Original Article

Simultaneously thoracoscopic resection of lung cancer and anterior mediastinal lesions by video-assisted thoracoscopic surgery

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Background: Video-assisted thoracoscopic surgery (VATS) has been widely applied to various types of pulmonary and mediastinal resections in recent years. However, there are still limited experiences of simultaneous thoracoscopic resection for lung cancer and mediastinal tumor. The aim of the study is to investigate the technical safety and feasibility of uniportal VATS for simultaneous resection for concurrent diseases of lung and anterior mediastinum and to compare with multiportal VATS.

Methods: From June 2014 to December 2017, all patients who underwent simultaneously thoracoscopic resection for lung cancer and anterior mediastinal mass under uniportal or multiportal VATS via the same incision were retrospectively reviewed. Study cohort was divided according to surgical approach. Perioperative outcomes, including operative time, intraoperative blood loss, and postoperative hospitalization, were compared between uniportal and multiportal VATS groups.

Results: A total of 51 patients were included in the study, of whom 33 patients had uniportal VATS and 18 patients had multiportal VATS. When compared to multiportal VATS group, uniportal VATS group had similar time of operation (149.1±49.0 *vs.* 159.1±58.5, P=0.518), intraoperative blood loss (103.0±184.3 *vs.* 105.6±80.2, P=0.956), and postoperative length of hospital stay (4.7±2.0 *vs.* 5.5±3.0, P=0.246). No operative deaths occurred in this study.

Conclusions: Uniportal VATS for simultaneously thoracoscopic resection for lung cancer and anterior mediastinal disease is technically safe and feasible and has comparable operative parameters with multiportal VATS.

Keywords: Video-assisted thoracoscopic surgery (VATS); mediastinal tumor; lung cancer

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Introduction

Video-assisted thoracoscopic surgery (VATS) has been increasingly adopted with reported advantages, compared to conventional thoracotomy, in terms of quality of life, safety, and reduced postoperative complications (1-3). VATS has been widely recognized in treating early-stage non-small cell adenocarcinoma (NSCLC) and mediastinal tumor, indicating advances in terms of shorter hospitalization, less

postoperative pain, and faster recovery (4-8).

Since the first introduction of single-port VATS by Rocco *et al.* in 2004 (9), it has been successfully applied to the surgery for the pulmonary and mediastinal lesions (10-14). As the technique remarkably developed in recent years, uniportal VATS started to be adopted by many centers, which is not inferior to multiportal VATS in terms of operative time, postoperative pain, and length of hospital stay (15,16).

Previously reported cases of synchronous pulmonary and mediastinal lesions, which are scarce, investigated the feasibility of simultaneous resection under VATS approach (17-20). However, due to the limited evidence of similar cases, there is no surgical case or guideline for uniportal VATS approach. Therefore, our purpose of this study is to demonstrate the technical feasibility and safety of uniportal-VATS for simultaneous resection of NSCLC and anterior mediastinal lesions.

Methods

Population

Patients who were performed VATS for lung cancer and anterior mediastinal tumor in the department of thoracic surgery of Shanghai Pulmonary Hospital between June 2014 and December 2017 were reviewed. The study included patients who underwent the ipsilateral simultaneous resection. Patients who received pulmonary surgery involving two lobes were excluded. As a result, 51 consecutive cases who underwent simultaneous ipsilateral resection of anterior mediastinal tumor and lung cancer were subjected to the study, which consisted of 33 patients by uniportal VATS and 18 patients by multiportal VATS.

All the patients had preoperative work-ups, including physical examination, chest X-ray and computed tomography (CT) scan/contrast-enhanced CT, abdominal/brain CT scan, and bone scan. If mediastinal cyst was suspected, the chest MRI was performed. Surgical decision was based on carefully preoperative assessment of surgical risk and patient's tolerance for the operation. The decision as to whether to use single- or multi-port VATS was based on individual surgeon's discretion. The Institutional Review Board (IRB) of Shanghai Pulmonary Hospital approved our retrospective review of the medical records.

