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ORIGINAL ARTICLE

Video-assisted thoracoscopic lobectomy in non-small-cell lung cancer patients with chronic obstructive pulmonary disease is associated with lower pulmonary complications than open lobectomy: a propensity score-matched analysis†

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Abstract

OBJECTIVES: Non-small-cell lung cancer (NSCLC) patients with chronic obstructive pulmonary disease (COPD) are at an increased risk of pulmonary complications after pulmonary resection. This study aimed to identify whether video-assisted thoracoscopic (VATS) lobectomy can reduce postoperative pulmonary complications compared with lobectomy by thoracotomy in NSCLC patients with COPD.

METHODS: Among a total of 1502 NSCLC patients who underwent lobectomy from April 2005 to June 2012 at the Seoul National University Hospital, 446 (29.7%) were diagnosed with COPD based on the spirometric criteria of the Global Initiative for COPD. Among the 446 patients, 283 presented with stage I NSCLC and were selected for this study. The study patients were divided into two groups: patients undergoing VATS ($n = 160$) lobectomy and patients undergoing thoracotomy ($n = 123$) lobectomy. A propensity analysis that incorporated preoperative variables, such as age, sex, Charlson comorbidity index, extent of smoking, preoperative pulmonary function, size of the mass, histological type of the tumour and additional lung resection, was performed, and postoperative outcomes were compared.

RESULTS: Matching based on propensity scores produced 91 patients in each group for the analysis of postoperative outcomes. There were only three operative mortalities in the thoracotomy group, and all of these patients died of postoperative pneumonia. The overall incidence of postoperative complications was 32.9% (30 of 91) and 22.0% (20 of 91) in the thoracotomy group and in the VATS group, respectively ($P = 0.14$). Compared with lobectomy by thoracotomy, VATS lobectomy was associated with a lower incidence of pulmonary complications (1.1 vs 12.1%; $P < 0.01$), shorter operation time (165 vs 201 min; $P < 0.01$) and shorter length of stay (6.0 vs 9.0 days; $P = 0.04$).

CONCLUSIONS: VATS lobectomy is associated with a lower incidence of pulmonary complications compared with lobectomy by thoracotomy in stage I NSCLC patients with COPD. VATS lobectomy may be the preferred strategy for appropriately selected NSCLC patients with COPD.

Keywords: Chronic obstructive pulmonary disease • Pulmonary surgical procedures • Video-assisted thoracic surgery • Thoracotomy

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is often concomitant with primary lung cancer and it poses risks to patients undergoing surgery. Although pulmonary lobectomy for early-stage non-small-cell lung cancer (NSCLC) offers patients the best chance of a cure, the presence of COPD puts these patients at an increased risk of postoperative pulmonary complications, which may be life-threatening [1–3]. It has been known that several pathophysiological processes in COPD may contribute to postoperative pulmonary complications. That is, pulmonary resection in COPD patients further damages the already impaired pulmonary reserve and causes acute respiratory failure by causing hypoventilation, hypoxia, hypercapnia and failure to clear secretions [1].

There have been several studies demonstrating the benefits of video-assisted thoracoscopic (VATS) lobectomy over lobectomy by thoracotomy, including faster patient recovery, reduced postoperative morbidity and shorter hospital length of stay without compromising the oncological principles of the surgery. VATS

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lobectomy also seems to be a preferred method in patients with high risks, such as old age [4] and poor pulmonary reserve [5]. However, reports on the benefits of VATS in NSCLC patients combined with COPD are limited and it has not been determined whether postoperative outcomes may be improved by the VATS approach. This study was performed to evaluate the influence of VATS lobectomy on early postoperative outcomes when compared with lobectomy by thoracotomy among propensity score-matched patient groups.

