Assessment of node dissection for clinical stage I primary lung cancer by VATS

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Abstract

Objective: The feasibility of systematic node dissection (SND) for stage I primary lung cancer by video-assisted thoracic surgery (VATS) remains controversial. The aim of this study was to assess the feasibility of SND by VATS. Methods: Four hundred and eleven patients with clinical stage I primary lung cancer were enrolled in this study. Two hundred and twenty-one patients, VATS group, underwent a major pulmonary resection with SND by VATS through a minithoracotomy (30-70 mm) and two access ports; 190 patients, open thoracotomy (OT) group, did so through anterolateral thoracotomy. The two groups were compared regarding clinical data including number of dissected nodes in each nodal station for evaluating the feasibility of SND by VATS. Results: In the right side, the total number (N) of nodes dissected (VATS 31 vs OT 33, P=0.899), N of mediastinal nodes dissected (20 vs 21, P=0.553), and N of dissected nodes in each nodal station were similar between the two groups. In the left side, total N of nodes dissected (28 vs 27, P=0.714), N of mediastinal nodes dissected (16 vs 17, P=0.333), and N of dissected nodes in each nodal station were similar between the two groups. There were three (1.4%) and five (2.6%) operation related deaths in the VATS group and OT group, respectively (P=0.48). Chest tube duration was shorter in the VATS group than the OT group (5.8 vs 7.6 days, P=0.001). The incidences of chylothorax, recurrent laryngeal nerve injury and pleural effusion requiring thoracentesis after surgery were similar in the VATS group and OT group, respectively (P=0.48). The 5-year actuarial recurrence-free survival rate and cumulative survival rate of pathological stage IA cases were similar between the two groups (88.6 vs 92.4%, P=0.714), (92.9 vs 86.5%, P=0.358). Conclusions: The SND by VATS was as technically feasible as SND through OT regarding number of dissected nodes and morbidity. It seems acceptable as an oncological treatment for clinical stage I lung cancer.

Keywords: Primary lung cancer; Video-assisted thoracic surgery; Systematic node dissection

1. Introduction

Recently, minimally invasive surgery is becoming more popular. In the field of general thoracic surgery, muscle sparing thoracotomy [1], VATS surgery [2,3], and active limited surgery [4,5] have been introduced. A video assisted thorascoscopic surgery (VATS) lobectomy with mediastinal node dissection for primary lung cancer was first performed in 1995 by McKenna and associates [6]. They reported that the survival rate for stage I lung cancer is similar between VATS lobectomies and lobectomies done by thoracotomy. It was reported that the analgesic requirement was significantly less in VATS lobectomies than in lobectomies by thoracotomy [7,8]. On the other hand, Nomori and associates [9] reported that although VATS lobectomy reduces chest pain during the first week after surgery compared with anterior limited thoracotomy (ALT), this advantage is lost within 2 weeks. Yim and associates [10] reported that VATS lobectomy has a reduced postoperative release of both proinflammatory and antiinflammatory cytokines compared with the open approach. Although minimally invasive surgery certainly sounds good, it is problematic if it decreases patient’s safety or the oncological treatment’s effect. There are few reports [11] on node dissection (ND) for primary lung cancer by VATS; therefore, the feasibility and safety of ND by VATS remains controversial. In this study, we retrospectively studied a series of patients with stage I primary lung cancer that had undergone major pulmonary resection with systematic node dissection (SND) at our institute.

2. Material and methods

2.1. Preoperative management

All patients who underwent major pulmonary resection gave written informed consent for performing ND before the
operation and those that refused were excluded from the study. They underwent preoperative staging and pulmonary function assessment. The preoperative workup was standardized for the staging and consisted of routine chest roentgenography, computed tomographic (CT) scanning of the thorax and the abdomen, computed tomographic scanning or magnetic resonance imaging of the brain, bone scintigraphy, and bronchoscopy. Neither mediastinoscopy nor positron emission tomography were performed for clinical stage I primary lung cancer. If the patients had cardiac symptoms such as chest oppression, pain, or palpitations, a cardiac evaluation was performed.

