Thoracolaparoscopy oesophagectomy and extensive two-field lymphadenectomy for oesophageal cancer: introduction and teaching of a new technique in a high-volume centre

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Abstract

OBJECTIVES: The aim of this study was to assess the experience of a high-volume centre with thoracolaparoscopy radical oesophagectomy and to evaluate the feasibility, tumour clearance, the learning curve and reproducibility of this technique.

METHODS: Eighty patients with thoracic oesophageal cancer who underwent thoracolaparoscopic oesophagectomy (TLE) were enrolled in this study. Two attending surgeons (Mingqiang Kang and Ruobai Lin) independently performed the procedure as operating surgeons. The 60 patients who had surgery performed on them by the senior attending surgeon, Mingqiang Kang, were divided into three groups of 20 patients: groups A, B and C. The results from the three groups were compared in order to detect any changes in the success of TLE as a way of monitoring the development of the surgeon’s technical skill. Another 20 patients had surgery performed on them by the new attending surgeon, Ruobai Lin, and were classified into the fourth group, D. The results from Group D were compared with those of the other three groups to evaluate the reproducibility of our technique.

RESULTS: There was no significant difference between the four groups with respect to age, gender, location of tumour or staging. The duration of both the thoracoscopic and laparoscopic procedures was significantly longer in Group A. The amount of estimated blood loss was significantly more in Group A than in the other groups. The number of lymph nodes dissected was similar in Groups A and D, whereas that of retrieved nodes was larger in Groups B and C. There was no significant difference in the incidence of respiratory complications, recurrent nerve palsy, anastomotic leaks, arrhythmia, chylothorax and delayed gastric emptying among the four groups.

CONCLUSIONS: When TLE procedures are started in units with a large volume of oesophageal resections, and when there is support from colleagues within the unit, transition from open to TLE can be achieved safely, with a satisfactory oncological outcome. A plateau of TLE skill was reached after 40 cases had been performed. If mini-fellowship training with supervision from senior surgeons is used, it is possible for a new attending surgeon to attain the requisite basic skill to perform TLE in a relatively short period of time.

Keywords: Thoracoscopy • Laparoscopy • Oesophageal neoplasms • Oesophagectomy

INTRODUCTION

Surgical resection offers a primary curative therapy for patients with resectable oesophageal cancer. But traditional open oesophageal cancer resection is a complex and severe surgical insult procedure associated with a significant morbidity and mortality [1, 2]. In an effort to decrease the morbidity and mortality associated with oesophageal cancer resection, minimally invasive surgical techniques have been more frequently applied for resection of malignant oesophageal diseases [3–5]. To date, different techniques have been described, which include thoracoscopic transthoracic oesophagectomy [6, 7], laparoscopic transhiatal oesophagectomy [8, 9], transcervical mediastinoscopy [10] and laparoscopic gastric preparation [3].

Our approach in this study was a combined thoracoscopic and laparoscopic approach with a neck anastomosis. Thoracolaparoscopic oesophagectomy (TLE) remains one of the most complex and technically challenging surgical procedures which should be relegated to surgeons experienced in both advanced laparoscopy/thoracoscopy and surgical oncology for oesophageal cancer [3, 11]. Therefore, a considerable learning curve is needed. However, there is currently no evidence on which to judge the length of such a learning curve, and how many operations the surgeon must perform in order to attain their best results. Will a patient operated on during the learning curve have greater risks and incur more adverse circumstances than the patient operated on later? The aim of this study was to assess the experience of a high-volume centre with TLE and to evaluate the feasibility, tumour clearance and the learning curve of this technology.

Since few thoracic surgeons are performing TLE, the education and meticulous training of new surgeons are vital. Questions
regarding the adequacy of this training and the need for post-accreditation supervision remain unanswered. We hypothesized that training can be effectively accomplished if a mini-fellowship approach is used. This study also aimed to evaluate the reproducibility of our surgical technique.

