Original Article

Comparison of treatment outcomes between single-port video-assisted thoracoscopic anatomic segmentectomy and lobectomy for non-small cell lung cancer of early-stage: a retrospective observational study

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Background: There are few reports of single-port video-assisted thoracoscopic surgery (S-VATS) anatomic segmentectomy and S-VATS lobectomy for early-stage non-small cell lung cancer (NSCLC) and no comparisons between them have yet been reported. Therefore, the aim of this study was to compare the safety and efficacy of S-VATS anatomic segmentectomy and S-VATS lobectomy for early-stage NSCLC.

Methods: In this retrospective observational study, the outcomes of 79 consecutive patients who had undergone S-VATS anatomic segmentectomy (32 patients) or S-VATS lobectomy (47 patients) for early-stage NSCLC from April 2014 to June 2015 were examined. The operation time, intraoperative blood loss, numbers of dissected lymph nodes and mediastinal nodal stations, numbers of staples used, postoperative drainage volume and duration, duration of hospital stay, costs, postoperative complications, local recurrence, and survival were compared between these two groups.

Results: The postoperative drainage volume was smaller and the postoperative drainage duration shorter in the S-VATS segmentectomy than the lobectomy group ($P<0.05$). There were no significant differences in operation time, intraoperative blood loss, number of staples used, number and stations of dissected mediastinal lymph nodes, duration of hospital stay, costs, or postoperative complications. At the time of writing, no deaths or local recurrences had occurred in either group.

Conclusions: S-VATS segmentectomy is as safe and effective as S-VATS lobectomy. Patients who undergo S-VATS segmentectomy seem to recover faster.

Keywords: Single-port video-assisted thoracoscopy; segmentectomy; lobectomy; non-small cell lung cancer (NSCLC); early-stage

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Introduction

There is an increasing trend toward performing minimally invasive surgery, and video-assisted thoracoscopic technology is a typical representative of new technology for minimally invasive thoracic surgery (1).

Compared with those who undergo traditional lobectomy, patients who undergo anatomic segmentectomy have less lung tissue resected and more lung function preserved, contributing to a subsequent higher quality of life (2-4). There are reportedly no significant differences

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Table 1 Clinical characteristics according to treatment group

Variable	Segmentectomy group (n=32, %)	Lobectomy group (n=47, %)	P value
Sex			
Male	10 (31.3)	18 (38.3)	0.52
Female	22 (68.7)	29 (61.7)	–
Age			
>50 years old	20	34	0.36
≤50 years old	12	13	–
Age ($\overline{X} \pm S$) (years old)	53.5±8.3	55.4±11.3	0.43
Smoking history	4 (12.5)	7 (14.9)	1.00
Preoperative complication	13 (40.6)	19 (40.4)	0.99
High blood pressure	7	10	
Diabetes	1	4	
COPD	1	1	
Cancer in other lung lobe after operation	2	1	
Other malignant tumor after operation	3	2	
Others	2*	2#	

*, one case of bronchial asthma and one of atrial premature beats; #, one case of phthisis and one of ventricular premature beat and diabetes.

in local tumor recurrence rate and total 5-year survival rate between these two surgical options (5-7). Anatomic segmentectomy is clearly the less invasive. The Non-small Cell Lung Cancer Clinical Practice Guidelines issued by the National Comprehensive Cancer Network in 2010 recommend anatomic segmentectomy as a suitable operative procedure for treating early-stage non-small cell lung cancer (NSCLC) (8). The size and number of operative incisions can be used as an index of the severity of operative wounds (9,10). In accordance with the above data, surgeons have gradually begun to attempt single-port video-assisted thoracoscopic surgery (S-VATS), which is less invasive than previously performed procedures. Although Gonzalez *et al.* have reported outcomes of S-VATS lobectomy (11) and anatomic segmentectomy (12) and Zhu *et al.* have reported the comparison of the feasibility and safety between single-port and triple-port complete thoracoscopic lobectomy for NSCLC (13), there are few reports comparing S-VATS anatomic segmentectomy and lobectomy for early stage NSCLC.

In this study we retrospectively analyzed data on 32 patients who had undergone S-VATS anatomic segmentectomy and 47 patients who had undergone S-VATS lobectomy for early stage NSCLC in our institution and explored the safety, efficacy, advantages, and disadvantages of these two operative procedures.

Methods

In this study, data for 79 patients who had undergone S-VATS procedures [32 anatomic segmentectomies (segmentectomy group) and 47 lobectomies (lobectomy group)] for early-stage NSCLC from April 2014 to July 2015 in the Department of Thoracic Surgery, Union Hospital Affiliated to Fujian Medical University were examined.

All patients had undergone a preoperative work-up including pulmonary function tests, computed tomography (CT) chest scans with or without positron emission tomography (PET)-CT scans, flexible bronchoscopy, and brain magnetic resonance imaging. Their preoperative images showed nodules or ground glass opacities in the lung without evidence of enlarged mediastinal lymph nodes or extensive adhesion to the chest wall. None had clinical, laboratory, or imaging evidence of contraindications to surgery or tumor distant metastases. There were no statistically significance differences between the two groups in general data, such as age and sex (P>0.05); thus, the groups were comparable (*Table 1*).

