

Comparison of Uniportal versus Multiportal Video-Assisted Thoracoscopic Surgery Pulmonary Segmentectomy

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Background: Uniportal video-assisted thoracoscopic surgery (VATS) has proven safe and effective for pulmonary wedge resection and lobectomy. The objective of this study was to evaluate the safety and feasibility of uniportal VATS segmentectomy by comparing its outcomes with those of the multiportal approach at a single center. **Methods:** The records of 84 patients who underwent VATS segmentectomy from August 2010 to August 2018, including 33 in the uniportal group and 51 in the multiportal group, were retrospectively reviewed and analyzed. **Results:** Anesthesia and operative times were similar in the uniportal and multiportal groups (215 minutes vs. 220 minutes, respectively; $p=0.276$ and 180 minutes vs. 198 minutes, respectively; $p=0.396$). Blood loss was significantly lower in the uniportal group (50 mL vs. 100 mL, $p=0.013$) and chest tube duration and hospital stay were significantly shorter in the uniportal group (2 days vs. 3 days, $p=0.003$ and 4 days [range, 1–14 days] vs. 4 days [range, 1–62 days], $p=0.011$). The number of dissected lymph nodes tended to be lower in the uniportal group (5 vs. 8, $p=0.056$). **Conclusion:** Our preliminary experience indicates that uniportal VATS segmentectomy is safe and feasible in well-selected patients. A randomized, prospective study with a large group of patients and long-term follow-up is necessary to confirm these results.

Key words: 1. Pulmonary segmentectomy
2. Video-assisted thoracoscopic surgery, uniportal
3. Video-assisted thoracoscopic surgery, multiportal

Introduction

The first pulmonary wedge resection by uniportal video-assisted thoracoscopic surgery (VATS) was reported in 2004 [1], and Gonzalez et al. [2] reported the first uniportal VATS lobectomy in 2011. Since then, the use of uniportal VATS has been expanded to involve almost all lung cancer resections, and it has proven to be a feasible and safe technique in carefully selected patients, with outcomes similar to those of multiportal approaches and the distinct advantage of requiring only a single incision [3-6].

Sublobar resection is now known to achieve outcomes equivalent to lobectomy in selected patients with stage IA non-small cell lung carcinoma [7,8], and uniportal VATS pulmonary segmentectomy has been performed by a limited number of hospitals and doctors. However, few reports have compared outcomes of uniportal versus multiportal VATS segmentectomy. Surgeons at the Seoul St. Mary's Hospital have been routinely performing uniportal VATS segmentectomy since January 2017, and because we have not yet analyzed our data to compare the feasibility and safety of uniportal VATS segmen-

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tectomy with the multiportal approach, the objective of this retrospective study was to compare our experiences with the 2 methods. Because of differences in the timing of the cases in which each method was used, this study was confined to a single surgeon's experience in order to minimize confounding factors.

Methods

1) Patients

The records of 84 patients who underwent uniportal (n=33) or multiportal (n=51) VATS segmentectomy by a single surgeon from August 2010 to August 2018 were retrospectively reviewed. Uniportal VATS segmentectomy has been performed since January 2017, and 30 of the total 33 attempted uniportal VATS segmentectomies were completed through a small (≤ 4 cm) single incision (Fig. 1), with 3 cases requiring an additional port. Both groups also included cases that were converted from VATS to open thoracotomy. The characteristics of the patients in



Fig. 1. Uniportal video-assisted thoracoscopic surgery incision (arrow).

both groups are presented in Table 1. The indications for segmental lung resection included tumor diameter < 2 cm with no nodal metastasis, tumor location within an anatomic segment, benign lung disease confined to a segment, large or deep-seated pulmonary metastasis, and poor lung reserve.

This study was reviewed and approved by the Seoul St. Mary's Hospital Institutional Review Board (IRB approval no., 2019-06-230-001) and the requirement for informed consent was waived.

2) Operative technique

All operations were performed by a single surgeon with the patients in a lateral decubitus position with semiflexion. Procedures were performed under double-lumen endotracheal intubation with general anesthesia or, after August 2016, with non-intubated anesthesia. During non-intubated anesthesia, oxygen was delivered by a mask, patients were sedated with a controlled infusion of propofol and dexmedetomidine to a target bispectral index of 40 to 60, and locoregional anesthesia (consisting of intrathoracic intercostal and vagal nerve blocks) was performed with mixed 2% lidocaine and 0.5% bupivacaine in a 1:1 ratio administered before the main procedure.