**PATIENTS AND METHODS**

**Patients**

Our medical centre is located in southeast China where there is a high incidence of oesophageal cancer. More than 150 cases of resection of oesophageal cancer are performed in our thoracic division per year. From October 2009 to March 2011, 80 patients with thoracic oesophageal cancer who underwent TLE in our institution were enrolled in this study. Two attending surgeons (Mingqiang Kang and Ruobai Lin) performed the procedure independently as the operating surgeons. We used a predetermined stepwise model for introduction of TLE. Kang, who is a specialist in general thoracic surgery with established expertise in open oesophagectomy and video-assisted thoracoscopic surgery, introduced this technique. After Kang became confident in his ability to routinely perform the operation in a safe manner, he embarked on teaching the new attending surgeon, Ruobai Lin, to perform the operation. Lin was transitioned from assistant to operating surgeon after a short fellowship period. Kang attended the first two operations and directed Lin and assistants during the TLE procedure and advised them on how to complete the operation safely and to maintain the quality of the curative dissection. Then, starting with the third patient, Lin performed the operation independently. During the initial period of Lin’s tenure, all members of the surgical team, including the assistants, remained the same to ensure consistency and to obtain early and maximal efficiency in performing TLE.

Osugi et al. [12] reported that he acquired the basic skills for video-assisted thoracoscopic surgery (VATS) oesophagectomy during his first 17 cases, but that a plateau in his technique was not reached until 34 cases had been performed. However, thoracolaparoscopic oesophageal cancer surgery includes thoraco-laparoscopic oesophagectomy and laparoscopic procedures, and most thoracic surgeons are not familiar with laparoscopic skills, so they might need more cases to climb the learning curve. Sixty patients who had surgery performed on them by the attending surgeon, Mingqiang Kang, were divided into three equal groups of 20 patients. The results of the three groups, A, B and C, were compared in order to determine changes in the outcome of TLE as a means of monitoring the development of the surgeon’s expertise. Twenty patients who had surgery performed on them by the attending surgeon, Ruobai Lin, were classified as Group D. The results from the patients in Group D were compared with those from the other three groups to measure the training of Lin and the effectiveness of the mini-fellowship and to evaluate the reproducibility of our technique.

**Surgical technique**

With the accumulation of experience from practice, the procedure was standardized and simplified.

After intubation with a double lumen tube for single lung ventilation, the patient is positioned in the left lateral-decubitus position. We make four incisions: a 2-cm incision at the eighth intercostal space (ICS) on the middle axillary line for the ultrasonic scalpel or endo-stapler; a 1-cm incision at the seventh ICS on the anterior axillary line for a camera; at the sixth ICS on the posterior axillary line for instruments; and a 4-cm utility incision at the fourth ICS on the anterior axillary line for retraction and counter-traction during the oesophageal dissection. Some degree of modifications were allowed, as shown in Fig. 1.

The procedure is begun by dividing the inferior pulmonary ligament up to the level of the inferior pulmonary vein with a harmonic ultrasonic scalpel. The mediastinal pleura overlying the oesophagus is then divided in order to expose the lower thoracic oesophagus. To facilitate traction and exposure, a Penrose drain is placed around the oesophagus. We routinely divided the azygos vein using a vascular endostapler. Basically, the same methods used for oesophagectomy under thoracotomy were applied. Circumferential mobilization of the oesophagus is undertaken cranially and caudally with surrounding lymph nodes and peri-oesophageal tissue to expose the aortic wall, left mediastinal pleura, pericardium, membranous portion of the tracheobronchus and the diaphragm. After the entire oesophagus is mobilized, the trachea was rotated by a self-made smooth tip retractor (as shown in Fig. 2). The retractor consists of a 3-cm wide tip, narrow intermediate pole and a hand grip. The tip is inserted through the 4-cm utility incision at the fourth ICS. It is rotated to retract the trachea or the main bronchus in order to...
allow meticulous dissection of lymph nodes deep into the upper mediastinal space. A 30° telescope presented a good view. The lymph nodes around the bilateral recurrent laryngeal nerves are completely removed, with identification and preservation of those nerves. Subsequently, the tracheobronchial nodes and subcarinal nodes are dissected separately.

The patient is then placed in the supine position. Five ports were used, as shown in Fig. 3: a 12-mm trocar at the left subcostal for the stapler or ultrasonic scalpel; an 11-mm trocar 1 cm over the umbilicus for a camera; two 5-mm trocars bilateral to the umbilicus area for endo-forceps; and one 5-mm trocar on the right flank for a liver retractor or endo-forceps. At first, the gastrocolic omentum is divided with preservation of the right gastroepiploic arcade. Short gastric arteries were divided carefully with the ultrasonic coagulating shears to prevent accidental tearing of the spleen. The stomach is retracted superiorly; all the nodes along the celiac trunk together with the common hepatic, splenic and left gastric artery were removed. Then the left gastric vessels are identified and divided with the Endo-GIA stapler or haemo-lock. The gastrohepatic ligament is divided. The right crus of the diaphragm was identified, and the peritoneum over it was cut. This cut was extended up to the hiatus. The hiatal opening was then widened. A complete lower thoracic oesophageal mobilization was done; the lower thoracic oesophageal mobilization was dissected all around at the level of the hiatus. We did not perform a pylorus drainage procedure with pyloromyotomy or pyloromyoplasty during laparoscopic procedures.