MATERIALS AND METHODS

Study subjects

This study protocol was approved by the Institutional Review of Board at Seoul National University Hospital as a minimal risk retrospective study (protocol number: H-1304-094-482), and the need for patient consent was waived. The medical records of 1502 consecutive patients who underwent lobectomy for NSCLC between April 2005 and June 2012 were retrospectively reviewed. The data were collected from our thoracic surgery database and patients' electronic medical records, which consisted of information on preoperative patient characteristics, disease status, operative procedures, details of the pathology report and postoperative outcomes. Among the 1502 patients who underwent lobectomy for NSCLC, 446 (29.7%) were diagnosed with COPD based on the spirometric criteria of the Global Initiative for Obstructive Lung Disease (GOLD), with a ratio of forced expiratory volume in 1 s (FEV_1) to forced vital capacity (FVC) that was <70% [6]. Of the 446 patients, patients who had pathologically confirmed stage I NSCLC were first selected for the study. The exclusion criteria applied for the first selected patients were (i) patients who received preoperative chemotherapy or radiation therapy and (ii) patients who underwent a surgical procedure other than a lobectomy, such as sleeve resection, chest wall resection or other combined major operations. Finally, 283 patients met the selection criteria and were enrolled in the study.

Perioperative management

Standard anaesthesia treatment with single-lung ventilation and perioperative fluid restriction were performed in all of the patients. To relieve postoperative pain, patients in the VATS group were given opioid-based, intravenous patient-controlled analgesia, whereas patients in the thoracotomy group were given epidural patient-controlled analgesia. To enhance lung expansion and expectoration of airway secretions, early postoperative ambulation, generous use of incentive spirometry and a nebulizer with a bronchodilator were used. All of the patients in the study were recommended to stop smoking 2 weeks or more prior to surgery. VATS lobectomy was performed fully under direct monitor-vision without rib spreading. Endoscopic staplers were used for individual ligation of the hilar structures, including the pulmonary vessels and bronchus. The same oncological principles, such as complete anatomic resection with adequate margins and complete mediastinal lymph node dissection for accurate staging, were applied for both the VATS lobectomy and the lobectomy by thoracotomy procedures. The type of procedure (VATS or thoracotomy) that was performed was determined by the individual surgeon's policy, which was based on the patient's medical condition. Initially, VATS lobectomy was indicated for patients with peripheral nodule <2 cm in diameter with non-solid consistency. But during the study period, the indications for VATS lobectomy were expanded gradually to all cases for which this approach was thought possible.

Postoperative outcomes

The postoperative outcomes of interest were (i) operative mortality, (ii) overall complications and pulmonary complications and (iii) length of hospital stay. Operative mortality was defined as any death occurring at any time during the same postoperative hospital stay or within 30 days of surgery. Postoperative complications included pulmonary complications, prolonged air leakage for more than 7 days, atrial fibrillation (AF), chylothorax, acute renal failure, reoperation, recurrent laryngeal nerve palsy and delirium. Postoperative pulmonary complications included atelectasis and sputum retention requiring bronchoscopy, COPD aggravation, postoperative pneumonia, acute respiratory distress syndrome and bronchopleural fistula. Postoperative pneumonia was defined by radiographic infiltrative shadows with at least two of the following: temperature >37.7°C, white blood cell count >10 000/mm^3 and positive sputum culture.