2.2. Surgical indication for VATS major pulmonary resection with SND

We started VATS lobectomy with SND for primary lung cancer in January 1997 at our institute. Our inclusion criteria for VATS lobectomy have changed with our knowledge of and ability to perform the procedure. Before December 2000, we passively recommended the VATS approach with SND as a first line procedure due to our inexperience, the inclusion criteria for VATS lobectomy were as follows: Clinical stage IA lung cancer; neither incomplete fissure area nor extensive pleural adhesion on the preoperative chest CT or intraoperatively; and the ability to physiologically tolerate one-lung ventilation. After January 2001, we recommended the VATS approach as a first line procedure because of experience in performing the procedure. After January 2002, inclusion criteria were extended as follows: clinical stage I patients whose greatest tumor diameter was 40 mm or less and the ability to physiologically tolerate one-lung ventilation. Extensive pleural adhesion on the preoperative chest CT or intraoperatively if emphysematous change of the lung was observed and incomplete fissure area were no longer considered inclusion criteria. Therefore, the rate of VATS major pulmonary resections for clinical stage I primary lung cancer has gradually increased every year, namely, 5.3% (2/38) in 1997 slowly increased to 81.6% (71/87) by 2003 (Fig. 1). Furthermore, after January 1999, patients were registered for a VATS segmentectomy if they had adenocarcinoma, the greatest tumor diameter was 20 mm or less and the rate of ground glass area to the greatest tumor area on the thin slice computer tomographic scanning was 50% or more. In addition, if patients had peripheral squamous cell carcinoma and the greatest tumor diameter was 20 mm or less, a VATS segmentectomy was performed. We performed SND for all clinical stage I primary lung cancer patients without intraoperative assessment of the frozen section of any nodes.

2.3. Criteria for intraoperative conversion of the VATS procedure to open thoracotomy

Before December 2001, the criteria were as follows: uncontrolled bleeding, dense pleural adhesion, or need to extend the procedure such as bronchoplasty or pulmonary artery plasty. After January 2002, dense pleural adhesion without emphysematous change in the lung was excluded from the criteria.

2.4. Patients’ profiles

From 1997 to 2004, 598 patients with primary lung cancer underwent pulmonary resection. Of these, 428 patients (71.6%) with clinical stage I primary lung cancer underwent major pulmonary resection with SND in our institute. We scheduled VATS major pulmonary resection for 238 of these 428 (55.6%) patients and 221 VATS major pulmonary resections were successfully performed. Unfortunately, 17 of 238 (7.1%) patients underwent conversion of the procedure to conventional thoracotomy, the reason being intraoperative uncontrolled bleeding in 7, dense pleural adhesion in 5, extended resection in 4 and an intraoperative cardiac event (ventricular fibrillation) in 1. These 17 cases were excluded from this study. Four hundred and twenty one patients were classified into the following two groups on the basis of the approach to the pleural space: the VATS group consisted of 221 patients who had undergone major pulmonary resection with SND by VATS; the OT group consisted of 190 patients who had done so through an anterolateral thoracotomy. We reviewed demographic data, clinical data (stage, tumor location, procedure) and pathological data (stage, greatest tumor size). The demographic data are summarized in Table 1. The ratio of females to males was higher in the OT group than the VATS group. There were no differences between the two groups regarding tumor location, surgical procedure, operative time or intraoperative blood loss. Pathological data showed the incident rate of adenocarcinoma was higher in the VATS group than in the OT group, and the disease was more advanced in the OT group than in the VATS group (Table 2).

