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ORIGINAL ARTICLE

Unexpected conversion to thoracotomy during thoracoscopic lobectomy: a single-center analysis

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Abstract

Background The aim of this study was to discuss indications and outcomes for conversion to thoracotomy during thoracoscopic lobectomy.

Materials and methods Patients who underwent lobectomy for non-small cell lung cancer between January 2012 and December 2016 were evaluated retrospectively. The study included 129 patients who underwent video-assisted thoracoscopic lobectomy (group-V) and 18 patients converted from thoracoscopic lobectomy to thoracotomy due to unexpected intraoperative complications (group-T).

Results The two patient groups showed no statistical differences in terms of demographic characteristics. Causes of unexpected conversions to thoracotomy were hemorrhage in six patients, dense pleural adhesions in seven patients, fused fissure in one patient, and fibrocalcified lymph nodes around the vascular structures in four patients. Operative time was 180.37 ± 68.6 min in group-V and 235 ± 72.6 min in group-T ($p = 0.003$). Intraoperative blood loss was 263.9 ± 180.6 mL in group-V, compared to 562.7 ± 296.2 mL in group-T ($p < 0.001$). Patient age ≥ 70 years was a significant risk factor for conversion to thoracotomy ($p = 0.015$, odds ratio 4.73). The 5-year survival rate in group-V was 71.4% {mean: 65.2 months [95% confidence interval (CI) 59.6–70.8]}, while that in group-T was 80% [mean 54.9 months (95% CI 45.9–63.8)] ($p = 0.548$).

Conclusion Advanced age was identified as the main risk factor for conversion to thoracotomy. However, early- and long-term outcomes were similar in the two groups, indicating that video-assisted thoracoscopic surgery is a safe and applicable method.

Keywords VATS · Thoracic surgery · Conversion to thoracotomy · Thoracotomy

Introduction

Surgery is the best treatment option for early-stage lung cancer. Lobectomy by video-assisted thoracoscopic surgery (VATS) has been successfully used in the surgical treatment of lung cancer since the 1990s [1]. Today, VATS is accepted as the standard method for early-stage lung cancer surgery, and its applications in advanced disease are also being explored. Studies have shown that VATS offers less pain [2], less postoperative morbidity, shorter hospital stays, and better preservation of pulmonary functions [3] relative to open surgery. In addition, recurrence and overall survival rates were found to be similar compared to thoracotomy [4–6].

Despite these advantages, conversion to thoracotomy (CThx) occurs more frequently during the thoracoscopic surgery training period. Small incisions and limited camera angles can cause technical difficulties during thoracoscopic surgery. CThx rates in lung cancer range from 2.5 to 23% [1, 7–10]. Such cases are associated with substantial intraoperative blood loss and prolonged operative times, and require additional lung manipulations.

The aim of this study was to evaluate preoperative risk factors for conversion in patients who underwent VATS lobectomy in our center due to early non-small cell lung cancer (NSCLC) and required CThx, and to compare

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long-term outcomes of converted patients and patients with completed VATS.

Materials and methods

The study was approved by the institutional review board and conducted in accordance with the principles of the Declaration of Helsinki.

Patients who underwent VATS lobectomy for NSCLC between January 2012 and December 2016 were included in the study. Between these periods 1309 patients underwent anatomical resections and 388 thoracoscopic resections were performed. We retrospectively evaluated routinely collected patient data from the hospital database. The patients were evaluated in two groups: patients who underwent lobectomy by VATS (group-V), and patients whose procedures started as VATS and were converted to thoracotomy due to unexpected intraoperative complications (group-T). A total of 147 patients were included (129 in group-V, 18 in group-T). In this study, we evaluated the cases of three surgeons who had 10 years VATS lobectomy experience. The flow chart of the study is shown in Fig. 1.

VATS planned for stage 1 and 2 NCSL cancers with tumor size less than 5 cm, and locating at the peripheral or sublober area of the lung. We planned thoracotomy approach for NSCLC patients that had a central tumor (pneumonectomy, completion pneumonectomy, and angioplastic/bronchoplastic lobectomy), those with an advanced lung cancer stage, those with a history of a previous lung operation, those with a history of neoadjuvant chemoradiotherapy and coronary bypass surgery. In all cases, the multi-disciplinary thoracic oncology board had recommended surgical resections.