Statistical analysis

Descriptive statistics were used to compare variables between the unmatched groups, using the $\chi 2$ test or Fisher exact test for categorical variables and the Student's t-test for continuous variables. Normally distributed continuous data were expressed as the mean ± standard deviation. Categorical data were expressed as counts and proportions. To control for potential differences in the perioperative characteristics of patients treated with VATS lobectomy or lobectomy by thoracotomy, propensity score methods were used with the help of the medical research collaborating centre (MRCC) at our institution. By using a multivariate logistic regression model, which included perioperative variables such as age, sex, Charlson comorbidity index, extent of smoking, preoperative pulmonary function, size of the mass, histology and additional pulmonary resection in other lobe, propensity scores were computed as the conditional probability of receiving either VATS lobectomy or lobectomy by thoracotomy. Using the Greedy 81 digit match algorithm, we created propensity score-matched pairs without replacement (a 1:1 match). Specifically, we sought to match each patient with thoracotomy to one with VATS who had a propensity score that was identical to 8 digits. If this match could not be found, the algorithm then proceeded sequentially to the next highest digit match (a 7-, 6-, 5-, 4-, 3-, 2- or 1-digit) on propensity score to make 'next-best' matches, in a hierarchical sequence until no more matches could be made. If a subject who received thoracotomy could not be matched to any subject who received VATS on the first digit of the propensity score, that subject was discarded from the matched analysis. Once a match was made, previous matches were not reconsidered before making the next match. Comparisons between the matched groups were performed with McNemar's test for categorical variables and paired *t* test or Wilcoxon rank sum test for continuous variables. All of the statistical analyses were performed using the SPSS package (version 19.0; IBM, Armonk, NY, USA). A two-sided *P*-value of <0.05 was considered to be statistically significant.

RESULTS

The enrolled study patients were divided into two groups: patients ($n = 160$) who underwent VATS lobectomy (VATS group) and patients ($n = 123$) who underwent lobectomy by thoracotomy (thoracotomy group). The 123 patients in the thoracotomy group included 19 patients with VATS procedures that were converted to thoracotomy for the following reasons: calcified lymphadenopathy (6 patients), pulmonary arterial bleeding (5 patients), planned conversion (3 patients), tumour location (2 patients), adhesion (2 patients) and failed lung isolation (1 patient). The perioperative characteristics of 283 patients are summarized in Table 1. Lobectomy by thoracotomy was more likely to be performed on male patients ($P = 0.03$) and older patients ($P = 0.04$). Additionally, patients in the thoracotomy group were more likely to have a higher smoking index ($P < 0.01$), lower FEV_1 ($P < 0.01$) and larger tumour size ($P < 0.01$). Matching based on propensity scores produced 91 patients in each group, and the paired groups were well balanced (Table 2). The model was well calibrated (Hosmer–Lemeshow test = 1.00) and showed a good discrimination (c-statistic = 0.70). The postoperative outcomes and a list of complications for both groups are shown in Table 3. There were no operative mortalities in the VATS group, whereas there were three operative mortalities in the thoracotomy group; this difference was not statistically significant. The cause of death was postoperative pneumonia in all of the cases. The median operative time was shorter in the VATS group compared with the thoracotomy group (165 vs 201 min; $P < 0.01$). Median length of hospital stay was also shorter in the VATS group compared with the thoracotomy group (6.0 vs 9.0 days; $P = 0.04$). However, the median number of lymph nodes dissected was lower in the VATS group compared with the thoracotomy group (24 vs 29; $P = 0.04$). The overall incidence of postoperative complications in the VATS group was lower than that in the thoracotomy group, although this difference was not statistically significant (22.0 vs 33.0%; $P = 0.14$). Compared with lobectomy by thoracotomy, VATS lobectomy was associated with a lower incidence of pulmonary complications (1.1 vs 12.1%; $P < 0.01$) including a lower incidence of postoperative pneumonia (1.1 vs 11.0%; $P = 0.01$). In the VATS group, there were no cases of atelectasis or sputum retention requiring bronchoscopy, acute respiratory distress syndrome (ARDS), bronchopleural fistula and COPD aggravation. Prolonged air leakage for more than 7 days and AF frequently

Table 1: Patients' characteristics in the VATS and thoracotomy groups prior to propensity score-matching