2.5. Surgical procedures

General anesthesia with selective lung ventilation was performed with a double lumen endotracheal tube. Patients were placed in a decubitus position on an operating table. A surgeon stood on the anterior side of the patients and began the operation. In the VATS group, two thoracoports were...
placed in the sixth or seventh intercostal space (ICS) on the anterior axillary line and seventh or eighth ICS on the posterior axillary line, and an anterolateral utility minithoracotomy (30-70 mm, average 50 mm) was made in the fourth ICS for an upper lobectomy or in the fifth ICS for a middle or lower lobectomy. A Lap Protector Mini (Hakko Medical Co., Tokyo, Japan) was placed on the site of the minithoracotomy to cover skin, subcutaneous tissue, rib and parietal pleura without rib-spread. Pulmonary vessel management was performed by using forceps or scissors for conventional surgery through a utility thoracotomy. During the procedure a left phrenic and vagus nerve were sometimes taped and retracted posterolaterally with a silk suture if necessary (Fig. 2a). At this time, an ENDO CLOSE (United States Surgical Corp., Norwalk, CT) was used to extract the sutures out of the thorax through the puncture hole. Secondary ND at the inferior mediastinum (subcarinal and paraesophageal) was performed after the right main bronchus or right intermediate bronchus was taped with a 0 silk suture, which was brought out of the thorax through a mini-thoracotomy and retracted to the anterolateral side. Therefore, the left main bronchus was located on the right side of the median line during the retraction (Fig. 2b). Nodes in the pulmonary ligaments were dissected while the right lower lobe was retracted to the cranialateral side. On the left side, at first, the paraaortic and subaortic nodes were dissected while preventing injury to the left phrenic and vagus nerve. During the procedure a left phrenic nerve and left vagus nerve were pushed to the anteromedian

#### Table 1

<table>
<thead>
<tr>
<th>Procedure</th>
<th>VATS (n = 221)</th>
<th>OT (n = 190)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmentectomy</td>
<td>18</td>
<td>7</td>
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</tr>
<tr>
<td>Lobectomy</td>
<td>197</td>
<td>173</td>
<td>0.319</td>
</tr>
<tr>
<td>Bilobectomy</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Pneumonectomy</td>
<td>0</td>
<td>2</td>
<td>0.319</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>215 ± 53</td>
<td>221 ± 66</td>
<td>0.394</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>236 ± 180</td>
<td>258 ± 149</td>
<td>0.375</td>
</tr>
</tbody>
</table>

RUL: right upper lobe; RML: right middle lobe; RLL: right lower lobe; LUL: left upper lobe; LLL: left lower lobe; IM: intermediate.

#### Table 2

<table>
<thead>
<tr>
<th>Pathological data</th>
<th>VATS</th>
<th>OT</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Histology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ad/non-ad</td>
<td>159/62</td>
<td>107/83</td>
<td>0.0013</td>
</tr>
<tr>
<td>Ad</td>
<td>159</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>Sq</td>
<td>46</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>16</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>p-T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/1</td>
<td>162/59</td>
<td>101/89</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>1</td>
<td>162</td>
<td>101</td>
<td>0.016</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>4</td>
<td>6</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>p-N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0/12</td>
<td>185/36</td>
<td>143/47</td>
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<td>0</td>
<td>185</td>
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<tr>
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</tr>
<tr>
<td>2</td>
<td>22</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>p-Stage</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I/II-III</td>
<td>179/42</td>
<td>127/63</td>
<td>0.0014</td>
</tr>
<tr>
<td>I (A/B)</td>
<td>179 (142/37)</td>
<td>127 (83/44)</td>
<td></td>
</tr>
<tr>
<td>II (A/B)</td>
<td>15 (6/9)</td>
<td>28 (12/16)</td>
<td></td>
</tr>
<tr>
<td>III (A/B)</td>
<td>27 (20/7)</td>
<td>35 (21/14)</td>
<td></td>
</tr>
<tr>
<td>GTD (mm)</td>
<td>24.8 ± 11.3</td>
<td>31.5 ± 15.7</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

p, pathological; c, clinical; T, T-factor; N, N-factor; GTD, greatest tumor diameter; Ad, adenocarcinoma; Sq, squamous cell carcinoma.