Preoperative evaluation

Routine biochemical and pulmonary function tests were done. Carbon monoxide diffusion capacity test (DLCO), ventilation perfusion scintigraphy, 6-min walk test, and stair climb test were used to evaluate patients with borderline pulmonary function test results.

Patients were routinely subjected to positron emission tomography (PET) to examine for distant metastases and mediastinal lymph nodes and cranial magnetic resonance imaging (MRI) screening for cranial metastases.

Low FEV1 value was defined as less than 60% of the patient's predicted value. Comorbidities were evaluated in four groups: cardiac problems (arrhythmia, heart failure, and myocardial infarction); respiratory problems (chronic obstructive pulmonary disease, and asthma), endocrinological problems (diabetes mellitus and goiter), and nephrologic problems (acute and chronic kidney failure).

Surgical procedure

Following double-lumen selective intubation, a 10-mm camera port was made on the anterior axillary line at the 8th intercostal space. Intrathoracic pathology, adhesions, and diaphragm level were assessed using a 30° 10-mm thoracoscope (Logic HD, Wolf, Knittlingen, Germany). A 5-cm utility incision was made in the fourth or fifth intercostal space at the anterior border of the latissimus dorsi muscle. When needed, a 2-cm auxiliary third-port incision was made in the mid-scapular area. Lobectomy was performed following the

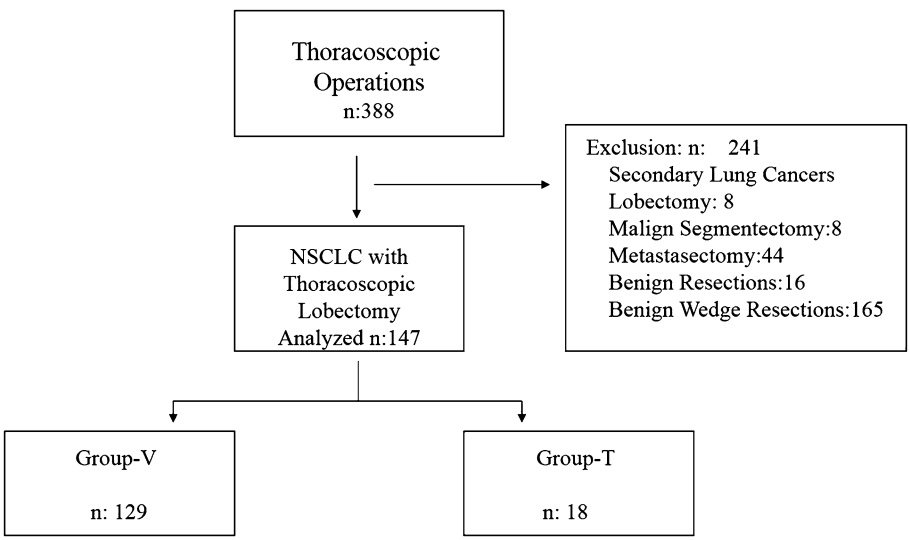

Fig. 1 Flow diagram of the study

same principles used in open surgery. Unplanned CThx was required due to pleural adhesions during hilar dissection, intraoperative hemorrhage, and anthracofibrosis of the hilar lymph nodes. VATS lobectomy was converted to thoracotomy by extending the utility incision posteriorly to a length of approximately 15–20 cm. Complications were managed and the surgeries completed using standard open technique.

Systematic lymph node dissection was performed in all cases. The hilar lymph nodes and at least three mediastinal stations, including the subcarinal station, were dissected. Pathologists also dissected the intraparenchymal lymph nodes (12, 13, 14) postoperatively.

Postoperative follow-up

Morbidity was defined as undesired conditions occurring in hospital or within the first postoperative 30 days. Morbidities were classified as respiratory (pneumonia, prolonged air leak, and atelectasis) or nonrespiratory (arrhythmia, chylothorax, neurogenic disorders, hoarseness, surgical-site infections requiring revision, and postoperative hemorrhage).