Variable	VATS (160 patients)	Thoracotomy (123 patients)	*P*-value
Sex			
Male	129 (80.6)	111 (90.2)	0.03
Female	31 (19.4)	12 (10.8)	
Age (years)	66.9 ± 8.4	68.8 ± 6.7	0.04
Smoking history			
Never	42 (26.3)	20 (16.3)	0.04
Regularly	118 (73.8)	103 (83.7)	
Smoking index (pack-year)	31.1 ± 27.1	38.9 ± 26.2	<0.01
Charlson Comorbidity index	1.7 ± 1.0	1.6 ± 1.0	0.74
Diabetes mellitus	21 (13.1)	19 (15.4)	0.58
Hypertension	67 (41.9)	44 (35.8)	0.30
Coronary artery disease	14 (8.8)	6 (4.9)	0.21
Cerebral vascular disease	8 (5.0)	4 (3.3)	0.47
Preoperative pulmonary function (%)			
FVC predicted	106 ± 15	103 ± 16	0.06
FEV_1 predicted	95 ± 16	89 ± 18	<0.01
FEV_1/FVC predicted	61 ± 8	60 ± 9	0.06
DLCO predicted	102 ± 19	99 ± 22	0.20
Histology			
Squamous	47 (29.4)	51 (41.5)	0.09
Adenocarcinoma	99 (61.9)	61 (49.6)	
Other non-small-cell	14 (8.8)	11 (8.9)	
Tumour location			
Right upper lobe	50 (31.3)	46 (37.4)	0.23
Right middle lobe	13 (8.1)	4 (3.3)	
Right lower lobe	38 (23.8)	23 (18.7)	
Left upper lobe	31 (19.3)	31 (25.2)	
Left lower lobe	28 (17.5)	19 (15.4)	
Tumour size (cm)	2.3 ± 1.0	2.9 ± 1.3	<0.01
Additional resection	14 (8.8)	13 (10.6)	0.61

Data presented as the number of patients or mean ± standard deviation.
Figures in parentheses indicate percentage.

Table 2: Patients' characteristics in the VATS and thoracotomy groups after propensity score-matching

Variable	VATS (91 patients)	Thoracotomy (91 patients)	*P*-value
Sex			
Male	81 (89.0)	79 (86.8)	0.62
Female	10 (11.0)	12 (13.2)	
Age (years)	69.1 ± 7.4	68.1 ± 7.2	0.37
Smoking history			
Never	15 (16.5)	18 (19.8)	0.68
Regularly	76 (83.5)	73 (80.2)	
Smoking index (pack-year)	36.7 ± 26.7	35.8 ± 25.1	0.78
Charlson Comorbidity index	1.5 ± 0.9	1.5 ± 0.9	0.83
Diabetes mellitus	11 (12.1)	14 (15.4)	0.69
Hypertension	39 (42.9)	32 (35.2)	0.37
Coronary artery disease	9 (9.9)	5 (5.5)	0.42
Cerebral vascular disease	3 (3.3)	2 (2.2)	1.00
Preoperative pulmonary function (%)			
FVC predicted	105 ± 16	104 ± 16	0.72
FEV_1 predicted	92 ± 15	92 ± 18	0.75
FEV_1/FVC predicted	61 ± 7	61 ± 8	0.60
DLCO predicted	99 ± 19	99 ± 23	0.95
Histology			
Squamous	34 (34.1)	31 (37.4)	0.88
Adenocarcinoma	50 (58.2)	53 (55.0)	
Other non-small-cell	7 (7.7)	7 (7.7)	
Tumour location			
Right upper lobe	33 (36.3)	31 (34.1)	0.23
Right middle lobe	7 (7.7)	3 (3.3)	
Right lower lobe	18 (19.8)	17 (18.7)	
Left upper lobe	16 (17.6)	26 (28.6)	
Left lower lobe	17 (18.7)	14 (15.4)	
Tumor size (cm)	2.6 ± 1.1	2.6 ± 1.2	0.65
Additional resection	6 (6.6)	9 (9.9)	0.41

Data presented as the number of patients or mean ± standard deviation.
Figures in parentheses indicate percentage.