A 4-cm minilaparotomy was then performed, as shown in Fig. 3, and a left cervical counter-incision was used to mobilize the cervical oesophagus. The oesophagus was divided in the lower neck, the specimen was extracted through the minilaparotomy and resection was completed by extracorporeal gastric stapling, applying a gentle stretch on the gastric conduit to avoid bunching and to maximize length. The lesser curve and lymph nodes and omentum were dissected en bloc. An extracorporeal stomach tube was prepared and pulled back through the posterior mediastinum into the neck. The oesophagogastric anastomosis was constructed using hand-sewing, linear stapler or circular stapler techniques.

Patients were closely monitored for any signs of complications which, if identified, were aggressively managed. A nasogastric suction tube was passed through the anastomosis and left in place until the water-soluble contrast swallow. A feeding jejunostomy was established in all cases (as shown in Fig. 3). Patients received enteral nutrition through the jejunostomy feeding tube on postoperative day 1. A water-soluble swallow was administered on day 8, and then oral feeds were started. Patients were discharged after the commencement of oral feeds.

Data analysis

All statistical analyses were performed with the Statistical Package for Social Sciences version 11.5 (SPSS, Chicago, IL, USA). Continuous variables, including age, the duration of the procedure, the amount of blood loss and number of dissected nodes, were tested for normality distribution first. If the assumptions of normality were met, continuous variables were expressed as mean ± standard deviation. Multiple comparisons of these variables between groups were carried out using one-way analysis of variance, and pairwise comparisons were done using Bonferroni correction. The amount of blood loss, which did not show any normal distribution, was expressed as median (interquartile range). Multiple comparisons of this variable between groups were carried out using the Kruskal–Wallis test, and pairwise comparisons using the Bonferroni correction. Discrete variables, including gender, tumour location, P stage and incidence of complications, were described as number. Comparisons of discrete variables between groups were carried out using Fisher’s exact test. P-values of <0.05 were considered statistically significant.

RESULTS

Patient and tumour characteristics are listed in Table 1. There was no significant difference between the four groups with regard to age, gender, location of tumour and staging. Seventy-seven patients had a preoperative histological diagnosis of oesophageal squamous cell carcinoma, and there were three patients with adeno-squamous carcinoma in the group. The final pathology of the patients included Stage I (19), Stage II (30) and Stage III (31).

There were two, one, one and two conversions to open thoracotomy in Groups A, B, C and D, respectively. The specific
indications for conversion were as follows: dense pleural adhesions and bulk tumour in Group A (n = 2), intraoperative bleeding from the azygos vein in Group B (n = 1), bulk tumour in Group C (n = 1), bulk tumour and intraoperative left main bronchial membranous injury in Group D (n = 2). There was no conversion during laparoscopic gastric mobilization.

The surgical outcomes of Group A were compared with those of Groups B, C and D. The duration of both the thoracoscopic and laparoscopic procedures was significantly longer in Group A, as shown in Table 2 (P < 0.05). The estimated amount of blood loss was significantly more in Group A than in the other groups (P < 0.05), but no patients received a blood transfusion.

We tried to achieve adequate lymph node clearance because the majority of our patients had squamous carcinoma. The number of dissected lymph nodes, whether mediastinal nodes or abdominal nodes, was similar in Groups A and D, whereas that of retrieved nodes was larger in Groups B and C (P < 0.05; Table 2). This trend demonstrated that the quality of lymph node retrieval improved as the surgeon became more experienced.