2.6. SND

On the right side, superior mediastinal ND was mostly performed without the transection of an azygos vein. The nodes were held with long forceps for conventional thoracic surgery. During the procedure, the superior vena cava (SVC) or the vagus nerve were compressed or pushed with a cherry dissector (Ethicon, Cincinnati, OH); the vagus nerve and azygos vein were sometimes taped and retracted posterolaterally with a silk suture if necessary (Fig. 2a). At this time, an ENDO CLOSE (United States Surgical Corp., Norwalk, CT) was used to extract the sutures out of the thorax through the puncture hole. Secondary ND at the inferior mediastinum (subcarinal and paraesophageal) was performed after the right main bronchus or right intermediate bronchus was taped with a 0 silk suture, which was brought out of the thorax through a mini-thoracotomy and retracted to the anterolateral side. Therefore, the left main bronchus was located on the right side of the median line during the retraction (Fig. 2b). Nodes in the pulmonary ligaments were dissected while the right lower lobe was retracted to the cranialateral side.

On the left side, at first, the paraaortic and subaortic nodes were dissected while preventing injury to the left phrenic and vagus nerve. During the procedure a left phrenic nerve and left vagus nerve were pushed to the anteromedian

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**Fig. 2. Thoracoscopic operative view after mediastinal node dissection.** (a) Node dissection at the right upper mediastinum. Retraction of the vagus nerve and compression of the SVC. (b) Node dissection at the right lower posterior mediastinum (subcarinal and paraesophageal). Retraction of the right main bronchus. BrS, Bronchial stump; AS, Anterior side; CS, Cranial side; RS, Retraction suture; Tr, Trachea; VN, Vagus nerve; Br, Bronchus; RMBr, Right main bronchus; SVC, Superior vena cava.
side and posterolateral side with a cherry dissector, respectively. After that, pretracheal and tracheobronchial nodes were dissected. During the dissection, the left main pulmonary artery was compressed to the caudal side with a cherry dissector. If a good operative field was not gained despite the compression as mentioned above, the Botallo’s ligament was simply transected after confirming the absence of intraductal blood flow (by puncturing the ligament with a 23 or 26 gauge needle). The dissection of the inferior mediastinal nodes and nodes in the pulmonary ligaments was performed in the same method as on the right side.

2.7. Node mapping and definition of dissected node number

Although node mapping reported by Naruke and associates [12] was used in this study, we defined #1, #2, #3 and #4 together as superior mediastinal nodes, #7, #8 and #9 as inferior mediastinal nodes, and #5 and #6 as paraaortic nodes for convenience. In relation to the number of dissected nodes, we counted the number of both nodes that were not cut and large nodes that were cut during the ND after excluding small pieces of nodes that may have been cut from the larger ones. We defined the dissected node number as the sum of the number of nodes that were not cut and the number of large nodes that were cut.

2.8. Pain score and postoperative analgesics

Pain was assessed at rest after the patient awoke in the morning on preoperative day 1, and postoperative week 1, 4, and 12 using the visual analogue scale described by Hazelrigg et al. [13]. This involved patients drawing a pain score from 0 (absent) to 10 cm (most severe imaginable) on a 10-cm line chart. To ensure that there were no obvious psychological differences in the groups with regard to pain perception, a pain reference was determined preoperatively in each patient as described previously [8]. Rokisoprophen sodium (Rokisonin, Sankyo Co., Ltd, Tokyo, Japan) was given to all patients in postoperative week 1 and 4 daily at an oral dose of 180 mg.

2.9. Statistical analysis

The Statistical analysis was performed using SPSS 11.0 software (SPSS Inc., Chicago, IL). All continuous variables are expressed as the mean ± one standard deviation. Differences between the two groups were assessed by means of unpaired Students’ t-test after the assurance of homogeneity by Levene’s test. Categorical data were compared using the Fisher’s exact test. Recurrent free and cumulative survival curves were constructed by the Kaplan-Meier method, and the log-rank test was used to compare the curves between the groups. All reported probability values are two-tailed, and P values of less than 0.05 were considered statistically significant.

