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Application of Video-Assisted Thoracic Surgery in the Standard Operation for Lung Tumors

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OBJECTIVE To evaluate the indication and short-term outcomes of video assisted thoracic surgery (VATS) for lung tumors.
METHODS Data of 306 consecutive patients undergoing VATS pulmonary resection between January 2009 and August 2010 in Cancer Institute & Hospital, Chinese Academy of Medical Sciences were retrospectively reviewed.
RESULTS There were 7 patients who underwent open thoracotomy, accounting for 2.29% (7/306). The overall morbidity rate of complications and the mortality rate induced by VATS was 1.63% (5/306) and 0.33% (1/306), respectively. There were no significant differences in morbidity and mortality rate between the patients receiving the VATS and the patients receiving the OT. The overall hospitalization, postoperative length of stay (LOS) and chest tube duration in the VATS lobectomy group (n = 167) were shorter than those in the open thoracotomy (OT), but the operative time in the VATS group was longer than that in the OT group (n = 124). There were no significant differences in the number of station of lymph nodal dissection (LND) and number of LND in pathological stage I between VATS group and OT group, but significant differences were found in the number of station of LND and the number of LND in pathological stage II and stage IIIA between the 2 groups. Compared with those who underwent OT wedge resection (n = 72), the patients who underwent VATS wedge resection (n = 108) had shorter operative time, chest tube duration and hospital LOS, and there were no significant differences in morbidity of the complications and mortality between the 2 groups.
CONCLUSION VATS lobectomy can be performed for patients with clinical stage I lung cancer (with tumor diameter smaller than 5 cm, without hilar and mediastinal lymph node enlargement). VATS lobectomy is superior to OT lobectomy in short-term outcomes, although further studies exploring long-term outcomes through longer follow-up is needed to determine the oncologic equivalency between the VATS and the open lobectomy. VATS is also superior to OT in pulmonary wedge resection.

KEY WORDS: thoracic surgery, video-assisted, lung neoplasms, thoracotomy.

Introduction

Video-assisted thoracic surgery (VATS) has become an important part of minimally invasive thoracic surgery (MITS) in the treatment of lung tumors. The role of VATS is well established in the diagnosis of lung nodules. Over the past one and half decades, the scope of applying VATS has undergone rapid evolution. It begins to move beyond diagnostic procedures for lung parenchyma conditions, to gain acceptance as a viable option for lung tumor treatment[1]. VATS lobectomy techniques have been adopted as a preferred approach in many medical centers because it causes less pain[2], fewer complications[3], and shorter lengths of stay[4] compared with open techniques. Long-term outcomes of VATS lobectomy are now available with similar long-term oncologic efficacies[5,6], when compared with those of open lobectomy. Other anatomic lung resections[7-9] have also been reported with acceptable morbidity, mortality, recurrence, and survival rates.

VATS for lobectomy or for pulmonary wedge resection has been employed in our institution for patients with early-stage non-small cell lung cancer (NSCLC), or with pulmonary metastases, or with benign lung tumors. The objectives of this study were to report the experiences and evaluate the indications and short-term outcomes of the resection of lung tumor with VATS.

Materials and Methods

Clinical data

Medical records were retrospectively reviewed from a cohort of 306 consecutive patients (VATS group) who had undergone VATS pulmonary resection in Cancer Hospital, Chinese Academy of Medical Sciences, Beijing between January 2009 and August 2010. There were 166 men and 140 women with median age of 54 years (range of 19 to 86 years).This study was reviewed and approved by the Institutional Review Board of Cancer Hospital, Chinese Academy of Medical Science. In the same period, 196 patients who had undergone lobectomy or wedge resection via open thoracotomy (OT group) were selected randomly as controls. Clinical variables were collected and compared between the 2 groups, including the time spent for the VATS, number of resected nodal, duration of chest tube drainage, morbidity, mortality, and length of stay. TNM staging was carried out according to AJCC 2009 cancer staging[10].

Surgery

The techniques of VATS resection for lung tumors had been described in a previous report[11] by the same group and were outlined as follows. General anesthesia with selective lung ventilation was performed with a double lumen endo-tracheal tube. Patients were placed in a lateral decubitus position on the operation table. In the VATS group, a Thoracoport™ was placed in the seventh or eighth intercostal space on the middle axillary line at first as observation port. A 3-6 cm window was used as the utility incision. Thoracotomy was opened from the fourth or fifth intercostal space without rib spreading. The third port hole was made according to the location of the tumor. For patients who underwent sleeve lobectomy, the 2 ends of the bronchus were brought together using uninterrupted sutures. The posterior suture line was completed first, followed by the anterior one. At last, a systematic lymph node dissection was mandatory. In the open thoracotomy group, conventional posterolateral incision was made with 20-25 cm in length for lobectomy and 10-15 cm in length for pulmonary wedge resection. All VATS specimens were placed into an impermeable bag and removed through the utility incision.