Surgical management

All patients were placed in the lateral decubitus position, intubated with a double-lumen tube. The procedure was carried out under general anesthesia and single lung ventilation. For uniportal VATS, an incision of 3–5 cm was made in the 4th or 5th intercostal space along the anterior axillary line for bi-portal VATS, an additional 1cm incision for camera placement was made at the 7th intercostal space of midaxillary line. For tri-portal VATS, the camera port of 1 cm was made at the 7th intercostal space of midaxillary line. One utility incision of 3–5 cm was made at 3rd/4th of anterior axillary line, and one 2 cm incision was made at 7th intercostal space of subscapular line. Both surgeons stood at the ventral site of the patient to firstly perform the lobectomy as detailed in our previous report (21). A 30° 10-mm video thoracoscope was applied and articulated instruments were used. Lymphadenectomy (systematic lymph node sampling or systematic mediastinal dissection), requires dissection of at least three mediastinal lymph node stations including subcarinal and is carried out with the use of energy devices. The patient was rotated to a 30° semi-supine position for mediastinal surgery. Routine thoracoscopic *en bloc* thymectomy approach or complete resection of mediastinal lesions was applied. Sublobar resection was applied to small tumors representing pure ground-glass nodules or part-solid nodules on CT. A 28 F chest drain is placed at the posterior part of the incision. The pain management protocol includes patient control analgesia (PCA) and oral analgesics if needed.

Data collection

Demographic, clinicopathological, and perioperative variables were collected. Intraoperative mortality was defined as death occurring within 30 postoperative days. Visual analog scale (VAS) score was used to evaluate the intensity of postoperative pain from 0 to 10, representing "no pain" to "worst pain". The VAS score was recorded in the daily nursing note. The first documented VAS score at 24 hours after surgery was analyzed for postoperative measurement. Lung cancer was staged according to the 8th edition of the TNM stage classification of NSCLC (22).

Statistics

Statistical analysis was performed using the SPSS statistical software package 22.0 (IBM Corp., Armonk, NY, USA). Student *t*-test and Mann-Whitney U test were used for numerical data, and the Pearson χ^2 test and Fisher's exact test were applied to categorical data. All analyses were

Table 1 Baseline information

Variable	Uniportal (n=33)	Multiportal (n=18)	P value
Age (year), mean ± SD	61.3±11.8	63.3±6.72	0.501
Sex, n (%)			
Female	20 (60.9)	12 (66.7)	
Male	13 (39.4)	6 (33.3)	
BMI (kg/m^2), mean ± SD	23.8±3.9	23.3±2.6	0.630
Smoking status, n (%)			0.645
Never	29 (87.9)	17 (94.4)	
Former/current	4 (12.1)	1 (5.6)	
Presentation, n (%)			0.102
Asymptomatic	16 (48.5)	13 (77.2)	
Symptomatic	17 (51.5)	5 (27.8)	
No. of preoperative comorbidity, n (%)			0.628
0	24 (72.7)	12 (66.7)	
1	5 (15.2)	5 (27.8)	
2	3 (9.1)	1 (5.6)	
3	1 (3.0)	0	
Diabetes mellitus, n (%)	3 (9.1)	1 (5.6)	
Hypertension, n (%)	7 (21.2)	6 (33.3)	
CAD, n (%)	2 (6.1)	0	
Arrhythmia, n (%)	2 (6.1)	0	
Tumor location, n (%)			0.405
LUL	8 (24.2)	4 (22.2)	
LLL	6 (18.2)	6 (33.3)	
RUL	8 (24.2)	6 (33.3)	
RML	2 (6.1)	0	
RLL	9 (27.3)	2 (11.1)	

SD, standard deviation; BMI, body mass index; CAD, coronary artery disease; LUL, left upper lobe; LLL, left lower lobe; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe.

two-tailed. A P value <0.05 was considered statistically significant.

Results

Patient characteristics

The baseline information of patients is summarized in *Table 1*. In the study cohort, 32 (63%) patients were female and 19 (37%) patients were male, who ranged in 29 to 83 years of age (median 63 years). More than half of patients (n=17, 51.5%) in uniportal VATS group presented with symptoms, but the majority in multiportal VATS group (n=13, 77.2%) was asymptomatic with no statistical difference. No patient had myasthenia gravis. Overall, no statistical difference between two groups was found among major demographic and clinical variables between single-

Table 2 Perioperative data

Variable	Uniportal (n=33)	Multiportal (n=18)	P value
Lung resection, n (%)			0.229
Lobectomy	27 (81.8)	12 (66.7)	
Segmentectomy	2 (6.1)	4 (22.2)	
Wedge resection	4 (12.1)	2 (11.1)	
Mediastinal resection, n (%)			0.223
Thymectomy	27 (81.8)	12 (66.7)	
Cyst excision	6 (18.2)	6 (33.3)	
Time of operation, minutes	149.1±49.0	159.1±58.5	0.518
Blood loss, mL	103.0±184.3	105.6±80.2	0.956
Length of stay, day	4.7±2.0	5.5±3.0	0.246
Tube drainage, day	4.2±2.1	5.2±2.5	0.128
Pain score [1–10]	2.27±0.8	2.28±0.5	0.980
Major complication, n (%)	1 (3.0)	1 (5.6)	

port and multiportal VATS groups.