Table 3: Postoperative outcomes of propensity score-matched and -unmatched patients: actual surgery analysis

	Propensity score-matched			Unmatched	
	VATS (91 patients)	Thoracotomy (91 patients)	*P*-value	VATS (69 patients)	Thoracotomy (32 patients)
Operative mortality	0 (0)	3 (3.3)	0.25	1 (1.4)	0 (0)
Operation time (min)	165 (100–355)	201 (75–480)	<0.01	155 (90–450)	190 (105–343)
Length of stay (day)	6 (3–22)	9 (3–349)	0.04	6 (3–101)	10 (3–41)
Lymph nodes dissected	24 (6–67)	29 (5–74)	0.04	23 (1–60)	33 (1–57)
Overall complication (at least one)	20 (22.0)	30 (33.0)	0.14	16 (23.2)	15 (46.9)
Pulmonary complication (at least one)	1 (1.1)	11 (12.1)	<0.01	4 (5.8)	4 (12.5)
Atelectasis or sputum retention	0 (0)	2 (2.2)	0.50	0 (0)	0 (0)
Pneumonia	1 (1.1)	10 (11.0)	0.01	3 (4.3)	4 (12.5)
ARDS	0 (0)	3 (3.3)	0.25	2 (2.9)	0 (0)
Bronchopleural fistula	0 (0)	1 (1.1)	0.25	0 (0)	0 (0)
COPD aggravation	0 (0)	1 (1.1)	1.00	1 (1.4)	0 (0)
Air leak >7 days	10 (11.0)	14 (15.3)	0.54	2 (2.9)	9 (28.1)
Atrial fibrillation	7 (7.7)	8 (8.8)	1.00	7 (10.1)	3 (9.4)
Acute renal failure	1 (1.1)	5 (5.5)	0.22	1 (1.4)	0 (0)
Chylothorax	1 (1.1)	2 (2.2)	1.00	1 (1.4)	0 (0)
Reoperation	0 (0)	2 (2.2)	0.50	1 (1.4)	0 (0)

Data presented as the number of patients or median value.
Figures in parentheses indicate either percentage or range.

Table 4: Postoperative outcomes of propensity score-matched and -unmatched patients: intent-to-treat analysis

	Propensity score-matched			Unmatched	
	VATS (86 patients)	Thoracotomy (86 patients)	*P*-value	VATS (93 patients)	Thoracotomy (18 patients)
Operative mortality	1 (1.2)	2 (2.3)	1.00	1 (1.1)	0 (0)
Operation time (min)	165 (95–480)	195 (75–343)	0.04	170 (90–450)	174 (115–320)
Length of stay (day)	6 (3–22)	9 (3–349)	0.04	6 (3–101)	11 (4–26)
Lymph nodes dissected	24 (3–67)	31 (1–74)	<0.01	23 (1–60)	33 (13–44)
Overall complication (at least one)	21 (24.4)	33 (38.4)	0.09	18 (19.4)	9 (50.0)
Pulmonary complication (at least one)	2 (2.3)	10 (11.6)	<0.01	5 (5.4)	3 (16.7)
Atelectasis or sputum retention	0 (0)	2 (2.3)	0.50	0 (0)	0 (0)
Pneumonia	2 (2.3)	9 (10.5)	0.02	4 (4.3)	3 (16.7)
ARDS	0 (0)	3 (3.5)	0.25	2 (2.1)	0 (0)
Bronchopleural fistula	0 (0)	1 (1.2)	1.00	0 (0)	0 (0)
COPD aggravation	0 (0)	1 (1.2)	1.00	1 (1.1)	0 (0)
Air leak >7 days	6 (7.0)	19 (22.1)	<0.01	6 (6.5)	3 (16.7)
Atrial fibrillation	9 (10.5)	9 (10.5)	1.00	6 (6.5)	1 (5.6)
Acute renal failure	1 (1.2)	5 (5.8)	0.22	1 (1.1)	0 (0)
Chylothorax	2 (2.3)	1 (1.2)	1.00	0 (0)	1 (5.6)
Reoperation	1 (1.2)	1 (1.2)	1.00	1 (1.1)	0 (0)

Data presented as the number of patients or median value.
Figures in parentheses indicate either percentage or range.

occurred in both groups, and there were no significant differences between two groups, respectively. There were two reoperations in the thoracotomy group: one bleeding-related reoperation and one technical error-related reoperation.