Statistical analysis

The SPSS software package 13.0 for Windows was used for statistical analysis. Data were presented as mean ± SD or median value, interquartile range (IQR) for continuous variables, and percentages for dichotomous variables. Continuous variables were analyzed using *t*-test or nonparametric test, and categorical variables were analyzed using χ^2 test. A *P*-value of less than 0.05 was considered significant.

Results

VATS was attempted in 306 patients in our institution, but the procedure was converted to thoracotomy in 7 patients (2.29%) as a result of pleural adhesions (n = 5) or bleeding of pulmonary branch (n = 2). VATS lobectomy was performed in 167 patients for lung cancer, VATS bilobectomy in 3 patients, VATS sleeve lobectomy in 4 patients, VATS left pneumonectomy in 3 patients, VATS segmentectomy in 14 patients, and VATS pulmonary wedge resection was performed in 108 patients. The VATS procedures were performed on primary lung cancers (n = 204), pulmonary metastases (n = 33) and benign lung tumors (n = 69). The median duration of chest tube drainage was 4 days (range of 1 to 18 days). The median length of hospital stay was 15 days (range of 5 to 66 days).

Overall morbidity of complications caused by the VATS procedures was 1.63% (5/306), including cardiac arrhythmia (n = 1), respiratory failure (n = 1), wound infection (n = 2), and postoperative bleeding (n = 1). One patient died of acute respiratory distress syndrome (ARDS), which made a mortality rate of 0.33% (1/306) in the study patients.

In regard to the time spent for pulmonary lobectomy, overall hospitalization, postoperative length of stay (LOS) and the duration of chest tube drainage, it was shorter in VATS group (n = 167) than that in the open thoracotomy (OT) group (n = 124), of which operation

Table1. Comparision of short-term outcomes between VATS lobectomy and open lobectomy for lung cancer (n = 291).

Characteristics	VATS group (n = 167)	OT group (n = 124)	P
Age, years	58.37 ± 11.06	60.02 ± 10.91	0.204
Sex (Male/Female)	98/69	84/40	0.142
History of smoking (%)	57 (34.1)	50 (40.3)	0.326
Charlson scores	0 (1)	0 (0)	0.127
Tumor location (%)			0.303
LUL	49 (29.3)	37 (29.8)	
LLL	34 (20.4)	15 (12.1)	
RUL	41 (24.6)	37 (29.8)	
RML	6 (3.6)	8 (6.5)	
RLL	37 (22.2)	27 (21.8)	
Operative time (h)	3.10 (1.50)	2.55 (1.00)	< 0.001
No. of LND			
Stage I	13.5 (14)	17.5 (13)	0.142
Stage II	15 (13)	25.5 (15)	< 0.001
Stage IIIA	26 (12)	37 (10)	< 0.001
No. of station of LND			
Stage I	7 (2)	7 (3)	0.281
Stage II	6 (2)	7 (1)	< 0.001
Stage IIIA	6 (2)	7 (3)	0.003
Histology (%)			0.417
Squamous cell carcinoma	43 (25.7)	40 (32.3)	
Adenicarcinoma	104 (62.3)	67 (54.0)	
Others	20 (12.0)	17 (13.7)	
Chest tube duration (d)	4(1)	5 (2)	0.007
Pathological stage (%)			0.160
I	118 (70.7)	84 (67.7)	
II	34 (20.4)	20 (16.1)	
IIIA	15 (9.0)	20 (16.1)	
Morbidity (%)	5 (3.0)	6 (4.8)	0.537
Mortality (%)	1 (0.6)	0 (0)	0.431
Hospital LOS (d)	15 (5)	17 (5)	< 0.001
Postoperative LOS (d)	9 (3)	10.5 (3)	< 0.001

VATS, video assisted thoracic surgery; OT, open thoracotomy; LUL, left upper lobe; LLL, left lower lobe; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LND, lymph node dissection; LOS, length of stay.

Table 2. Comparisons of short-term outcomes between VATS lobectomy and open lobectomy for Stage I lung cancer (n = 202).