Short-term mortality was determined based on deaths that occurred in hospital or within the first postoperative month, including intraoperative deaths.

Demographic data, morbidities, length of hospital stay, histopathological features, mortality, and 5-year survival rates were evaluated. Histopathological evaluation was done according to the 8th edition of the IASLC staging guidelines [11].

Follow-up data were obtained through office visits or telephone interviews with the patient, a relative, or their primary physicians.

Patients were followed in conjunction with the oncology team with chest CT and physical examination every 3 months for the first 2 years, every 6 months between 2 and 5 years, and once a year thereafter. Mean postoperative follow-up time was 33 months.

Statistical analysis

Continuous variables are presented as a mean ± standard deviation and discrete variables are presented as frequencies. The demographic and clinical characteristics of the patients and variables, such as age and hospitalization time, were tested for a normal distribution using the Kolmogorov–Smirnov test. The *t* test was used to calculate the mean values of these variables in the two groups, and the Chi square test was used to compare morbidity between the two groups. Survival probabilities were estimated by the Kaplan–Meier method. The calculations were performed using SPSS software (Version 22, SPSS Inc., Chicago, IL, USA). A p value < 0.05 was considered significant.

Results

The study included 37 women (25.2%) and 110 men (74.8%) with a mean age of 59.6 ± 10.0 years. Group-V included 18 patients (12.2%) and group-T consisted of 129 patients (87.8%). Sixty-eight patients (46.3%) had comorbidities. The two patient groups showed no statistical differences in terms of demographic characteristics (Table 1).

Causes of unexpected conversions to thoracotomy were hemorrhage in six patients, dense pleural adhesions in seven patients, fused fissure in one patient, and fibrocalcified lymph nodes around the vascular structures in four patients.

Eighty-eight patients (59.9%) had adenocarcinoma, 38 (25.9%) had squamous cell carcinoma, and 21 patients had large cell and carcinoid tumors. Mean tumor diameter was 2.78 ± 1.33 cm. Disease was stage I in 111 patients (75.5%), stage II in 28 patients (19%), and stage III in 8 patients (5.4%). There was no statistically significant difference between the two groups in terms of histopathology or stage. Mean number of lymph nodes removed was 15.53 ± 7.04 in group-V and 16.66 ± 7.47 in group-T ($p = 0.578$). Eighty-eight patients (59.9%) underwent 2-port VATS lobectomy and 41 (27.9%) underwent 3-port VATS lobectomy. Mean utility incision length was 4.68 ± 0.83 cm (Table 2). Operative time was 180.37 ± 68.6 min in group-V

Table 1 Demographic characteristics of patients

Variables	Group-V, *n* (%)	Group-T, *n* (%)	*p* Value
Gender			
Male	98 (76)	12 (66.7)	0.394
Female	31 (24)	6 (33.3)	
Age (years)	59.4 ± 9.72	61.83 ± 12.1	0.305
< 70	115 (89.1)	11 (61.1)	0.001
≥ 70	14 (10.9)	7 (38.9)	
Smoking (packet/year)	27.44 ± 20.8	32 ± 20.9	0.421
Smoking habit			
Former	85 (81.7)	11 (68.8)	0.227
Active	19 (18.3)	5 (31.3)	
Comorbidity	58 (45)	10 (55.6)	0.398
Cardiac	28 (21.7)	9 (50)	0.010
Respiratory	25 (19.4)	5 (27.8)	0.408
Endocrinologic	17 (13.2)	2 (11.1)	0.807
Neurological	3 (2.3)	1 (5.6)	0.440
FEV1 (L)	2.34 ± 0.73	2.13 ± 0.70	0.534
FEV1 (%)	81.0 ± 16.8	79.1 ± 25.4	0.741
ASA score			
1	22 (17.2)	3 (16.7)	0.997
2	77 (60.2)	11 (61.1)	
3	29 (22.7)	4 (22.2)	
Chest drain removal	3.83 ± 3.52	4.94 ± 2.66	0.001

and 235 ± 72.6 min in group-T ($p = 0.003$). Intraoperative blood loss was 263.9 ± 180.6 mL in group-V, compared to 562.7 ± 296.2 mL in group-T ($p < 0.001$).