Next, conversions from VATS to thoracotomy (n = 19) were analysed in the VATS group by the 'intent-to-treat' method (attempted VATS = 179, thoracotomy = 104). Among the 19 patients converted from VATS to thoracotomy, 6 patients (31.5%) experienced seven postoperative complications; pneumonia in 2, AF in 2, reoperation in 1, prolonged air leakage in 1 and chylothorax in 1. Matching based on propensity scores produced 86 patients in each group, and postoperative outcomes were compared between the two groups (Table 4). The median operative time and median length of hospital stay were shorter in the VATS group compared with the thoracotomy group, respectively (all $P = 0.04$). The median number of lymph nodes dissected was lower in the VATS group compared with the thoracotomy group (24 vs 31; $P < 0.01$). There was a trend towards a lower incidence of overall postoperative complications in the VATS group than that in the thoracotomy group (24.4 vs 38.4%; $P = 0.09$). Compared with lobectomy by thoracotomy, VATS lobectomy was associated with a lower incidence of prolonged air leakage ($P < 0.01$) and pulmonary complications ($P < 0.01$) including a lower incidence of postoperative pneumonia ($P = 0.02$).

DISCUSSION

The main finding of the present study is that VATS lobectomy is associated with lower postoperative pulmonary complications (1.1 vs 12.1%; $P < 0.01$), lower postoperative pneumonia (1.1 vs 11.0%; $P = 0.01$) and a shorter hospital length of stay (6 vs 9 days; $P = 0.04$) compared with lobectomy by thoracotomy in well-matched COPD patients.

These findings are important because COPD is a commonly encountered comorbid disease in lung cancer and poses risks to surgery. Previous studies reported that some (50–80%) lung cancer patients had co-existing COPD, and the risk of patients with COPD developing lung cancer was two to three times higher than it was for smokers without COPD [7, 8]. Furthermore, cardiorespiratory comorbidities, which could increase perioperative morbidity, are more frequently diagnosed in COPD patients due to their higher propensity for smoking [9]. Among the patients undergoing pulmonary resection, postoperative pulmonary complication is the most important factor affecting postoperative outcomes. This risk is of particular importance in the surgical treatment of NSCLC combined with COPD because postoperative pulmonary complications occur more frequently in patients with COPD than in those without COPD [1, 2, 10]. Schussler *et al.* reported that the incidence of postoperative pneumonia was 25% after major lung resection and that COPD, a greater extent of resection, the presence of intraoperative bronchial colonization and male sex were independent risk factors for pneumonia [10]. Sekine *et al.* reported several series that evaluated the influence of COPD on postoperative outcomes of patients who underwent surgery for NSCLC [1, 2]. They reported that the presence of COPD was significantly associated with increased postoperative pulmonary complications, as well as with increased mortality. They also reported that postoperative pneumonia occurred more frequently even in the mild COPD group compared with the non-COPD group (10.1 vs 4.2%). In our study, the incidence of pneumonia was 1 of 91 patients (1.1%) in the VATS group and 11 of 91 patients (12.1%) in the thoracotomy group. There were three mortalities only in the thoracotomy group, and the cause of death was pneumonia in all cases.

Since a series of reports demonstrated the feasibility and safety of VATS lobectomy [11, 12], the procedure has been widely and commonly accepted for early-stage NSCLC. Data supporting the benefit of VATS lobectomy over lobectomy by thoracotomy have been reported based on numerous studies. In these reports, VATS lobectomy showed better postoperative outcomes, including reduced post-operative pain, a lower incidence of postoperative complications (e.g. pneumonia, respiratory failure and prolonged air leakage) and a shorter length of hospital stay, compared with lobectomy by thoracotomy [5, 13–15]. While mortality rates of VATS lobectomy and lobectomy by thoracotomy are similar, VATS lobectomy generates less pain, preserves immune function and preserves pulmonary function [13], resulting in fewer postoperative complications. Especially, these benefits are most likely greater for high-risk patients who are susceptible to postoperative complications. Investigators have recently demonstrated that VATS lobectomy results in fewer postoperative complications in high-risk patients, such as the elderly and patients with limited pulmonary reserve [4, 5]. However, there are little data from well-designed studies that compare VATS lobectomy and lobectomy by thoracotomy in patients with COPD.