Characteristics	LUL (n = 62)		LLL (n = 33)		RUL (n = 60)		RML (n = 10)		RLL (n = 37)	
	VATS (n = 37)	OT (n = 25)	VATS (n = 24)	OT (n = 9)	VATS (n = 32)	OT (n = 28)	VATS (n = 5)	OT (n = 5)	VATS (n = 20)	OT (n = 17)
Operative time (h)	3.10 (1.43)	2.50 (1.25)	3.10 (1.33)	1.50 (1.88)*	3.00 (1.80)	2.70 (1.03)	2.75 (0.73)	1.75 (1.40)	3.50 (3.00)	2.30(0.93)*
No. of nodal dissections	14 (21)	20 (11)	18 (11)	22 (10)	13(10)	12.5 (20)	7 (11)	15 (13)	12 (18)	17(21)
Chest tube duration (d)	4 (3)	6 (3)	4 (1)	5 (3)	4 (1)	5.5(1)*	5 (3)	4 (1)	5 (2)	5(2)
Morbidity (%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4(14.3)*	0 (0)	0 (0)	2 (10.0)	1(5.9)
Mortality (%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0(0)
Hospital LOS (d)	14 (5)	18 (5)*	15.5 (8)	18 (5)	14 (4)	16 (5)	16.5 (9)	21 (5)	17 (6)	17(5)
Postoperative LOS (d)	8 (3)	11 (3)*	8.5 (4)	11 (4)	8 (3)	10.5 (2)*	10 (5)	9 (20)	9 (3)	10(3)

VATS, video assisted thoracic surgery; OT, open thoracotomy; LUL, left upper lobe; LLL, left lower lobe; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LOS, length of stay; * indicates $P < 0.05$.

time was also longer. There were no significant differences in morbidity rate of complications and mortality rate between the VATS group and the OT group. There was no significant difference in the number of station of lymph nodal dissection (LND) or in the number of LND in pathological stage I between the VATS group and the OT group, but significant differences were found in the number of station of LND and the number of LND in pathological stage II and stage IIIA between the 2 groups (Table 1).

Further analysis on stage Ⅰ lung cancer also showed longer operation time spent for VATS left lower lobectomy and right lower

Table 3. Comparisons of short-term outcomes between upper lobectomy and middle lobectomy or lower lobectomy via VATS for lung cancer (*n* = 167).

Characteristics	LUL + RUL (*n* = 90)	LLL + RML + RLL (*n* = 77)	*P*
Operative time (h)	3.25 (1.50)	3.00 (1.20)	0.040
No. of LND	16 (18)	17 (22)	0.677
Chest tube duration (d)	4 (3)	4 (2)	0.019
Postoperative LOS (d)	10 (2)	8 (3)	0.018
Hospital LOS (d)	16 (6)	14 (4)	0.060
Morbidity (%)	2 (2.2)	3 (3.9)	0.663
Mortality (%)	0 (0)	1 (1.3)	0.325

VATS, video assisted thoracic surgery; OT, open thoracotomy; LUL, left upper lobe; LLL, left lower lobe; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LND, lymph node dissection; LOS, length of stay.

Table 4. Comparisons of short-term outcomes between VATS pulmonary wedge resection and open pulmonary wedge resection (*n* = 180).

Characteristics	VATS group (*n* = 108)	OT group (*n* = 72)	*P*
Age, years	55.93 ± 13.06	58.08 ± 12.34	0.271
Sex (Male/Female)	47/60	42/30	0.068
History of smoking (%)	35 (32.7)	24 (33.3)	0.931
Charlson scores	0 (0)	0 (0)	0.392
Tumor location (%)			0.198
LUL	26 (24.3)	25 (34.7)	
LLL	20 (18.7)	6 (8.3)	
RUL	35 (32.7)	19 (26.4)	
RML	7 (6.5)	6 (8.3)	
RLL	20 (18.5)	16 (22.2)	
Operative time (h)	1.50 (0.9)	1.7 (0.7)	0.031
Chest tube duration (d)	4 (1)	4 (2)	0.035
Morbidity (%)	0 (0)	2 (2.8)	0.235
Mortality (%)	0 (0)	0 (0)	1.000
Hospital LOS (d)	14 (6)	17 (7)	0.001

VATS, video assisted thoracic surgery; OT, open thoracotomy; LUL, left upper lobe; LLL, left lower lobe; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LOS, length of stay.

lobectomy than that spent for OT lobectomy, shorter length of stay (LOS) of the patients receiving left upper lobectomy, shorter postoperative LOS of the patients receiving left upper lobectomy and right upper lobectomy, shorter duration of chest tube drainage of the patients undergoing right upper lobectomy than that of the patients undergoing OT lobectomy. No significant difference in the number of LND in all kinds of lobectomy between VATS lobectomy and OT lobectomy group (Table 2).