Multiportal thoracic surgery was routinely performed via a 4-port approach with the camera port in the eighth intercostal space in the mid-axillary line, the utility incision in the fifth intercostal space, and working ports in the seventh intercostal space anteriorly and the sixth intercostal space posteriorly.

In the uniportal group, a 4-cm incision was made at the fourth or fifth intercostal space on the anterior axillary line. The soft tissue and intercostal muscles were retracted with a small wound protector

Table 1. Patient characteristics

Characteristic	Uniportal (n=33)	Multiportal (n=51)	p-value
Age (yr)	67.7±9.9	63.9±9.3	0.082
Sex (male)	14 (42.4)	27 (52.9)	0.346
Body mass index (kg/m ²)	24.7±3.0	23.7±3.2	0.166
Tuberculosis history	5 (15.2)	5 (9.8)	0.460
Chronic obstructive pulmonary disease	15 (45.5)	12 (23.5)	0.036
Current smoker	8 (24.2)	12 (23.5)	0.940
Cardiac disease	2 (6.1)	4 (7.8)	1.000
Previous cancer history	5 (15.2)	7 (13.7)	0.855
Forced expiratory volume in 1 second (L)	2.3±0.8	2.4±0.6	0.490

Values are presented as mean±standard deviation or number (%).

Table 2. Histopathological factors

Variable	Uniportal (n=33)	Multiportal (n=51)	p-value
Tumor size (mm)	1.9±2.2	1.8±1.1	0.838
Affected segment, right lung			
S1	2 (6.1)	2 (3.9)	0.644
S2	2 (6.1)	5 (9.8)	0.699
S3	0	1 (2.0)	1.000
S6	3 (9.1)	5 (9.8)	1.000
S7-10	5 (15.2)	9 (17.6)	0.764
Affected segment, left lung			
S1+2	1 (3.0)	0	0.393
S1+2, 3	6 (18.2)	20 (39.2)	0.042
S4, 5	4 (12.1)	1 (2.0)	0.075
S6	7 (21.2)	5 (9.8)	0.144
S7-10	3 (9.1)	3 (5.9)	0.675
Histologic type			
Adenocarcinoma	30 (90.9)	42 (82.4)	0.350
Squamous cell carcinoma	2 (6.1)	7 (13.7)	0.472
Adenosquamous cell carcinoma	0	1 (2.0)	1.000
Small cell carcinoma	0	1 (2.0)	1.000
Metastasis from rectal cancer	1 (3.0)	0	0.393
Pathologic stage of non-small cell lung cancer ^{a)}			
IA1	10 (30.3)	13 (25.5)	0.629
IA2	15 (45.5)	19 (37.3)	0.455
IA3	3 (9.1)	12 (23.5)	0.144
IB	0	3 (5.9)	0.276
IIA	0	1 (2.0)	1.000
IIB	2 (6.1)	2 (3.9)	0.644
IIIA	2 (6.1)	0	0.151

Values are presented as mean±standard deviation or number (%)

^{a)}According to the eighth American Joint Committee on Cancer staging system.

(Endo Keeper; NELIS, Bucheon, Korea). A 10-mm, 30° thoracoscope was used in all cases.

The majority of dissections were performed using endoscopic hook electrocautery and a 5-mm endoscopic ultrasonic scalpel (Harmonic Scalpel; Ethicon Endo-Surgery Inc., Cincinnati, OH, USA). The pulmonary vessels were divided with flexible linear staplers or Hem-o-Lok clips (Weck Surgical Instruments; Teleflex Medical, Durham, NC, USA). The resected segment was removed from the thoracic cavity in a protective bag. The ultrasonic scalpel was used for sampling or dissection of mediastinal lymph nodes. A 24F chest tube was placed in the thoracic cavity at the end of every procedure.

3) Postoperative course

The chest tube was removed when there was no

air leak and the amount of daily drainage was <200 mL. Patients were discharged 1 day after removal of the chest tube if the follow-up chest X-ray showed no signs of pneumothorax and no signs of complications.