Perioperative outcomes

As shown in *Table 2*, most of the patients received major resection for pulmonary lesions, and thymectomy for mediastinal disease. Uniportal VATS group has a mean operative time of 149.1 minutes (median, 150 minutes; range, 90 to 283 minutes), which is shorter than multiportal VATS group with a mean operative time of 159.1 minutes (median, 155 minutes; range, 65 to 280 minutes) without being statistically different. Intraoperative bleeding, postoperative length of stay, chest tube drainage, and postoperative pain score of uniportal VATS were comparable to those in the multiportal VATS group.

There was no perioperative death in both groups. Combined pleura resection due to the local invasion of mediastinal tumor was performed in five patients, of whom four were by uniportal VATS and one by tri-portal VATS. In the uniportal VATS group, 1 patient required conversion to muscle-sparing incision due to intraoperative bleeding during separating the extensive pleural adhesion. Intraoperative bleeding of this patient was 1,100 mL. Detailed information of the operation is listed in *Table 3*.

Postoperative major complications included one case of pulmonary embolism in the multiportal VATS group and another case of pneumonia and chylopleura in the uniportal VATS. The case of pulmonary embolism was resolved by using low molecular weight heparin. The case of pneumonia was also recovered after conservative treatment.

Histopathological outcomes

The histopathologic data is presented in *Tables 3* and *4*. The mean size of the pulmonary and mediastinal lesions was 1.7±1.3 and 3.7±2.2 cm, respectively. Of the lung lesions (*Table 3*), invasive adenocarcinoma was the most identified type of tumor in both groups, and most lesions were in an early stage. Of the mediastinal lesions (*Table 4*), 5 types of disease were found after surgical resection, including thymoma, bronchogenic cyst, pericardial cyst, thymic cyst, and thymic hyperplasia. Mediastinal cyst accounts for a large portion of benign disease in both groups (51.5% and 66.7%).

Discussion

Uniportal VATS has first been introduced in 2004 by Rocco (9), and applied to various kinds of operation, including lobectomy, segmentectomy, and thymectomy in recent years (13,23,24). In this retrospective study, we

Table 3 Histology types of pulmonary disease

Variable	Uniportal (n=33)	Multiportal (n=18)
Size, cm	1.8±1.2	1.6±1.4
Number of lesions, n (%)		
1	32 (97.0)	16 (88.9)
2	0	2 (11.1)
3	1 (3.0)	0
Histology type, n (%)		
AIS	1 (3.0)	2 (11.1)
MIA	6 (18.2)	2 (11.1)
IAC	22 (66.7)	10 (55.6)
Mucinous adenocarcinoma	1 (3.0)	1 (5.6)
SCC	1 (3.0)	1 (5.6)
IAC + AIS	2 (6.1)	2 (11.1)
pT descriptor, n (%)		
Tis	2 (6.1)	2 (11.1)
T1	25 (75.8)	15 (83.3)
T2	6 (18.2)	0
T3	0	1 (5.6)
pN descriptor, n (%)		
N0	33 (100)	17 (94.4)
N2	0	1 (5.6)
pTNM, n (%)		
0	2 (6.1)	2 (11.1)
1a	25 (75.8)	13 (72.2)
1b	4 (12.1)	1 (5.6)
2a	2 (6.1)	0
2b	0	1 (5.6)
3a	0	1 (5.6)

AIS, adenocarcinoma in situ; MIA, minimally invasive adenocarcinoma; IAC, invasive adenocarcinoma; SCC, squamous cell carcinoma; T, tumor; N, lymph node; M, metastasis.

demonstrated that simultaneous resection of lung cancer and anterior mediastinal disease was safe and feasible through VATS approach. Compared to multiportal VATS, perioperative outcome of uniportal VATS were similar in terms of time of operation, intraoperative bleeding, postoperative length of stay and chest tube drainage.

