Short-Term Results of Thoracoscopic Lobectomy and Segmentectomy for Lung Cancer in Koo Foundation Sun Yat-Sen Cancer Center

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ABSTRACT

Background: Thoracoscopic lobectomy and segmentectomy have been demonstrated to be safe and technically feasible for curative resection of lung cancer. This minimally invasive surgery is increasingly popular and adopted by the world all over. We report our short-term results of thoracoscopic lobectomy/segmentectomy operations comparing with previous surgical approach for lung cancer resection by muscle-sparing vertical minithoracotomy in Koo Foundation Sun Yat-Sen Cancer Center.

Methods: We performed a retrospective review of 317 consecutive patients who underwent lobectomy or segmentectomy either by thoracoscopic surgery (n=121) or muscle-sparing vertical mini-thoracotomy (n=195) for lung cancer in Koo Foundation Sun Yat-Sen Cancer center between Jan 2000 and Jun 2009. The operative details, postoperative complication, and length of stay were statistically analyzed.

Results: Thoracoscopic lobectomy and segmentectomy were performed successfully in 121 patients. One patient was converted to open thoracotomy during operation due to uncontrolled bleeding. There is no significant difference in age factors (p=0.763), forced expiratory volume in one second (p=0.480) or comorbidities (p=0.549) between these two groups. Thoracoscopic group had a significantly predominant percentage in women, diabetes mellitus, less smoking index and chronic obstructive pulmonary disease incidence. Patients undergoing a thoracoscopic surgery had a shorter length of stay (6.8±3.4 vs. 10.2±9.1 days, p<0.001), longer operative time (3.6±1.0 vs. 3.2±1.2 hours, p=0.004), and less blood loss (102.7±95.7 vs. 140.1±171.2 ml, p<0.029). There was no significant difference in postoperative complication rate between the two groups (18.2% vs. 23.6%, p=0.255). No surgical mortality was found in the thoracoscopic group.

Conclusions: Our findings suggested thoracoscopic surgery for lung cancer would be as safe as muscle-sparing vertical mini-thoracotomy in lobectomy and segmentectomy.

Key Words: Video-assisted thoracoscopic surgery, lobectomy, segmentectomy, lung cancer

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Introduction

Lung cancer is the leading cause of cancer death worldwide. It is also the most common cause of cancer death in women and the second in men in Taiwan (1). Surgical resections are the mainstay treatment for patients with early-stage non-small cell lung cancer (NSCLC). Growing evidences have suggested that video-assisted thoracic surgery (VATS) would be an alternative surgical approach for this group of patients instead of conventional thoracotomy (2-6). Proponents of VATS emphasized the benefits in terms of decreased postoperative pain, less impairment in pulmonary function, shorter chest tube duration, and consequently shorter hospital stay (3-5). However, this technique has not yet gained widespread acceptance in the surgical community, mainly because of the apprehension for its surgical safety and oncologic efficacy.

Relative few reports have demonstrated the results of VATS for lung cancer in Taiwan. Here, we reviewed our experience in management of 317 lung cancer patients who underwent lobectomy or segmentectomy regardless of VATS or muscle-sparing vertical mini-thoracotomy (MSVMT). The aim of our study is the analysis of

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operative details, postoperative complications and length of hospital stay.

Patients and Methods

Data Collection

We retrospectively reviewed all patients who, from January 2000 to June 2009, underwent lobectomy or segmentectomy for lung cancer in Koo Foundation Sun Yat-Sen Cancer Center. A total of 317 consecutive patients were enrolled in the study. Preoperative staging workup included complete blood count, serum biochemistry tests, chest CT scan, histologic diagnostic procedures, and positron emission tomography-computed tomography (PET-CT). All patients were evaluated with chest computed tomography. 76.7% of patients were staged by PET-CT. Pre-operative tissue diagnostic tools included sputum cytology, transbronchial biopsy, and trans-coetaneous CT or sonography guided biopsy. Clinical data, including age, sex, smoking index, pulmonary function test, preoperative comorbidities, operative time, operative blood loss, postoperative complication, length of hospital stay, and tumor characteristics were all collected. Surgical mortality was defined as death during the same hospitalization or within 30 days after the operation.