3. Results

3.1. Number of dissected nodes in each station

In the right side, the total number of nodes dissected (VATS 31 ± 12 vs OT 31 ± 18, P = 0.899), number of mediastinal nodes dissected (20 ± 9 vs 21 ± 13, P = 0.553), and number of dissected nodes in each nodal station were similar between the two groups. In the left side, the total number of nodes dissected (28 ± 10 vs 27 ± 15, P = 0.714), number of mediastinal nodes dissected (16 ± 8 vs 17 ± 10, P = 0.333), and number of dissected nodes in each nodal station were similar between the two groups (Table 3).

3.2. Postoperative mortality, morbidity and postoperative chest tube drainage

There were three (1.4%) and five (2.6%) operation related deaths in the VATS group and OT group, respectively (P = 0.48). The occurrences of postoperative morbidity such as chylothorax, recurrent laryngeal nerve injury and pleural effusion requiring thoracentesis were similar between the two groups. The amount of postoperative pleural fluid discharge was lower in the VATS group than in the OT group. The total amount of pleural fluid discharged before removal of a chest tube was 1094 ± 696 ml and 1455 ± 796 ml in the VATS group and OT group, respectively (P = 0.009). The duration of chest tube placement was shorter in the VATS group than in the OT group. The total amount of pleural fluid drained before chest tube removal was 1094 ± 696 ml and 1455 ± 796 ml in the VATS group and OT group, respectively (P = 0.009).

3.3. Postoperative pain

In the first 50 cases (25 cases in each group) of our series, pain scores were 0.8 ± 0.5 in the VATS group vs 0.7 ± 0.5

Table 3

<table>
<thead>
<tr>
<th>Right side</th>
<th>Left side</th>
</tr>
</thead>
<tbody>
<tr>
<td>VATS</td>
<td>OT</td>
</tr>
<tr>
<td>P-value</td>
<td>P-value</td>
</tr>
<tr>
<td>Total</td>
<td>31 ± 12</td>
</tr>
<tr>
<td>Mediasstinal</td>
<td>20 ± 9</td>
</tr>
<tr>
<td>SWN</td>
<td>13 ± 6</td>
</tr>
<tr>
<td>IMN</td>
<td>8 ± 5</td>
</tr>
<tr>
<td>PAN</td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>3 ± 3</td>
</tr>
<tr>
<td>#11</td>
<td></td>
</tr>
<tr>
<td>#11s</td>
<td>3 ± 2</td>
</tr>
<tr>
<td>#11i</td>
<td>3 ± 3</td>
</tr>
</tbody>
</table>

SWN, superior mediastinal nodes; IMN, inferior mediastinal nodes; PAN, paraaortic mediastinal nodes.
in the OT group in preoperative reference, 1.0±0.7 vs 3.1±1.4 (P=0.0001) in postoperative week 1, 0.4±0.5 vs 0.7±0.6 in postoperative week 4 and 0.2±0.5 vs 0.3±0.6 in postoperative week 12. There was only a significant difference in postoperative week 1 between the two groups.

3.4. Hospital cost

In the most recent 40 cases (25 cases in VATS group and 15 cases in OT group) of our series, the hospital costs of both procedures were 1,267,320±139,002 yen (including operation fee of 552,000 yen) in the VATS group and 1,197,867±131,800 yen (including operation fee of 431,000 yen) in the OT group; there were no significant differences in the cost between the groups (P=0.127).

3.5. Actuarial recurrence-free survival rate and cumulative survival rate

Four patients in the VATS group and six patients in the OT group had recurring lung cancer after the surgery when only the patients in stage IA were considered. Local or regional recurrence was observed in two patients in the VATS group and two in the OT group, which occurred in the hilar and mediastinum. New nodal swelling in the dissected mediastinum was observed in one patient in the OT group by postoperative computed tomography. There were no instances of tumor implantation in the chest wall at port sites. The five-year actuarial recurrence-free survival rate and cumulative survival rate of pathological stage IA cases were similar between the two groups (VATS group vs OT group: 88.6 vs 92.4%, P=0.698; 92.9 vs 86.5%, P=0.358) (Fig. 3).