4) Statistical analysis

We retrospectively analyzed the perioperative data of patients who underwent VATS segmentectomy. Continuous variables are presented as means with standard deviations or medians with ranges, and categorical variables are presented as counts and percentages. For comparisons between groups, continuous variables were analyzed using the independent-sample t-test and categorical variables were analyzed using the chi-square or Fisher exact test. All statistical analyses were performed using

Table 3. Postoperative outcomes			
Variable	Uniportal (n=33)	Multiportal (n=51)	p-value
Adhesion	11 (33.3)	11 (21.6)	0.231
Incomplete fissure	12 (36.4)	15 (27.5)	0.388
Anesthesia time (min)	215 (135-385)	220 (160-364)	0.276
Operation time (min)	180 (115-360)	198 (87-360)	0.396
Blood loss (mL)	50 (20-500)	100 (10-1,100)	0.013
No. of dissected lymph nodes	5 (0-25)	8 (0-35)	0.056
Airway			0.000
Mask	24 (72.7)	1 (2.0)	
Double-lumen intubation	9 (27.3)	50 (98.0)	
Duration of chest tube (day)	2 (1-11)	3 (1-28)	0.003
Postoperative hospital stay (day)	4 (1-14)	4 (1-62)	0.011
Conversion to open thoracotomy	1 (3.0)	3 (5.9)	1.000
Use of 1 additional port (2-port)	3 (9.1)		
Postoperative complications			
Prolonged air leak (>5 days)	3 (9.1)	8 (15.7)	0.515
Pneumonia	2 (6.1)	2 (3.9)	0.644
Subcutaneous emphysema after removal of chest tube	1 (3.0)	1 (2.0)	1.000
Chylothorax	1 (3.0)	0	0.393

Values are presented as number (%) or median (range).

IBM SPSS ver. 24.0 (IBM Corp., Armonk, NY, USA), and statistical significance was defined by p-values < 0.05.

Results

The characteristics of patients who underwent VATS segmentectomy by either the uniportal or multiportal approach were similar (Table 1), but chronic obstructive pulmonary disease (COPD) was significantly more common among patients in the uniportal group (45.5% versus 23.5%, $p=0.036$). Tumor size and pathologic type did not differ significantly between groups (Table 2). Regarding the affected segment, in the left lung, upper division resection was most common among patients in the multiportal group, and significantly more patients in the multiportal group underwent left upper division resection compared to the uniportal group, in which superior segment resection was most frequent. In the right lung, the basal segment was most frequently resected in both groups. Malignancy was the indication for segmental resection in all patients in both groups; 83 of the 84 cases were primary lung cancer, and the remaining case was metastatic rectal cancer (uniportal resection). The multiportal group included

1 case of small cell lung cancer and 1 case of primary adenosquamous lung carcinoma. In the uniportal group, 30.3% of the tumors were pathologic stage IA1 and 45.5% were stage IA2, and in the multiportal group, 25.5% and 37.3% of tumors were stage IA1 and IA2, respectively.

The operative findings and postoperative outcomes are summarized in Table 3. The uniportal and multiportal groups did not differ significantly in the frequency of adhesions or incomplete fissure, and microscopic examination confirmed R0 resection in all cases. The median anesthesia time (uniportal: 215 minutes [range, 135-385 minutes] versus multiportal: 220 minutes [range, 160-364 minutes]; $p=0.276$) and operative time (uniportal: 180 minutes [range, 115-360 minutes] versus multiportal: 198 minutes [range, 87-360 minutes]; $p=0.396$) were not significantly different between groups, but the median blood loss was significantly lower in the uniportal group (50 mL [range, 20-500 mL] versus 100 mL [range, 10-1100 mL]; $p=0.013$). Furthermore, the use of non-intubated anesthesia was significantly more common in the uniportal group (72.7% versus 2.0%, $p=0.000$), and the total chest tube duration and postoperative hospital stay were significantly shorter in the uniportal group (2 days [range, 1-11 days] versus 3

days [range, 1–28 days]; $p=0.003$ for chest tube duration and 4 days [range, 1–14 days] versus 4 days [range, 1–62 days]; $p=0.011$). The number of dissected lymph nodes tended to be smaller in the uniportal group ($n=5$; range, 0–25) than in the multiportal group ($n=8$; range, 0–35), but the difference was not significant ($p=0.056$).

The rate of conversion to open thoracotomy was similar in the uniportal and multiportal groups (3.0% versus 5.9%, respectively; $p=1.000$). Reasons for conversion included severe pleural adhesions, technical difficulties, and hemorrhage. The rate of postoperative complications was also similar. Prolonged air leak, defined as an air leak that persisted for more than 5 days postoperatively, was treated with pleurodesis using fibrinogen and thrombin. One patient in the uniportal group developed chylothorax, which resolved after conservative treatment and fasting for 7 days. There was no postoperative hemorrhage or mortality in either group. Three cases (9.1%) in the uniportal group required 1 additional port for adhesiolysis ($n=2$) and angulation of the stapler to divide the bronchus ($n=1$). All 3 of those patients had severe adhesions and all had basal-segment lesions.