Surgical techniques

Patients in both groups were placed in a lateral position on the non-affected side and subjected to intravenous anesthesia with double-lumen intubation. During the procedure, one-lung ventilation was performed on the healthy side and the lung collapsed on the affected side. A 3.5–4.5 cm incision was made between the fourth and fifth ribs in the anterior axillary line, silica gel incision protective casing introduced, and a 30° video-assisted thoracoscope inserted to check for any extensive compact adhesions to the chest as well and identify the diseased region and its relationship with surrounding organs and the situation regarding dissection of the lung hilum. Rib retractors were not used during the procedures. The laparoscopic apparatus was guided by a monitor and video-assisted thoracoscope and other instruments were inserted and removed through

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this single port. In patients with deep lesions according to preoperative imaging, segmentectomy and lobectomy were performed immediately; otherwise, pulmonary wedge resection was performed first. The results of examination of a fast frozen section of the excised lung tissues and of a sampled lymph node from the lobar node and segmental node stations were assessed to determine whether to then perform anatomic segmentectomy or lobectomy. On completion of the procedure, bleeding was completely stopped and the lung inflated to check for leakage. When the surgeon had confirmed there was no air leakage under an airway pressure of 30 cmH_2O (2.94 kPa), the wound surfaces at the lymph node and tracheal end were covered with hemostatic gauze and sprayed with fibrin glue. Next, a 28# or 32# chest tube was placed though the incision and an Abel drainage tube (Central Venous Catheter, 8Fr-20, Baihe Medical, China) connected to a drainage pack placed between the seventh and eighth ribs in the posterior axillary line. Thus the upper tube discharged air and the lower tube drained liquid.

Segment dissociation

We identified the vein and artery by CT photographs preoperatively and by the surrounding lung tissue and source and branch of the segmental vascular intraoperatively. The way to identify the segmental bronchus was similar to the segmental vascular. If the segmental bronchus was variational and different to identify, fiber bronchoscope could be applied to recognize the target bronchus intraoperatively. The surgeon would use vessel smooth forceps to clamp the target segmental bronchus and then the lungs were dilated to confirm the border of the target segmental lung issues. Divided the bronchus using the linear staple. At last, removed the target segment using the linear stapler along its border. The order to dissociate the vein, artery and bronchus of the target segment were unfixed (13).

Postoperative care

On the first postoperative day, the drainage volume of closed thoracic drainage tube was <150 mL/day, there was no air leakage occurred, and posteroanterior and lateral films of the chest showed satisfactory placement of tubes on the affected side in both groups. When the drainage volume of the chest drainage pack was <100 mL/day and posteroanterior and lateral films of the chest showed no obvious pleural effusion after the closed thoracic drainage tube had been removed, the Abel drainage tube was removed. When the patients were able to get out of bed without supplementary oxygen and had no postoperative complications (or any complications had resolved or improved markedly), they were discharged from hospital.

Variables assessed

The operation time, intraoperative blood loss, numbers and stations of mediastinal lymph nodes dissected, numbers of staples used, postoperative drainage volume and duration, duration of hospital stay, costs, incidence and nature of postoperative complications, and mortality rate were compared between two groups.

Statistical analysis

All data are expressed as mean ± standard deviation ($\bar{x}\pm s$). The χ^2 and Student's *t*-tests were performed with SPSS 19.0 statistical software. P<0.05 indicates a statistically significant difference.

The study was approved by the ethics committee of the Union Hospital Affiliated to Fujian Medical University.

Results

All 79 patients underwent S-VATS operative treatment as planned; the operations proceeded smoothly with no need for thoracotomy or second operative procedures.

Distribution of pulmonary tissue dissected

Lobectomy group: 11 cases of the left upper lobectomy; 6 cases of the left lower lobectomy; 15 cases of the right upper lobectomy; 4 cases of the right middle lobectomy; 10 cases of the right lower lobectomy; 1 case of the right middle and lower lobectomy.

Segmentectomy group: 3 cases of the left upper lobe posterior segmentectomy (S2); 1 case of the left upper lobe apicoposterior segmentectomy (S1 + S2); 4 cases of the left upper lober trisegmentectomy (S1 + S2 + S3); 3 cases of the left upper lobe lingular segmentectomy (S4 + S5); 1 case of the left upper lobe anterior lingular segmentectomy (S3 + S4 + S5); 2 cases of the left lower lobe dorsal segmentectomy (S6); 1 case of the left lower lobe anterior medial basal segmentectomy (S7 + S8); 1 case of the left lower lobe basal segmentectomy (S7 + S8 + S9 + S10); 4 cases of the right

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Table 2 Postoperative pathological data by patient group

Variable	Segmentectomy group (n=32)	Lobectomy group (n=47)	P value
Pulmonary tumour length (mm)	7.3±2.4	16.2±9.0	<0.01
Pathological pattern			–
CIS	2	0	
Squamous-cell carcinoma	0	2	
Micro invasive adenocarcinoma	27	12	
Invasive adenocarcinoma	3*	33	
Pathological type			–
CIS	2	0	
IA	30	37	
IB	0	10	
Invaded the visceral pleura	0	9	

*, in three cases, lung function was too poor to perform lobectomy. CIS, carcinoma *in situ*.

upper lobe apical segmentectomy (S1); 5 cases of the right upper lobe posterior segmentectomy (S2); 2 cases of the right upper lobe anterior segmentectomy (S3); 2 cases of the right upper lobe apicoposterior segmentectomy (S1 + S2); 3 cases of the right lower lobe dorsal segmentectomy (S6).