Table 1: Demographics and clinicopathologic factors of patients who underwent thoracolaparoscopic oesophagectomy

<table>
<thead>
<tr>
<th>Factor</th>
<th>A (n = 20)</th>
<th>B (n = 20)</th>
<th>C (n = 20)</th>
<th>D (n = 20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
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<td>17</td>
<td>15</td>
<td>16</td>
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</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Age (years) Mean ± SD</td>
<td>60.7 ± 9.5</td>
<td>62.0 ± 11.3</td>
<td>59.8 ± 7.9</td>
<td>58.6 ± 7.6</td>
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<tr>
<td>Range</td>
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<td>45–85</td>
<td>40–71</td>
<td>40–71</td>
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<td>Tumour location</td>
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<td>Lower</td>
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<td>3</td>
<td>5</td>
<td>7</td>
<td></td>
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<td>P stage</td>
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<td></td>
<td></td>
</tr>
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<td>7</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>8</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>8</td>
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</tr>
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</table>

NS: not significant.

Table 2: Surgical results of a thoracolaparoscopic oesophagectomy

<table>
<thead>
<tr>
<th>Factor</th>
<th>A (n = 20)</th>
<th>B (n = 20)</th>
<th>C (n = 20)</th>
<th>D (n = 20)</th>
<th>P</th>
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<td>2</td>
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<td>Dense pleural adhesion</td>
<td>1</td>
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<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>Bulk tumour</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Massive haemorrhage</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Injure the vital organ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total operation time (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest operation time</td>
<td>160 ± 38</td>
<td>136 ± 23a</td>
<td>123 ± 29a</td>
<td>120 ± 25a</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Abdomen operation time</td>
<td>134 ± 17</td>
<td>112 ± 14a</td>
<td>104 ± 13a</td>
<td>104 ± 16a</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Blood loss total (ml)</td>
<td>200 (200–250)</td>
<td>150 (100–200)a</td>
<td>100 (100–150)a</td>
<td>125(100–150)a</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Number of retrieved nodes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mediastinal nodes</td>
<td>13 ± 5</td>
<td>17 ± 8ab</td>
<td>16 ± 4ab</td>
<td>12 ± 4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Abdominal nodes</td>
<td>12 ± 4</td>
<td>14 ± 6ab</td>
<td>14 ± 4ab</td>
<td>11 ± 6</td>
<td>&lt;0.05</td>
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NS: not significant.

Table 3: Major complications after a thoracolaparoscopic oesophagectomy

<table>
<thead>
<tr>
<th>Complication</th>
<th>A (n = 20)</th>
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<th>C (n = 20)</th>
<th>D (n = 20)</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Pneumonia and atelectasis</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Vocal cord palsy</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>Anastomotic leaks</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Chylothorax</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Delayed gastric emptying</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Overall</td>
<td>5a</td>
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<td>5a</td>
<td>4b</td>
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<td>1</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Overall</td>
<td>5a</td>
<td>5a</td>
<td>5a</td>
<td>4b</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: not significant.

Table 3: Major complications after a thoracolaparoscopic oesophagectomy

<table>
<thead>
<tr>
<th>Complication</th>
<th>A (n = 20)</th>
<th>B (n = 20)</th>
<th>C (n = 20)</th>
<th>D (n = 20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia and atelectasis</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Vocal cord palsy</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>Anastomotic leaks</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Chylothorax</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Delayed gastric emptying</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Overall</td>
<td>5a</td>
<td>5a</td>
<td>5a</td>
<td>4b</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: not significant.
The rates of major morbidity in Groups A, B, C and D were 25, 25, 25 and 20%, respectively (Table 3). There was no significant difference in the incidence of respiratory complications, anastomotic leaks, arrhythmia, chylothorax and delayed gastric emptying among the four groups. Postoperative hoarseness and palsy of the recurrent laryngeal nerve were observed in three patients in Groups A and D, but only in one patient in Groups B and C. However, there was no significant difference in postoperative hoarseness or recurrent nerve palsy among the four groups. An anastomotic leak was detected in one patient in Group B. The leak was minor and managed conservatively. No port-site metastasis was seen. There were no hospital deaths among the 80 patients.

**DISCUSSION**

With advances in surgical instruments, optical devices, and surgical techniques, combined treatment of thoracoscopic and laparoscopic oesophagectomy is now increasingly adopted for oesophageal cancers. However, achieving proficiency in TLE can be challenging. Many surgeons remain skeptical about this procedure, because of a steep learning curve, longer duration of the operation and perceived inadequate tumour clearance.

In our centre, there has been adequate opportunity for thoracic surgical trainees to receive sufficient training in this technique in a relatively short period of time. The surgical outcomes in the introduction period confirmed that an experienced surgeon, working with the assistance of a regular surgical team, can master the basic skills of TLE safely after 20 cases of oesophageal cancer.