The indications for VATS pulmonary resections remained the same as MSVMT approach. The indications of surgical pulmonary resection included clinical T1-3, N0-1, single station N2 and absence of distant organs metastasis. The eligibility of criteria for segmentectomy included cT1N0M0 NSCLC with size diameter smaller than 2 cm and peripheral tumor. We started VATS lobectomy/segmentectomy with radical lymph node dissection for lung cancer in 2005. The initial criteria for VATS approach are described as following: clinical stage I neither extensive pleural adhesion nor endobronchial lesion on preoperative evaluation. After 2007, we extended the indication of VATS approach to be contingent upon the increased experience in performing the procedure. Now, patients considered appropriate for thoracoscopic approach include those with tumor size smaller than 5 cm in diameter without central airway involvement where the local lymph node status is concerned. Incomplete fissure and extensive pleural adhesion were no longer contraindication for VATS approach. Therefore, the numbers of VATS lobectomy/segmentectomy increased eventually over the years.

Surgical Technique

Thoracoscopic surgery was performed via a 4 to 5cm mini-thoracotomy at the anterior axillary line. The utility incision was placed according to the 4th or 5th intercostals space where it provided access for complete hilar and mediastinal dissection. The 30-degree thoracoscope was placed at the 8th or 9th intercostals space in the mid-axillary line. Another 10-mm accessory port was not routinely placed at the tip of the scapula. Rib resection or rib spreading was not permitted in the VATS group. All pulmonary vessels and bronchus in the resected lobe were basically sectioned by using endoscopic staplers. All procedures were performed under video screen for guidance. An en-bloc hilar and mediastinal lymph node dissection were completed in the same fashion as done in an open thoracotomy The lung specimen was secured in a plastic bag while it was being withdrawn from the utility minithoracotomy. No epidural pain control was needed in this group.

MSVMT was performed at the 4th or 5th intercostals space. The latissmus dorsi muscle was preserved and the serratus anterior muscle was splitted. In addition, a mental retractor was introduced for opening the intercostals space. All pulmonary vessels and bronchus in the resected lobe were basically divided after triple ligation. Radical lymph node dissection was routinely performed for definitive pathologic staging including both hilar lymph nodes and ipsilateral mediastinal lymph node stations. Epidural pain control was generally used in this group.

Pathology

All resected specimens were examined for pathologic staging. Histological typing was determined according to the World Heath Organization classification (7). The disease stages were determined according to TNM classification of the American Joint Committee for Cancer Staging and Revised International System for Staging Lung Cancer (8).

Statistical Analysis

The continuous data are expressed as the mean ± SD. Comparisons of categorical data between the 2 groups were made by using χ^2 or Fisher exact test. Continuous data were compared by using 2-tailed *t* test. Statistical analysis was considered to be significant when the probability value was below 0.05. Data analysis was performed using Statistical Package for the Social Science software (version 12.0; SPSS, Chicago, Ill).

Results

In 2005, we began using VATS lobectomy or segmentectomy in NSCLC (Table 1). Among the 317 patients studied, 122 patients were planned to undergo VATS. There was one conversion to open thoracotomy

during surgery because of uncontrolled bleeding, where the intraoperative blood loss was 500ml; the patient was discharged uneventfully on postoperative 13th day. As a result, 121 patients successfully underwent VATS lobectomy (n=105) or segmentectomy (n=16). 195 patients underwent lobectomy (n=179) or segmentectomy (n=16) via MSVMT. The detailed clinical characteristics of all patients were listed in Table 2. The data were categorized according to the type of surgical procedure. There is no significant difference among the factor of age (p=0.763), forced expiratory volume in one second (p=0.480) and comorbidities (p=0.549) between the two groups. VATS group had a significantly predominant percentage in women, diabetes mellitus, less smoking index and chronic obstructive pulmonary disease incidence.