4. Discussion

Although the therapeutic effect of ND including extensive mediastinal lymphadenectomy remains controversial [14–16], the diagnostic effect is clear. A large, prospective randomized multi-center trial of mediastinal lymph node sampling versus complete lymphadenectomy during pulmonary resection in patients with N0 or N1 (less than hilar) NSCLC is currently under way (American College of Surgeons Oncology Group, ACOSOG protocol Z0030). In Japan, general thoracic surgeons usually perform SND through open thoracotomy as a standard operation for clinical stage I primary lung cancer.

4.1. Number of dissected nodes in each station

Many general thoracic surgeons have thought that ND for primary lung cancer by VATS is inferior to that through open thoracotomy. However, surprisingly, there are no reports written in English on the inferiority of ND by VATS to that done through open thoracotomy. Some reports [11,17] show that no differences were observed in the number of dissected nodes by the VATS approach and open thoracotomy. In fact, Sagawa and associates [11] reported on the completeness of ND for primary lung cancer by VATS. After they performed pulmonary resection with hilar and mediastinal ND by VATS, a standard thoracotomy was carried out to complete the SND. On the right side, the average number of dissected nodes by VATS and remnant nodes were 40.3 and 1.2, respectively. The average weights of the dissected tissues by VATS and remnant tissues were 10.0 and 0.2 g, respectively. On the left side, there were 37.1 and 1.2 lymph nodes and 8.3 and 0.2 g of dissected tissues, respectively. From these results, they concluded that ND with VATS was technically feasible, and the remnant lymph nodes and tissues were 2.3%, which seems acceptable for clinical stage I lung cancer.

It is very difficult to assess the completeness of ND. In literature, there were no definitions of completeness. We suppose that many thoracic surgeons agree that ND is complete if they can find neither node nor fat tissue around each station. We have aimed at being able to observe the anterolateral wall of the trachea and right main bronchus on the posterior side, subclavian artery on the upper side, posterior wall of the superior vena cava on the anterior side, right main pulmonary artery on the lower side, and lateral wall of the ascending aorta on the back side following right superior mediastinal ND; the inferior wall of the aortic arch on the upper side, the anterolateral wall of the tracheobronchial area on the posterior side, the left lateral wall of the ascending aorta on the anterior side, the anterior wall of the descending aorta on the posterior side, and the left main
pulmonary artery on the inferior side following left paraaortic ND; the carina on the upper side, the median wall of the main bronchi on the bilateral sides, the upper edge of the lower pulmonary vein on the lower side, and the retropericardium on the back wall following subcarinal ND. Although we think that the best way to discover the completeness of the lymphadenectomy is assessment of residual node tissue in each station, it is hard to assess residual node tissue because it is difficult to identify the existence of nodes by the use of diagnostic imaging immediately after operation due to surgical trauma. Although the best way is to anatomize the regions, we cannot do this. Therefore, we compared the number of dissected nodes between the two groups. Of course, we think that assessment of dissected tissue weight is one way to assess the feasibility of ND. However, there are individual differences in visceral fat tissue weight, which makes assessment of the completeness by dissected tissue weight problematic. We know that the two ways are not absolutely adequate, but we can gain indirect results of the completeness through them.

It is difficult to perform SND by VATS for primary lung cancer without any devices or instruments. It is important to determine how the thoracoscopy will be introduced to the target zone or how to move the site that is going to be dissected to an area where ND can be performed easily. It is very important to keep obstacles from blocking the thoroscopic view.