Our study reveals superior early postoperative outcomes in the VATS group with respect to postoperative pulmonary complications, including pneumonia, operation time and length of hospital stay. The incidence of postoperative complications and mortality among the VATS and thoracotomy groups are comparable with those reported by Flores *et al.* [16]. The incidence of postoperative pulmonary complications in the thoracotomy group is comparable with the incidence in another series of patients with COPD [2]. Importantly, in this study, VATS lobectomy reveals a favourable outcome with respect to postoperative pulmonary complications, which could be attributed mainly to postoperative pneumonia. We performed a propensity score-matched analysis in the enrolled stage I NSCLC patients, as this disease entity is the optimal candidate for VATS lobectomy. Because patients were well matched between the VATS and thoracotomy groups according to their perioperative variables, as listed in Table 2, we could minimize the impact of potential confounding variables. Several studies have demonstrated that factors, such as patient' age and pulmonary function test results, including FEV_1 and DLCO, are independent risk factors for postoperative morbidity and mortality [17–19]. In this study, these factors were very similar between the VATS and thoracotomy groups. However, some studies showed that VATS lobectomy was a stronger predictor of postoperative morbidity than age and pulmonary function [20, 21]. Regarding the severity of COPD, most patients in this study presented with mild-to-moderate COPD, and there were few patients with severe COPD. The most likely reason for this finding is that many patients with severe COPD tend to be treated with sublobar resection or non-surgical treatment, such as radiotherapy and chemotherapy due to their poor cardiopulmonary reserve. Another reason is that lung cancer develops more frequently in patients with mild-to-moderate COPD compared with those with severe disease. In their large-scale study, de Torres *et al.* demonstrated that mild-to-moderate COPD is an independent factor that is associated with the development of lung cancer in established COPD [22]. In terms of the oncological aspect, a concern remains regarding the adequacy of nodal assessment in VATS lobectomy. In the present study, the median number of lymph nodes dissected in the VATS group was significantly lower relative to the thoracotomy group (24 vs 29, $P = 0.04$). However, the number of lymph nodes dissected depends on the surgeon's policy in early-stage NSCLC rather than on a technical limitation of the VATS approach. The median number of lymph nodes dissected in the VATS group is comparable with that of other studies [23]. With regard to conversions from VATS to thoracotomy, the overall incidence of postoperative complications in these patients was 31.5%. In the literature, conversion from VATS to thoracotomy does not appear to pose postoperative complications other than those associated with thoracotomy alone [24]. When the intent-to-treat analysis was performed, attempted VATS lobectomy was also associated with improved postoperative outcomes.

This retrospective study has several limitations. First, we used a small dataset from a single institutional retrospective study; therefore, selection bias was unavoidable. However, propensity score-matching gives the present study the power to represent. Second, diagnosis of COPD was made only by functional limitation, based on spirometry data, and other spirometric or clinical criteria were not considered to confirm COPD [25].

In conclusion, VATS lobectomy is a safe and feasible procedure for early-stage NSCLC in patients with COPD because it demonstrates favourable postoperative outcomes. Additionally, VATS lobectomy might be optimal for patients with co-existing COPD due to fewer postoperative complications, including postoperative pneumonia, and shorter length of hospital stay compared with lobectomy by thoracotomy. We believe that VATS lobectomy can be regarded as

a preferred strategy for appropriately selected NSCLC patients with COPD.

Conflicts of interest: none declared.

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