clear operative field for lymph node dissection along the left recurrent laryngeal nerve in prone video-assisted thoracoscopic surgery. Journal of Nippon Medical School. 2011;**78**(3):199-204

[29] Makino H, Yoshida H, Maruyama H, Yokoyama T, Hirakata A, Ueda J, Takada H, Matsutani T, Nomura T, Hagiwara N, Uchida E. An original technique for lymph node dissection along the left recurrent laryngeal nerve after stripping the residual esophagus during video-assisted thoracoscopic surgery of esophagus. Journal of Visualized Surgery. 2016;**2**(166):1-6

[30] Oshikiri T, Yasuda T, Harada H, Goto H, Oyama M, Hasegawa H, Ohara T, Sendo H, Nakamura T, Fujino Y, Tominaga M, Kakeji Y. A new method (the "Bascule method") for lymphadenectomy along the left recurrent laryngeal nerve during prone esophagectomy for esophageal cancer. Surgical Endoscopy. 2015;**29**(8):2442-2450

[31] Xi Y, Ma Z, Shen Y, Wang H, Feng M, Tan L, Wang Q. A novel method for lymphadenectomy along the left laryngeal recurrent nerve during thoracoscopic esophagectomy for esophageal carcinoma. Journal of Thoracic Disease. 2016;**8**(1):24-30

[32] Zheng W, Zhu Y, Guo CH, Zheng B, Han ZY, Chen C. Esophageal suspension method in scavenging peripheral lymph nodes of the left recurrent laryngeal nerve in thoracic esophageal carcinoma through semi-prone-position thoracoscopy. Journal of Cancer Research and Therapeutics. 2014;**10**(4):985-990

[33] Kaburagi T, Takeuchi H, Kawakubo H, Omori T, Ozawa S, Kitagawa Y. Clinical utility of a novel hybrid position combining the left lateral decubitus and prone positions during thoracoscopic esophagectomy. World Journal of Surgery. 2014;**38**:410-418

[34] Lin M, Shen Y, Feng M, Tan L. Minimally invasive esophagectomy: Chinese experiences. Journal of Visualized Surgery. 2016;**2**(134):1-4

[35] Fujiwara H, Shiozaki A, Konishi H, Otsuji E. Mediastinoscope and laparoscope-assisted esophagectomy. Journal of Visualized Surgery. 2016;**2**(128):1-7

[36] Wong I, Tong DKH, Tsang RKY, Wong CLY, Chan DKK, Chan FSY, Law S. Continuous intraoperative vagus nerve stimulation for monitoring of recurrent laryngeal nerve during minimally invasive esophagectomy. Journal of Visualized Surgery. 2017;**3**(9):1-7