During dissection of superior mediastinal nodes and subcarinal nodes, exposing the operative field requires great effort. Kaseda and colleague [18] reported the following ND technique: During the dissection of the upper mediastinum, an azygous vein was ligated with a suture and transected. The vagus nerve was taped with silk thread, which was brought outside the thorax with an ENDO CLOSE. During dissection at the subcarina, the esophagus and bronchus were compressed by a mini retractor (ENDO MINI-RETRACT, United States Surgical Corp., Norwalk, CT). The right main bronchus was then retracted laterally using an ENDO MINI-RETRACT to obtain a good operative view.

We also think that techniques such as anterolateral retraction of the operative side main bronchus by silk sutures with which the bronchus was taped and compression of the esophagus during the dissection of subcarinal nodes is very useful and effective. During the dissection of the right upper mediastinum, we obtained a good thoroscopic view and operative field without transection of an azygous vein using techniques such as posterolateral retraction of the vagus nerve and lateral retraction of the azygous vein. During the dissection of the left upper mediastinum, the left main pulmonary artery was compressed to the caudal side with a cherry dissector or the aortic arch was pushed to the cranial side. Although a transection of Botallo’s ligament was sometimes performed in order to spread the aorto-pulmonary window if necessary, the transection was easy and did not increase morbidity.

4.2. Postoperative morbidity related to SND

Recurrent laryngeal, phrenic and vagus nerve injury, chylothorax and persistent pleural effusion are known as possible complications following mediastinal ND for primary lung cancer. In this study, we did not investigate injury of the phrenic or vagus nerve because it is very difficult to accurately assess these injuries. Our outcomes show that VATS lobectomy with SND does not increase the occurrence of postoperative mortality or morbidity.

4.3. Postoperative chest tube drainage

Although there are many reports [8,14] on duration of chest tube replacement after major pulmonary resection, most of which show a shorter duration in VATS lobectomy than lobectomy through open thoracotomy, there are few that report differences of chest tube drainage between VATS lobectomy and lobectomy through open thoracotomy. In our series, the amount of postoperative chest tube drainage fluid was lower in the VATS group than in the OT group. We think that it is because the lymph duct was carefully closed during the ND, and the parietal pleural injury was less in the VATS group than in the OT group. The thorascopic view is enlarged 2.5-4 times compared to the direct view, so small vessels including those with lymph ducts or veins are mostly, carefully closed with hemoclips or electrocautery coagulation. We think that these procedures reduce postoperative pleural fluid production.

4.4. Postoperative pain

In this series, although VATS major pulmonary resection reduced chest pain during the first week after surgery compared with OT, this advantage was lost within 1 month. This result was similar to that reported by Nomori [9].

4.5. Actuarial recurrence-free survival rate and cumulative survival rate

Gharagozloo et al. [19] reported that in their VATS lobectomy for stage I lung cancer at a mean follow-up of 37 months, local recurrence rate was 0.013 per person per year, and that actuarial recurrence-free survival was 88 and 85% at 36 and 60 months, respectively. On the other hand, Ohtsuka et al. [20] showed that after the VATS lobectomy for primary lung cancer, the 3-year survival rate was 93% in 82 patients with clinical stage I disease and 97% in 68 patients with pathological stage I disease and that the 3-year disease-free survival rate was 79% in patients with clinical stage I disease and 89% in patients with pathological stage I disease. Local recurrence was observed in six patients (6%). We think that the recurrence rate is similar between the two groups if SND for primary lung cancer by VATS is considered feasible. In our series, the actuarial recurrence-free survival rate and cumulative survival rate in pathological stage IA cases were similar between the two groups. These results support the belief that SND for primary lung cancer by VATS is feasible.