The study demonstrates a learning curve for TLE. An improvement was observed in operative and postoperative parameters: operating time, blood loss, lymph node yield and complication rate. The duration of the procedure and the amount of blood loss were significantly less in Group B than in Group A. The number of dissected lymph nodes, including mediastinal and abdominal nodes, was significantly larger in Group B than in Group A. However, as more cases were completed, there was no statistically significant difference between Groups B and C in the outcome measures mentioned above. Therefore, we hypothesized that a plateau of efficiency of TLE was reached after 40 cases had been performed.

Although Ruobai Lin had little experience with minimally invasive oesophageal surgery at the beginning of this study, supervision and instruction from the fully trained surgeon, Mingqiang Kang, allowed him to perform VATS safely during the initial period. The surgical outcome of Group D was similar to that of Groups B and C. The learning curve for a mentored surgeon would not be as steep as for a newly invasive esophagectomy (MIE) surgeon. We concluded that it is possible for a new attending surgeon to attain the requisite basic skills to perform TLE in a relatively short period of time with supervision from a senior surgeon.

There was a notable exception in that the number of dissected lymph nodes, whether mediastinal or abdominal nodes, was significantly fewer in Group D than in Groups B and C (P < 0.05; Table 2). The incidence of recurrent nerve palsy was higher in Group D than in Groups B and C, although there was no statistically significant difference. The foremost reason was that a lymphadenectomy, especially along the bilateral recurrent laryngeal nerve during a thorascoscopic oesophagectomy, is thought to be a burdensome step because of the difficult operative exploration at the upper mediastinum. More cases seem to be necessary for a new MIE surgeon to achieve a meticulous dissection of this portion and to produce stable operative views and technical proficiency in this procedure.

Lymph node involvement is an important prognostic indicator in oesophageal carcinoma. Extensive lymphadenectomy allows for accurate staging, reduces local/regional recurrence including lymph node recurrence and increases long-term survival [13, 14]. Following the same oncological principles as traditional open oesophagectomy, the number and extent of lymph node resection can be used as benchmarks to evaluate the quality of TLE. According to UICC standards, at least 12 nodes dissected are proposed as the new threshold for accurately defining the pN category in patients with oesophageal cancer who underwent two-field lymphadenectomy by open thoracoscopic oesophagectomy. The average number of retrieved nodes in the current series was 25 (range 15–59), which meets the criteria. This suggests that TLE in the left lateral-decubitus position is oncologically equivalent to open surgery.

A complex hierarchy of factors affecting the learning curve is involved. A factor such as learning the complexity of the upper mediastinal lymph node dissection is vital. In particular, observing the bilateral recurrent laryngeal nerve lymphatic chains were of more importance for identifying possible nodal metastases because of a high frequency of tumour spread over 30% of the patients, wherever the primary cancer was located in the mediastinum [15, 16]. In thoracoscopic oesophagectomy, the lymph node dissection around the bilateral recurrent laryngeal nerve is technically difficult step; it is also a difficult procedure to perform in open surgery. In our experience, the bilateral recurrent laryngeal nerve lymph nodes could be dissected meticulously by utilizing the magnifying effect of the video, while keeping the camera in close proximity and at an adequate angle to the dissection area. First, dissection of the right recurrent laryngeal nerve was begun cranially along the right vagus nerve. The original portion of the right recurrent laryngeal nerve was exposed and surrounding lymph nodes were dissected (Supplementary Video S1). Subsequently, the trachea was rotated by a self-made smooth tip retractor (Fig. 2). The infradiaphragmatic nodes were dissected first, and then the recurrent portion of the left recurrent laryngeal nerve was identified below the aortic arch. The tissue, including the left recurrent laryngeal nerve and lymph nodes, was dissected sharply just along the trachea and the left bronchus (Supplementary Video S2).

Another important factor that affects the learning curve is the surgeon’s case volume [17–19]. It has been suggested that surgical outcomes of traditional oesophagectomy are strongly influenced by the surgeon’s case volume. This means that a considerable number of cases are necessary to reach a plateau of optimal surgical outcomes in oesophageal cancer surgery. In a similar way, TLE has been identified as a volume-sensitive procedure. Benefits should be balanced by a determination to ensure the safety of the patient and to avoid compromising the oncologic integrity of the procedure, especially in the early phase of the transition from open to thoracolaparoscopic surgery. After our experience with the successful introduction of this technique in our centre, we advocate that TLE should first be practiced at high-volume institutions.