As shown in Table 3, operation time spent for upper lobectomy was longer than that spent for middle lobectomy or lower lobectomy, same as the duration of chest tube drainage and that of the postoperative LOS.

Compared with those who underwent OT wedge resection (*n* = 72), patients who underwent VATS wedge resection (*n* = 108) had a shorter operation time, shorter duration of chest tube drainage and shorter LOS, although there were no significant differences in morbidity rate and mortality rate between VATS wedge resection group and OT wedge resection group (Table 4).

Discussion

VATS is one of the most important developments in thoracic surgery in recent years, and it is an integral component of minimal invasive thoracic surgery, which well embodies the concept of fast-track surgery. Compared with VATS esophagectomy and VATS removing mediastinal tumors, VATS lobectomy has been performed more frequently for early lung cancer worldwide, and there is tendency that VATS lobectomy could replace most procedures performed in the open lobectomy[12].

In this VATS lobectomy series, postoperative morbidity and mortality rate was 1.63% and 0.33%, respectively. The time spent for postoperative length of stay and chest tube drainage in the VATS lobectomy group was shorter than that in the OT lobectomy group, which is comparable to that in previous reports[5,6]. A secondary analysis of data from the American College of Surgeons Oncology group Z0030 randomized clinical trial showed the same results[13]. All of these studies demonstrate that VATS lobectomy is a safe procedure and has better short-term outcomes compared with OT lobectomy.

Currently, there are two kinds of incisions in VATS lobectomy[14]. One is assisted VATS lobectomy: minithoracotomy, which uses a thoracoscope serving only as a light source, and the other is complete endoscopic surgery, that is 3-6 cm in length incision as utility port without rib spreading, through which lobectomy and systematic lymph node dissection are completed. Complete VATS lobectomy is used in this institution and there is no significant difference in the number of lymph node dissections between VATS lobectomy group and OT lobectomy group for pathological stage I lung cancer. Many thoracic surgeons have considered that lymph node dissection for primary lung cancer in VATS is inferior to that in OT. Regarding this issue, Watanabe et al.[15] reported the result of a nonrandomized study on the feasibility of the lymph node dissection in VATS. They found that for pathological stage I lung cancer patients, the total number of node dissections and number of mediastinal node dissections in each nodal station in the VATS group (n = 221) were similar to those in the OT group (n = 190). Similarly, Shigemura et al.[16] reported the result of a multi-institution retrospective study. They found no significant difference in the number of dissected lymph nodes among 3 groups: complete VATS lobectomy group (n = 56), assisted VATS lobectomy group (n = 34) and conventional thoracotomy group (n = 55). These studies showed the feasibility of VATS lobectomy for pathological stage Ⅰ lung cancer.

We also found that there is a significant difference in the number of dissected lymph nodes between the VATS lobectomy group and the OT lobectomy group for pathological stage Ⅱ and stage IIIA lung cancer. Although Sagawa et al.[17] found that the lymph node dissection with VATS was technically feasible and the remnant ("missed" by VATS) lymph nodes and tissue were 2% to 3%, which seems acceptable for clinical stage I lung cancer. Different surgeons with different surgical techniques in the institution may be the reason for this result. As in stage I lung cancer, surgery is relatively easy, while in stage II and stage IIIA lung cancer, lymph node dissection, especially mediastinal lymph node (N_2) dissection may not be as easy as that performed in stage I lung cancer. Thus, learning curve plays an important role in the procedure of lymph node dissection. Recently, Denlinger et al.[18] reported on a retrospective study and found a similar result.

Though Watanabe[19] and Kim et al.[20] found the 5-year survival of the patients receiving VATS lobectomy for clinical stage I, pathological N_1 and N_2 lung cancer is comparable to that of the patients receiving OT lobectomy for the same diseases, but the number of patients in their trials was relatively small (69 and 96 patients respectively). American College of Chest Physicians (ACCP)[21] recommends that in patients with stage I NSCLC who are considered appropriate candidates for thoracoscopic anatomic lung resection, the use of VATS by surgeons experienced in these techniques is an acceptable alternative to open thoracotomy. The National Comprehensive Cancer Network Clinical Practice Guidelines in Non-Small Cell Lung Cancer[22] recommends that VATS is a reasonable and acceptable approach for patients with no anatomical and surgical contraindication, as long as there is no compromise of standard oncologic and dissection principles of thoracic surgery. Thus, the indication of VATS lobectomy may be as follows: clinical stage I lung cancer, tumor size smaller than 5 cm[23] without hilar and mediastinal lymph node enlargement on preoperative CT scan.