The operative details and postoperative complications were demonstrated in Table 3. The pre-operative tissue diagnostic rates were similar. The VATS group demonstrated a significantly longer operation time (p=0.004), less intraoperative blood loss (p=0.029), shorter wound length (p<0.001) and shorter length of hospital stay (p<0.001). No significant difference was found in the location of lung cancer. There was no significant difference between the two groups, but VATS group showed significant prolonged air leak (p=0.048). There was only one surgical mortality on postoperative 23rd day because of pneumonia deteriorated into acute respiratory distress syndrome in the MSVMT group; no surgical death in VATS group.

The pathologic characteristics of tumor were shown in Table 4. The VATS group had smaller tumor in size (p<0.001), fewer in total lymph node dissection numbers (p=0.005), fewer in positive lymph node numbers (p=0.006), more adenocarcinoma (p<0.001) and earlier

Tab 1: Number of Cases of Performed Per Year

Year	VATS	MSVMT
2000	-	16
2001	-	23
2002	-	30
2003	-	27
2004	-	27
2005	12	20
2006	15	23
2007	24	12
2008	41	13
2009/6	29	4
Total	121	195

MSVMT = muscle-sparing vertical mini-thoracotomy
VATS = video-assisted thoracoscopic surgery

Tab 2: Patient Characteristics

	VATS	MSVMT	*p* Value
Numbers of cases	121	195	
Age (years) (mean ± SD)	61.5±10.9	61.9±11.1	0.763
Sex (male/female)	47/74	128/67	<0.001
Smoking index	9.20±20.04	20.2±26.7	<0.001
FEV1 (L)	2.27±0.60	2.32±0.64	0.480
FEV1/FVC (%)	78.26±7.61	76.21±10.78	0.050
Comorbidities	87(71.9%)	134(68.7%)	0.549
Dypertension	47(38.8%)	57(29.2%)	0.085
Diabetes mellitus	20(16.5%)	16(8.2%)	0.029
CAD	4(3.3%)	8(4.1%)	0.774
COPD	5(4.1%)	22(11.3%)	0.037
Liver disease	13(10.7%)	16(8.2%)	0.548
Previous malignancy	23(19.0%)	26(13.3%)	0.202

p value less than 0.05 was considered significant.
CAD = coronary artery disease
COPD = chronic obstructive pulmonary disease
FEV1 = force expiratory volume in one second
FVC = forced volume capacity
MSVMT = muscle-sparing vertical mini-thoracotomy
VATS = video-assisted thoracoscopic surgery

Tab 3: Operative Detail and Postoperative Complication

	VATS	MSVMT	*p* Value
Operation times (hours)	3.6±1.0	3.2±1.2	0.004
Estimated blood loss (ml)	102.7±95.7	140.1±171.2	0.029
Wound length (cm)	4.8±1.1	11.6±4.0	<0.001
Pre-operative diagnostic rate	88.4%	85.6%	
Lesion location			0.394
Right upper lobe	51 (42.1%)	64 (32.8%)	
Right middle lobe	9 (7.4%)	13 (6.7%)	
Right lower lobe	21 (17.4%)	33 (16.9%)	
Left upper lobe	25 (20.7%)	50 (25.6%)	
Left lower lobe	15 (12.4%)	35 (17.9%)	
Complication	22 (18.2%)	46 (23.6%)	0.255
Prolonged air leak >7 days	7 (5.8%)	3 (1.5%)	0.048
Arrythmia	3 (2.5%)	8 (4.1%)	0.541
Chylothorax	4 (3.3%)	6 (3.1%)	1.000
COPD with AE	3 (2.5%)	7(3.6%)	0.747
Pulmonary embolism	0 (0%)	1(0.5%)	1.000
Bleeding	2 (1.7%)	8 (4.1%)	0.328
Pneumonia	2 (1.7%)	3 (1.5%)	1.000
Reoperation	1 (0.8%)	2 (1.0%)	1.000
Empyema	0 (0%)	4 (2.1%)	0.302
Myocardial infarction	0 (0%)	1(0.5%)	1.000
Curative resection	96.7%	95.9%	1.000
Surgical mortality	0(0%)	1 (0.5%)	1.000
Length of stay (days)	6.8±3.4	10.2±9.1	<0.001

p value less than 0.05 was considered significant.