The wide use of chest CT helps identify early-stage lung cancer with mediastinal lesions in asymptomatic patients more frequently. In surgery for both the diseases, VATS has been the main surgical approach that associated with reduced postoperative pain, shorter length of postoperative hospitalization, faster recovery, and fewer postoperative complications, without compromising short- and long-term oncological outcomes (2,25-31). As the advent of uniportal

Table 4 Histology types of mediastinal disease

Variable	Uniportal (n=33)	Multiportal (n=18)
Size, cm	3.5±2.1	4.2±2.3
Thymoma, n (%)		
A	1 (3.0)	0
AB	3 (9.1)	0
B1	1 (3.0)	0
B2	1 (3.0)	1 (5.6)
Micronodular thymoma, n (%)	2 (6.1)	0
Mediastinal cyst, n (%)		
Bronchogenic	7 (21.2)	5 (27.8)
Pericardial	2 (6.1)	1 (5.6)
Thymic	8 (24.2)	6 (33.3)
Thymic hyperplasia, n (%)	8 (24.2)	5 (27.8)

VATS, which is considered with less trauma and better cosmesis with inferior outcome of conventional multiportal VATS, several reports described the safety and technical feasibility of uniportal VATS in clinical application (15,23).

Gonzalez *et al.* described the first series of uniportal VATS lobectomy (32). We have previously reported the largest single-institutional series (N=1,063) of uniportal VATS (21). The procedures included diagnostic and therapeutic managements for both pulmonary and mediastinal diseases. In our study, uniportal VATS was used for simultaneous resection for coexisting pulmonary and mediastinal lesions. Previous works have been done on investigating uniportal VATS for mediastinal tumor, and Wu *et al.* (10,15) reported that uniportal VATS was a favorable approach regarding short-term clinical outcome. Li and his colleagues (24) reported uniportal VATS with potential advantages of better postoperative outcomes for patients with loco-regional mediastinal disease, when compared with multiportal techniques.

Rare cases reported the thoracoscopic simultaneous resection of pulmonary and mediastinal disease (18,19,33). So far, Lin *et al.* (17) reported the largest single-institutional series (N=19) of simultaneously thoracoscopic resection for coexisting pulmonary and thymic diseases, and their results demonstrated that VATS is a technically safe and feasible procedure for these anatomically adjacent lesions. In this series, 51 patients underwent simultaneously thoracoscopic resection of coexisting NSCLC and anterior mediastinal lesion, and uniportal-VATS was applied in the majority of patients (n=33).

Operative time, intraoperative blood loss, and conversion are critical parameters when evaluating the safety of a surgical approach. In our study, patients in the uniportal group have shorter mean operative time, less intraoperative blood loss, and reduced postoperative hospitalization, with no significant difference. One (3%) patient in the uniportal VATS group was converted to muscle-sparing incision because of extensive pleural adhesion. The mean hospital stay was 4.7 and 5.5 days for uniportal and multiportal VATS group. It seemed to be comparable with uniportal VATS approach for lung cancer and mediastinal disease in previous reports. One patient in each group experienced postoperative complication that required long hospitalization and long chest tube drainage, and both patients recovered through conservative treatment. One multi-portal case was identified as occult N2 with positive single N2 station in the final pathology reports (T1N2M0, 3a).

The location of incision is designed for the accessibility of both lesions. In our experience, mediastinal lesions can be approached through an incision at either 3rd or 4th intercostal space. Therefore, in simultaneous resection of primary NSCLC and synchronous anterior mediastinal lesions, the incision setup is mainly based on the intended pulmonary procedure. Preliminary reports previously described their experience on incision design for uniportal

thoracoscopic resection of lung cancer and mediastinal tumor (10,23,24,34). If the intended procedure was a pulmonary lobectomy, we selected the 4th intercostal space for the upper lobe and 5th intercostal space for the lower lobe. If sublobar resection was planned preoperatively, we chose the 4th intercostal space for mediastinal lesion located above innominate vein and otherwise the 5th intercostal space to get better exposure of the mediastinal lesion. The decision on simultaneous resection and surgical approach is made after careful discussion on its safety and feasibility for a radical treatment with senior physicians.

Our study has several limitations. Firstly, bias of this retrospective study is unavoidable in patient selection and procedure preference between surgeons is unknown despite the fact that characteristics of these patients and surgical techniques appear similar. Secondly, the relatively small sample size may also result in statistical bias. Thus, further study should be conducted in multicenter collaboration research with more patients. Third, the long-term prognosis outcomes are still uncertain and need further study. Further randomized clinical trials are needed to clarify the role of uniportal and multiportal VATS procedures in the clinical condition.

In conclusion, VATS for simultaneously thoracoscopic resection for lung cancer and anterior mediastinal disease is technically safe and feasible. The uniportal VATS was non-inferior to the multi-portal VATS in terms of perioperative outcomes.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The Institutional Review Board (IRB) of Shanghai Pulmonary Hospital approved our retrospective review of the medical records. The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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