4.6. Study limitation

This study is a clinical review of patients who underwent major pulmonary resection with SND for clinical stage I primary lung cancer. We elucidated the completeness of SND
by VATS by comparing dissected node numbers between VATS and open thoracotomy mostly by the same operator (Watanabe); therefore, bias of the surgical technique seems to be minimal. Although clinical follow-up was complete, patients were not randomly assigned to either group. Due to the changes in the criteria for VATS major pulmonary resection, most of the patients who underwent a VATS major pulmonary resection were in recent cases. Therefore, selection bias may affect our results. The male ratio, clinical T-factor, histology (rate of adenocarcinoma) and pathological factors were different between the two groups. Specifically, in the VATS group the male ratio was lower, and the clinical and pathological factors were better than in the OT group. However, these factors are likely to make the number of nodes and dissected nodes greater in the OT group. We think the fact that under these background conditions there were no differences in the number of dissected nodes between the two groups gives evidence for the feasibility of SND for primary lung cancer by VATS. Of course, the best model is a randomized clinical trial, and we think that a multicenter randomized clinical trial should be performed.

In addition, there is some doubt whether an assessment by only the number of dissected nodes is as feasible as an assessment of the oncological treatment. A qualitative assessment of dissected nodes is very difficult and has not yet been established. The incidence of cut or crushed nodes will surely be greater during ND by VATS than open thoracotomy because of the need to grasp the node more strongly and increased node traction. The cutting and crushing may cause dissemination of cancer cells to the pleural or mediastinal space if the node is involved; therefore, we have included only patients with clinical N0 primary lung cancer as candidates for VATS lobectomy. However, in patients with pathological N1 or N2 primary lung cancer, the dissemination may become a subject of discussion.

5. Conclusions

No significant differences were observed with regard to number of dissected nodes between the VATS group and OT group. There were no differences in operative mortality, morbidity or late phase outcome between the two groups. We, therefore, conclude that VATS lobectomy with SND should be the surgical procedure for patients with clinical stage I primary lung cancer because it is less invasive and the oncological treatment is just as effective as lobectomy with SND by OT.

References


Appendix A. Conference discussion

Dr M. Dusmet (London, United Kingdom): I have two short questions for you. How were the patients selected for VATS surgery or open surgery? Was it random or not?

Dr Watanabe: We select a patient for VATS lobectomy who is a clinical stage I patient.

Dr Dusmet: But all the patients were stage I.

Dr Watanabe: I have two short questions for you. How were the patients selected for VATS surgery or open surgery? Was it random or not?
The right to select the approach procedure was left to patients themselves. Therefore, this study is not a randomized model but a retrospective cohort model.

Dr Dusmet: How many patients were converted from VATS to open thoracotomy?

Dr Watanabe: We had scheduled 254 VATS lobectomies and performed 237 VATS lobectomies. So 17 patients underwent the conversion to open thoracotomy. The reasons included intraoperative bleeding in 7, dense pleural adhesions in 4, extended resection in 5, and intraoperative cardiac event, ventricular fibrillation in 1.

Dr A. Sihoe (Hong Kong, China): I have just a simple technical question. You have shown that the number of lymph nodes in the two groups dissected were the same in each station, but how can you be sure that the extent of dissection was the same? How can you be sure, for example, in the VATS group that you have actually dissected all the lymph nodes rather than just biopsied them? Would it not be better in this regard instead of just counting the number of lymph nodes in the tissue that you dissect from each station?

Dr Watanabe: We had not performed node biopsy but node dissection by VATS, so we dissected nodes with around fatty tissue. The basic technique of node dissection by VATS is the same as node dissection through open thoracotomy. As you said, the assessment of node dissection is difficult. We think that the best way for it is assessment of residual node tissue in each station. We think that assessment of lymph node tissue weight is one way to assess the feasibility of node dissection, but we did not do so in this series.

Dr G. Friedel (Gerlingen, Germany): How do you dissect and resect so many lymph nodes of station III and IV on the left side? How do you retract the aortic arch?

Dr Watanabe: Pardon?

Dr Friedel: If you resect lymph nodes of station III or IV on the left side, you have to retract the aortic arch. How do you do it thoracoscopically?

Dr Watanabe: We have performed VATS lobectomy only for clinical stage I lung cancer without intraoperative pathological examination of dissected nodes. We have performed dissection of n1 and n2a nodes. Dissection of nodes in station of #1 or #2 has not been performed. Therefore, the retraction of aortic arch was unnecessary and was not performed.