Certain measures can be taken to lessen some of the adverse effects of the learning curve and there are other steps that can...
help surgeons ease into this specialty. Primary education about
this procedure for a fixed and well-coordinated surgical team is
essential and the team needs to optimize and standardize the
surgical procedure. The left lateral-decubitus position was pre-
ferred because we were trained, and had experience with per-
forming right lateral thoracotomy. The anatomic orientation was
the same not only for the operating surgeon, but also for the
entire team. We believe that the familiar position and anatomic
orientation may help a team to adapt to TLE and may also
reduce the learning curve. A 4-cm utility thoracic incision is
created at the anterior axillary line at the fourth intercostal
space, particularly when teaching the operation. This additional
port allows the fellow to assist more effectively, using retraction
for improved exposure or for simultaneous insertion of added
instruments. In addition, conversion to open surgery, if required,
is better achieved with the patient in this position. The auxiliary
utility incision was then extended into a standard axillary
thoracotomy.

An ~4-cm incision is placed in the upper abdomen later
during the course of the abdominal operation. Compared to
forming a totally laparoscopic stapled gastric tube, this miniila-
parotomy is more convenient for the construction of the gastric
tube and placement of the jejunostomy feeding tube [20]. We
preferred to perform extracorporeal stapling to better delineate
the gross distal extent of the tumour and ensure an adequate
gastric resection margin. In addition, applying a gentle stretch to
the stomach while the stapler is being used helps to maximize
conduit length and avoid bunching the conduit. In our experi-
ence, this incision does not compromise the minimally invasive
nature of the procedure in the postoperative period.

No patients in this study received pyloromyotomy as part of
their MIE. Our technique has since evolved to construct a
tubular gastric conduit rather than leaving a large gastric reser-
voir. Construction of the gastric conduit into a tube improves
gastric emptying [21]. We start jejunum feeding early on post-
operative day 1. Enteral nutrition is the preferable means of nu-
tritional support to promote the recovery of gastrointestinal
motility. A nasogastric suction tube was left in place until the
water-soluble contrast swallow to confirm normal gastric
emptying.

There was a patient with a laceration of the tracheal bronchus
during TLE in both Group A and Group D. Both injuries were
detected on the table. In one patient, we converted to a mini-
 thoracotomy with direct visualization for suturing the rent. In
the other patient, we used thoracoscopic instruments to repair the
trachea and prevented another thoracotomy. The stomach tube
was used to abut the tracheal rent and act like a patch. Tracheal
bronchus laceration is a potentially fatal complication of oeso-
phagectomy. Its incidence is reported to be 0.6–1.8% during oeso-
phagectomy [22–24]. Bulky tumours and metastatic lymph
nodes adjacent to the trachea or bronchus had been implicated as
the cause of tracheal bronchus tears in this procedure. So this
was not a specific risk of our procedure, but collateral damage in
the learning curve.

This study has the inherent limitations of being retrospective
with a non-randomized review. Additionally, there may have
been a number of other factors that affected the ability of the
surgeons that have not been identified in this report. For
example, there are two main operative approaches in the trad-
titional treatment of oesophageal cancer used in mainland China:
approaching via a right or left lateral thoracotomy. Surgeons
who are accustomed to doing a left lateral thoracotomy would
need more cases to familiarize themselves with the anatomic
orientation and surgical procedure adapted to TLE. No doubt
this would require a longer learning curve.

In conclusion, this article demonstrates that when TLE is com-
enced in surgical units with a large volume of oesophageal
resections, and when there is support from colleagues within the
unit, transition from open to TLE can be achieved safely, with a
satisfactory oncologic outcome. Historically, the prolonged oper-
ation and meticulous manipulation in this procedure do chal-
lenge the stamina and endurance of the surgeons during the
initial phase. We hypothesized that a plateau of efficiency was
reached after 40 cases had been performed. Because of the
technical complexity of this challenging operation, surgeons
interested in learning this complex operation should attend a
mini-fellowship with supervision from senior surgeons experi-
enced with the procedure. The well-established stepwise model
of surgical attending physicians learning new techniques from
others, mastering them and then teaching the method to new
staff is both rational and practical.

SUPPLEMENTARY MATERIAL
Supplementary material (Videos 1 and 2) is available at EJCTS
online.

Conflict of interest: none declared.

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