Complications occurred in 31 patients (21.1%). Complications occurred in 27 patients (20.9%) in group-V and in 4 patients in group-T (22.2%) ($p = 0.900$). 4 (3.1%) patients in group-V and 1 (5.6%) in group-T had pneumonia. Of the 10 patients who had atelectasis, 6 (4.7%) were in group-V and 4 (22.2%) in group-T. The most common complication in group-V was prolonged air leak, in 15 patients (11.6%). In group-T, prolonged air leak occurred in 3 patients (16.7%) ($p = 0.541$).

In the non-respiratory complications, arrhythmia occurred in 4 patients (3.1%) in group-V and in 3 patients (16.7%) in group-T ($p = 0.011$). Chylothorax occurred in 3 patients (2.3%) in group-V and not seen in group-T ($p = 1$). Wound infections were seen in 3 patients (16.7%) in group-T and 2 patients (1.6%) in group-V ($p = 0.013$). Hoarseness was observed in 1 patient (0.8%) in group-V and not in group-T ($p = 0.690$). Cerebrovascular disease was observed in 2 patients (1.6%) in group-V and not in group-T ($p = 1$).

Table 2 Comparison of histopathologic and surgical results

Variables	Group-V, *n* (%)	Group-T, *n* (%)	*p* value
Side			
Right	78 (60.5)	9 (50)	0.397
Left	51 (39.5)	9 (50)	
Operation			
RUL	41 (32.3)	5 (27.8)	0.756
RML	7 (5.5)	0	
RLL	27 (21.3)	4 (22.2)	
RLB	3 (2.4)	0	
LUL	28 (22)	4 (22.2)	
LLL	21 (16.5)	5 (27.8)	
Histopathology			
Adenocarcinoma	76 (58.9)	12 (66.7)	0.635
SqCC	35 (27.1)	3 (16.7)	
Others (carcinoid, LCC)	18 (14)	3 (16.7)	
Tumor diameter (cm)	2.82 ± 1.34	2.48 ± 1.24	0.484
Tumor diameter			
< 5 cm	113 (88.6)	18 (88.9)	0.876
≥ 5 cm	16 (12.4)	2 (11.1)	
Pathological stage			
1	99 (76.7)	12 (66.7)	0.596
2	23 (17.8)	5 (27.8)	
3	7 (5.4)	1 (5.6)	
Lymph node metastasis	14 (10.9)	5 (27.8)	0.045

LCC large cell carcinoma, *SqCC* squamous cell carcinoma, *RUL* right upper lobectomy, *RML* right middle lobectomy, *RLL* right lower lobectomy, *RLB* right lower bilobectomy, *LUL* left upper lobectomy, *LLL* left lower lobectomy

In group-V, hemorrhage occurred in 2 patients (1.6%) and not in group-T.

Atelectasis and surgical-site infections were more common in group-T. Prolonged air leak was managed with pleurodesis in 11 patients and resolved spontaneously in 7 patients. In patients with chylothorax, oral feeding was stopped and treatment with somatostatin was initiated. One patient with chylothorax underwent revision VATS. Median length of hospital stay was 4 days in group-V and 5 days in group-T ($p < 0.001$).

Univariate analysis of group-T patients showed that older age at surgery, cardiac comorbidity, and lymph node metastasis were significant risk factors. In logistic regression analysis, age ≥ 70 years was a significant risk factor [odds ratio (OR) 4.73, $p = 0.015$]. Cardiac comorbidity and lymph-node metastasis were not statistically significant factors (OR 2.27, $p = 0.146$ and OR 2.79, $p = 0.113$, respectively).

There was no intraoperative mortality. The 30-day mortality rate was 1.3% ($n = 2$). These two patients underwent VATS lobectomy and died due to pneumonia at postoperative 1 month after adjuvant therapy.