The results of this study have shown that short-term outcomes of VATS upper lobectomy is inferior to that of VATS middle or lower lobectomy and this might be due to the more complicated operative technique of upper lobectomy than that of middle or lower lobectomy.

The median hours spent for VATS lobectomy (186 min) was longer than that for OT (150 min). The short time of carrying out VATS lobectomy techniques in the institution accounted for this difference. The time of 126 to 152 min spent for VATS lobectomy performed by skilled thoracic surgeons is comparable to that for OT lobectomy[24,25], It is crucial for every thoracic surgeon to perform 30 to 50 cases of VATS lobectomy so as to pass the learning curve[25-27].

In this series, there were 3 patients undergoing VATS bilobectomy, 4 patients undergoing VATS sleeve lobectomy, 3 patients undergoing VATS left pneumonectomy, and 21 patients undergoing VATS segmentectomy. Besides lobectomy, there are some other types of anatomical pulmonary resection. Santambrogio et al.[28] reported the first case of VATS sleeve lobectomy for mucoepidermoid carcinoma of the left lower lobar bronchus in 2002. Mahtabifard et al.[7] reported the largest series of complete VATS sleeve lobectomies up to now. In their series, 13 patients underwent VATS sleeve lobectomy including 8 non-small cell lung cancers, 4 typical carcinoid and 1 metastatic sarcoma. Median operative time was 167 min. Complications caused by the VATS sleeve lobectomy occurred in 4 patients and no deaths within 30 days after the VATS. They concluded that VATS sleeve lobectomy could be possible in experienced medical centers and the rates of morbidity and mortality induced by the VATS sleeve lobectomy would be acceptable. VATS pneumonectomy for lung cancer is also a rare procedure. Craig et al.[29] reported their initial experiences of 6 cases with non-small cell lung cancer receiving VATS pneumonectomy, including 4 cases undergoing left pneumonectomy and 2 cases undergoing right pneumonectomy and found that VATS pneumonectomy is technically feasible with a 6-cm incision. Sahai et al.[8] reported 24 cases of pneumonectomy and concluded that thoracoscopic pneumonectomy could be done safely. Leshnower et al.[9] reported 15 cases of VATS segmentectomy and concluded that VATS segmentectomy was a safe procedure, which caused fewer complications and reduced hospital stay when compared with an open segmentectomy. They found that VATS segmentectomy could be the ideal oncologic procedure for patients with small size of lung cancers (< 2 cm) and/or limited cardiopulmonary reserve and significant comorbidities.

This series also showed that compared with those who underwent OT wedge resection, patients who underwent VATS wedge resection had shorter operative time, chest tube duration and hospital LOS, although there were no significant differences in morbidity rate or mortality rate between VATS wedge resection group and OT wedge resection group. Currently, because the morbidity of the complications and mortality caused by VATS wedge resection is so low, there is a trend that needle biopsy will be performed less often. VATS is one of the most common and simplest methods for lung biopsy[23].

This study had several limitations. Firstly, it was a retrospective study; secondly, it was only observed short term outcomes of the VATS approach for lung cancer resection owing to this work being carried out recently, therefore, long term outcomes, such as survival and quality of life of lung cancer patients need to be evaluated in a follow-up study; lastly, the results were obtained from one cancer center, and may not be applicable to other medical centers.

Conclusion

From this series, it has been concluded that the indication for VATS lobectomy is clinical stage I lung cancer (tumor size < 5 cm without hilar and mediastinal lymph node enlargement). Short-term outcomes via VATS are superior to that of OT, although longer follow-up for the long-term outcomes is needed to determine the oncologic equivalency between the VATS lobectomy and OT lobectomy. For pulmonary wedge resection, VATS is superior to OT. As Mahtabifard et al.[7] stated that with growing experiences with VATS pulmonary resection, absolute and relative contraindications to VATS have been reduced. In the near future, VATS pulmonary resection might be the main procedure in lung tumor surgery.

Conflict of interest statement

No potential conflicts of interest were disclosed.

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