AE = acute exacerbation

COPD = chronic obstructive pulmonary disease

MSVMT = muscle-sparing vertical mini-thoracotomy

VATS = video-assisted thoracoscopic surgery

stage ($p<0.001$) compared with MVST group. The numbers of total lymph nodes dissection and positive lymph nodes removed were fewer in the VATS group.

Discussion

VATS lobectomy for lung cancer was first described in the early 1990s (9-10). The first randomized controlled trial by Kirby concluded that VATS lobectomy was associated with lower postoperative complications, but not with significant decrease in intraoperative blood loss, duration of chest tube drainage, length of stay, or postoperative pain (11). McKenna et al. reported the largest single-institutional series on VATS lobectomy to date (12). In their series of 1,100 patients, the mortality rate was only 0.8% and morbidity rate was 15.3%. The mean length of hospital stay was 4.78 days. The short-term postoperative results suggested that VATS lobectomy is a safe and feasible surgical procedure in the hands of experienced surgeons. The Cancer and Leukemia Group B (CALGB) 39802 prospective (6), multi-institutional study elucidated the technical feasibility and safety of standardized VATS lobectomy for early-stage NSCLC. It was designed to evaluate success rate, morbidity, mortality, cancer recurrence, and failure-free survival. The study demonstrated technical feasibility and showed low complication and chest tube duration.

Lobectomy remained the standard surgical resection for early lung cancer. However, with the increasing prevalence of computed tomography application, early lung cancer with small size nodule became more easily detectable. There was a resurgence of interest in anatomic segmentectomy for very early lung cancer, especially in patients with compromised cardio-pulmonary function,

Tab 4: Tumor characteristics

	VATS	MSVMT	*p* Value
Tumor size	2.7±1.0	4.0±2.3	<0.001
Total LN numbers	21.7±9.9	25.4±12.6	0.005
Positive LN numbers	1.0±2.9	2.3±5.4	0.006
Histology			<0.001
Adenocarcinoma	110 (90.9%)	125(64.1%)	
SqCC	3 (2.5%)	47(24.1%)	
Others	8 (6.6%)	23 (11.8%)	
Pathologic stage			<0.001
Stage Ia	63 (52.1%)	33 (16.9%)	
Stage Ib	27(22.3%)	55 (28.2)	
Stage IIa	4 (3.3%)	8 (4.1%)	
Stage IIb	4 (3.3%)	36 (18.5%)	
Stage IIIa	17(14.0%)	35 (17.9%)	
Stage IIIb	6 (5.0%)	17 (8.7%)	
Stage IV	0 (0%)	8 (4.1%)	
Uncertain	0 (0%)	3 (1.5%)	

p value less than 0.05 was considered significant.
LN = lymph node
MSVMT = muscle-sparing vertical mini-thoracotomy
SqCC = squamous cell carcinoma
VATS = video-assisted thoracoscopic surgery

who might not tolerate lobectomy due to inadequate postoperative reserved pulmonary function (13). Growing data suggested that segmentectomy was an alternative to lobectomy in patients with clinical T1N0M0 status, especially when tumor diameter was less than 2 cm. This anatomic segmental resection could be performed safely without compromising oncologic results (13-15). In some institutions, segmentectomy with radical lymph node dissection was performed not only in high-risk patients but also in low-risk patients with clinical T1N0M0 and tumors ≤2 cm in diameter (16-17). It could offer the benefit of significantly better preservation of pulmonary function compared with lobectomy (18-19). In our institution, segmentectomy was designed as an alternative standard resection for peripheral clinical T1N0M0 lung cancer with diameter ≦2 cm regardless of the risk level. According to the published data, we considered segmentectomy could preserve more pulmonary function without compromising cancer survival. In our data, a total of 32 patients underwent segmentectomy. There were 16 patients in the VATS group and the other 16 in the MSVMT group. In this study, we focus the analysis of the postoperative complication difference between VATS and MSVMT, not segmentectomy and lobectomy. We merged the data of VATS lobectomy with VATS segmentectomy before comparing the VATS group with MSVMT group on account of both lobectomy and segmentectomy being considered as radical curative anatomic resection for early lung cancer. We compared the data difference on postoperative complications between the two groups and found no significant difference (18.2% vs. 23.6%, p=0.255). There was no surgical mortality in the VATS group and only one conversion. We concluded that VATS lobectomy/segmentectomy was a safe and technical feasible surgical approach in our institute based on the present data.