Mean survival time was 66.13 ± 2.44 months and the 5-year survival rate was 73.3%. In survival analysis of patients with adenocarcinoma and squamous cell cancers, the 5-year survival rate was 71.4% in group-V (mean 65.27 months, 95% CI 59.6–70.8) and 80% in group-T (mean 54.9 months, 95% CI 45.9–63.8) ($p = 0.548$) (Fig. 2).

Discussion

VATS is now considered a safe and effective method with comparable oncologic outcomes to open surgery. However, unforeseen situations can arise due to factors such as the use of small incisions and the presence of adhesions in the lung.

The decision to convert to open surgery is made by each surgeon based on their skills and patience. In our study, the CThx rate was 12.2%. The most common reason for CThx is severe intrathoracic adhesions. In the literature, nodal anthoracofibroses and vascular injuries are among the most common reasons for CThx. Byun et al. [12] reported that anthoracofibrosis was responsible for 40% of CThx in their study, and emphasized that this may be a cause specific to Asian populations. In contrast, Wanatabe [13] and Jones [14] reported that vascular injuries were the most common cause of CThx. Mason et al. [15] stated that careful examination of preoperative computed tomography (CT) images may enable detection of fibrocalcific adhesions and prediction of VATS complications. Pleural adhesions are accepted as a relative contraindication for thoracoscopic surgery [16]. Due to the low socioeconomic conditions, prevalence of tuberculosis [17], and high rates of previous infection in Turkey, pleural adhesions are common [18]. This may explain the

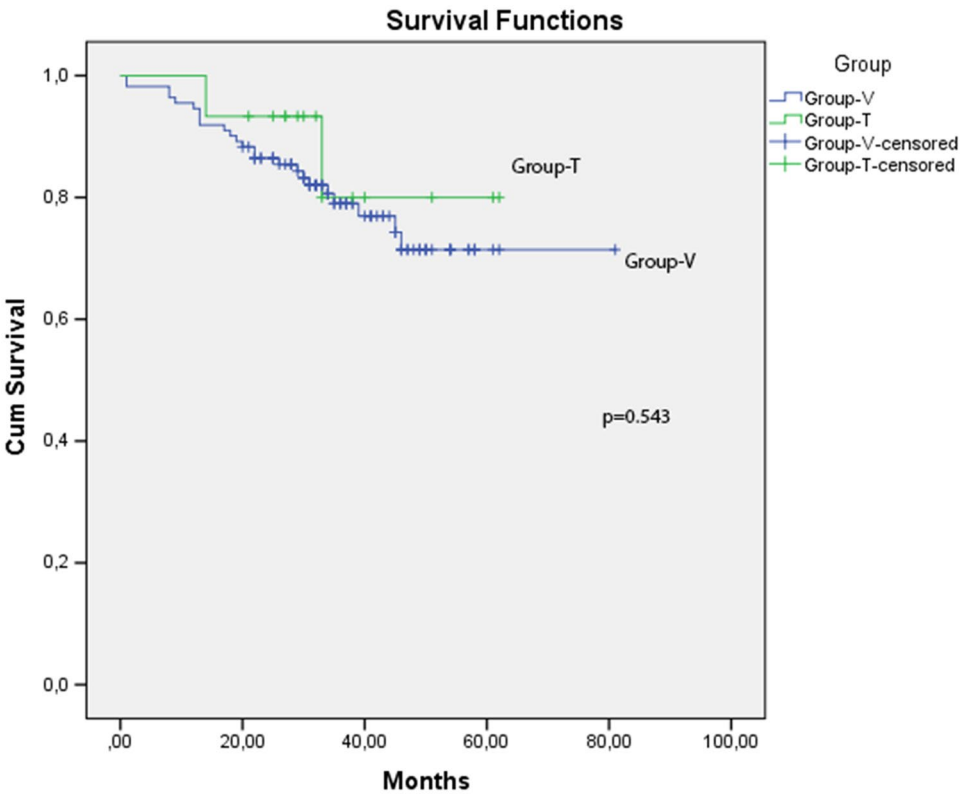

Fig. 2 Kaplan–Meier curves show overall survival after video-assisted thoracoscopic surgery (VATS) lobectomy vs. VATS converted to open thoracotomy in patients with adenocarcinoma and squamous cell carcinoma

differences in CThx causes between our study and other reports in the literature.