Discussion

Since Rocco et al. [1] reported the first single-port VATS wedge resection in 2004, the frequency of uniportal VATS procedures has been increasing. Because it requires only a single incision, uniportal VATS minimizes injury to the chest wall and intercostal nerves, which in turn has the obvious advantage of minimizing postoperative pain [9], and propensity score matching analyses comparing the outcomes of uniportal and multiportal VATS lobectomy in patients with lung cancer have confirmed that the uniportal and multiportal approaches are similar in terms of safety and efficacy [5,6].

However, few studies to date have examined the safety and efficacy of uniportal VATS segmentectomy as compared to the multiportal approach. Surendrakumar et al. [10] reported that the transition from open segmentectomy to uniportal VATS segmentectomy was followed over a short period of time by a significantly reduced postoperative hospital stay and did not compromise operative or postoperative outcomes,

and a propensity-matched analysis by Wang et al. [11] demonstrated that single-incision VATS lobectomy and segmentectomy were feasible, and could achieve comparable perioperative outcomes to multiple-incision approaches with a shorter operative time, improved lymph node dissection, and reduced intraoperative blood loss.

The patient characteristics and histologic findings in the 2 groups in our study were mostly similar, except for the affected segment and the higher prevalence of COPD in the uniportal group. However, the patients in the 2 groups underwent segmentectomy during different time periods because we rarely attempted multiportal surgery after we began routinely performing uniportal surgery.

We consider that the intraoperative blood loss may have been lower in the uniportal group at least partially because there were several patients in the multiportal group who had a large amount of bleeding. The significant differences between groups in chest tube duration and postoperative hospital stay also arose because of individual cases. Specifically, 1 patient in the multiportal group had prolonged air leakage for 28 days and another patient in the multiportal group was hospitalized for 62 days because of cerebrovascular disease that required transfer to the neurology department.

The anesthesia and operative times were similar in our patient groups. We initiated non-intubated VATS after August 2016 to reduce the risk of complications of intubation [12,13], and this corresponded closely to the January 2017 introduction of uniportal VATS at our institution. As such, the rate of non-intubated anesthesia was significantly higher in the uniportal group, which is a potential source of bias. However, a study by AlGhamdi et al. [14], which presented our institution's experience with non-intubated anesthesia, corroborates our outcomes for anesthesia times. In the earlier study, the perioperative surgical outcomes, including anesthesia and operative times, length of hospital stay, total chest tube duration, blood loss, and complication rates, for non-intubated VATS lobectomy were comparable to those of intubated lobectomy. The only significantly different surgical outcome between groups in that study was the number of dissected lymph nodes (non-intubated: mean, 12.6 versus intubated: mean, 18.0; $p=0.003$), which may have been related to the larger number

of patients with ground glass opacities in the non-intubated group. In the present study, the number of dissected lymph nodes in the uniportal group was lower than in the multiportal group, but the difference was not significant. These results seem to highlight the multiple influences, beyond non-intubated anesthesia, on lymph node dissection. Lymph node dissection may be more challenging during uniportal VATS, but uniportal VATS also facilitates a direct view that sometimes confers an advantage [15]. Either way, most of the patients who underwent segmentectomy in our study had stage IA tumors, and we propose that uniportal VATS segmentectomy may be best applied in patients with early-stage lung cancer. A similar approach to patient selection was advocated by Hernandez-Arenas et al. [16], who, acknowledging that segmentectomy is a technically more complex procedure than lobectomy, recommended starting the transition to uniportal segmentectomy by selecting 'easy' cases, such as those involving upper division or lingular or dorsal segments with clear fissures. Our experience that 3 of 3 basal segmentectomies required an additional port during the learning period supports this recommendation. Over time and with experience, the frequency of such conversions has decreased.

This study has several limitations, including the small number of patients, the retrospective design, and the dissimilarities of the time period, characteristics, and anesthetic methods between the 2 groups. Due to the above limitations, we attempted to perform propensity score matching to improve the comparison. However, the small number of patients made it difficult to carry out propensity score matching.

In conclusion, our preliminary experience with uniportal VATS segmentectomy for pulmonary lesions has demonstrated the safety and feasibility of this approach for well-selected patients. A randomized, prospective, comparative study with a large group of patients and long-term follow-up is necessary to confirm the clinical utility and advantages of uniportal VATS segmentectomy.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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