Although the surgical risks of VATS lobectomy/segmentectomy are considered to be acceptable, this new operative approach has been adopted slowly over the past decade. There seems to lack a generally accepted standard procedure for VATS lobectomy/segmentectomy; however, surgical techniques, differently modified, are proposed from all over the world. The obstacles associated with VATS included enigmatic technique skill, steep learning curve, operative safety and oncologic concerns. There are relatively few VATS reports for lung cancer in Taiwan to date. We started VATS lobectomy/segmentectomy with radical lymph node dissection for lung cancer in 2005. The initial criteria for thoracoscopic surgery was limited to small clinical early lung caner. Gradually, we extended the indications of thoracoscopic surgery because of cumulative experiences through time. In our institution to date, patients considered appropriate for thoracoscopic approach

include those tumors smaller than 5 cm in diameter without central airway involvement or chest wall invasion. Radical lymph node dissection should be routinely done for definitively pathologic staging of mediastinal lymph node status. Even those patients with single station N2 status by PET-CT scan staging are considered candidates for thoracoscopic surgery.

Many controversies regarding VATS approach face further debates for consensus, which include the length of utility thoracotomy, the application of rib spreader, the usage of endoscopic instruments versus conventional instruments and visualization through the incision or only by the monitor. Even now, the thoracoscopic techniques vary among nations, which may attribute, to some degree, different results in the outcomes. We performed VATS approach, which composed of video-monitor dependent visualization, non-ribs spreading, and shorter-than-six cm working wound length. A total of two to three chest wall incisions were used in our institution.

Better quality of lymphadenectomy may lead to more accurate tumor staging and therefore influence statistical result. Patients with 15 or fewer mediastinal lymph nodes dissected had worse survival outcome than those with more than 15 (20). Generally, we performed a radical mediastinal lymph node dissection for all patients as much as we can. Our data demonstrates the number of dissected nodes is smaller in the VATS group (p=0.005), but the mean numbers of lymph node was larger than 15, which could indicate the accurate tumor staging. We presumed that patients in the VATS group had earlier stage lung cancer, contributing to reduced numbers of lymph node. Of course, it is impossible to discuss the technical impact of lymph node dissection simply based on the numbers. As a matter of fact, the technical quality of node dissection need to be further analyzed according to long-term loco-regional disease-free survival rate.

Adequate postoperative pain control has been known to decrease postoperative pulmonary complications. Diminish pain from chest wall incisions will improve the ability to breathe deep, effectively cough and prevent correlative atelectasis. VATS requires only two small skin incisions for thoracoscopic insertion and utility thoracotomy window without rib spreading, which lessen a lot of postoperative pain (21). The optimal postoperative pain control methods for thoracoscopic surgery have been controversial. Epidural anesthesia may be the most popular and well known means of choice, however several associated complications have been reported in literatures, such as nausea, vomiting, hypotension, pruritus, constipation and technical related complications (22). Epidural analgesia is no longer used in VATS group in our institution the potential risk could be avoided. We prescribed oral non-steroid inflammatory drugs and oral opioids for postoperative pain control. Some patients needed several additional shots of intravenous opioids on postoperative first day. We didn't compare the pain scale between the two groups. In fact, epidural anesthesia was only used in MSVMT group.

Thoracoscopic group had a significantly predominant percentage in women, diabetes mellitus, earlier stage, adenocarcinoma, less smoking index and chronic obstructive pulmonary disease incidence in this retrospective study. Limited by the retrospective nature, the patient selection bias contributed to results. Definitive conclusions regarding the VATS cannot be made on account of the nature of this nonrandomized trial. We showed our 10-year surgical experience of lung cancer and the recognized advantages of VATS approach based on our study are shorter hospital stay, less blood loss, less epidural anesthesia necessaries, acceptable postoperative complication and no surgical mortality. In conclusion, our retrospective analysis demonstrated that VATS lobectomy/segmentectomy is technically feasible, safe and holds more comparative advantages to MSVMT approach.

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