Jones et al. [14] determined a maximum size limit of 5 cm for thoracoscopic tumor resection. Li et al. [19] reported that tumor diameter was not a factor in CThx according to their multivariate analysis. In addition, they stated that tumors 5 cm and larger were peripherally located and the hilar structures were clearly visible. However, for tumors close to the hilar region and large tumors, they argued that early CThx is necessary to limit anesthesia and operative times. Tumor diameter, histopathology, and stage were not associated with CThx in the present study.

In our study, the main risk factors for CThx in univariate analysis were age ≥ 70 years, cardiac comorbidity, and positive lymph node status. However, only age ≥ 70 years emerged as a significant risk factor in logistic regression analysis (OR 4.73, $p = 0.015$). Lymph-node positivity has been reported as a risk factor for CThx in numerous studies [19–21]. Li and Park [19] argued that this is mainly due to the lymph nodes interfering with vascular dissection. Comorbidity and age have not been identified as risk factors in previous studies. We attribute the higher rate of CThx in patients 70 years and older in our study to age-related loss of vascular elasticity.

Pulmonary artery injuries and hemorrhages are the main mortal complications [9, 10]. In our study, vascular injury occurred in 11 patients during thoracoscopic lobectomy. Uncontrollable bleeding necessitated CThx in six patients. In the event of hemorrhage, pressure was applied with nanofiber 'peanuts' or surgical gauze for an average of 5 min to achieve hemostasis. Based on the surgeon's experience, 4–0 polypropylene sutures were used to repair the vascular injury. If the bleeding could not be controlled by pressure or suturing, the procedure was converted to thoracotomy. Control of vascular structures in the fissure is more difficult. Nomori et al. [22] claimed that the main vessels and bronchi should be controlled before incising the fissure. In our practice, we use the Endo GIA to incise the fissure. However, it should always be kept in mind that vascular injury may occur when using the Endo GIA. Jones et al. [14] reported pulmonary artery damage in two patients associated with Endo GIA that resulted in CThx. Similarly, Li et al. [19] stated that using the Endo GIA during fissure dissection can cause injury to the posterior walls of the vessels. In our study, vascular injury associated with Endo GIA use occurred in two patients. In one patient, hemorrhage was controlled with gauze, while in the other patient hemostasis was achieved after CThx.

Although the patients who underwent CThx in our study had more blood loss and longer hospital stays, neither group experienced intraoperative or postoperative mortal complications. Early postoperative atelectasis and surgical-site infections were more common among patients who had CThx. The higher frequency of surgical site infections may

be due to the fact that the incisions are different from those made in standard thoracotomy, and massive intraoperative hemorrhage may result in impaired tissue healing. When total complications were compared, there was no statistically significant difference between the groups. Sawada et al. [20] observed no intraoperative mortality or life-threatening postoperative complications in patients who had VATS lobectomy converted to thoracotomy.

Another important parameter in VATS lobectomy is the evaluation of long-term results. This enables an assessment of the safety and feasibility of conversion from VATS lobectomy [15]. Jones et al. [14] reported similar survival outcomes in patients who had CThx ($p = 0.162$). Park et al. [21] also found that survival and recurrence outcomes were comparable in VATS and CThx patients ($p = 0.626$ and $p = 0.767$). In the present study, long-term survival results were similar in the two patient groups.

Limitations

The main limitations of this study are its retrospective nature, the lack of preoperative performance data, the small number of patients, and the fact that multiple surgeons performed the procedures. In addition, the evaluation of three experienced surgeons in the study also creates bias.

Conclusion

Advanced age was identified as the main risk factor for CThx in this study. Although operative time, intraoperative blood loss, length of hospital stay, and incidence of atelectasis and surgical site infections were greater in patients who converted to thoracotomy, short- and long-term outcomes were similar. These findings support the safety and validity of VATS lobectomy. Careful preoperative patient selection should reduce the likelihood of conversion to open surgery.

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