Postoperative pathological results

According to postoperative pathological examination of the operative specimens, the maximum diameters of pulmonary tumours resected were 7.3±2.4 and 16.2±9.0 mm in the segmentectomy and lobectomy groups, respectively; this difference is statistically significant (P<0.01) (*Table 2*).

Differences between the two groups in operation time, intraoperative blood loss, postoperative hospital stay, costs, numbers of staples used, and rate of postoperative complications were all not statistically significant (all P>0.05). However, differences between the segmentectomy and lobectomy groups in the numbers of lymph nodes dissected and postoperative drainage volume and duration were all statistically significant (all P<0.05) (*Table 3*).

Table 3 Comparison between treatment groups of intraoperative and postoperative variables ($\bar{x}\pm s$)

Variable	Segmentectomy group (n=32)	Lobectomy group (n=47)	P value
Operation time (min)	186.5±57.0	196.1±50.2	0.39
Intraoperative blood loss (mL)	77.3±50.9	82.5±53.9	0.67
Dissected lymph nodes (n)	13.6±5.8	16.7±6.2	0.03
Dissected mediastinal nodal stations (n)	3.4±0.9	3.8±1.0	0.05
Dissected mediastinal lymph nodes (n)	9.6±4.9	10.9±4.8	0.22
Postoperative drainage duration (day)	4.7±1.6	5.9±3.2	0.03
Postoperative drainage volume (mL)	670.1±386.1	1,171.7±1,515.4	0.04
Hospital stay (day)	6.0±2.6	7.4±5.0	0.14
Costs (thousand Yuan)	53.8±6.9	54.8±12.6	0.68
Staplers (n)	8.3±1.9	7.4±2.5	0.10
Postoperative complications (%)	6.3 (2/32)	17.0 (8/47)	0.19
Pulmonary infection	2	4	–
Auricular fibrillation	0	2	–
Pleural effusion	0	1	–
Persistent air leakage	0	1	–

Follow-up

Patients in the two groups were followed up for 105–577 days (mean 313.9 days) clinically and via telephone. There were no tumor recurrences or tumor-related deaths.

Discussion

Gonzalez-Rivas *et al*. reported 17 patients who underwent S-VATS anatomic segmentectomy (12). The mean surgical time was 94.5±35.0 minutes (range, 40–150 minutes). The mean number of nodal stations explored was 4.1±1.0 (range, 0–5) with a mean of 9.6±1.8 (range, 7–12) lymph nodes resected. The mean maximum tumor diameter was 2.3±1.0 cm (range, 1–4 cm). In our study, S-VATS anatomic segmentectomy was performed in 32 patients. Their mean surgical time was 186.5±57.0

minutes (range, 100–320 minutes). The mean number of nodal stations explored was 3.6±0.8 (range, 4–7) with a mean of (13.6±5.8) (range, 5–29) lymph nodes resected. The mean maximum tumor diameter was 0.7±0.2 cm (range, 0.4–1 cm). Because S-VATS segmentectomy has not been performed for very long in our institution, the durations of our procedures were longer than those reported by others; however, the durations of these procedures at our institution are progressively decreasing. The other findings listed above are similar to those reported by others.

In this study, the tumors of the patients in the segmentectomy group had maximum diameters of 0.7±0.2 cm (range, 0.4–1.0 cm) according to measurement of operative specimens; all met the criteria for eligibility for anatomic segmentectomy (8). To guarantee acceptable margins, resection of adjoining pulmonary segments was performed for lesions that were determined by intraoperative examination to be located in or close to the boundary of a pulmonary segment. Additionally, fast pathologic examination detected no metastases in lymph nodes from the lobar node and segmental node stations in all cases in the segmentectomy group; postoperative pathological examination confirmed no metastases in their mediastinal lymph nodes. Therefore, anatomic segmentectomy in these patients with NSCLC was considered safe and effective.

It is currently recommended that mediastinal lymph node dissection should cover three or more mediastinal nodal stations (including subcarinal lymph nodes) and the number of mediastinal lymph nodes dissected should not be less than 10 (14-17). In this study, S-VATS was successfully used to perform lymph node dissection in 79 patients with primary bronchogenic carcinoma. The number of groups of mediastinal lymph nodes dissected was 3–7 (mean 3.7±1.0) and of mediastinal lymph nodes dissected 4–31 (mean 10.4±4.9), which is in accordance with the requirements for mediastinal lymph node dissection. These results are similar to those reported by Gonzalez-Rivas *et al.*, who dissected 16±8 lymph nodes (18). Significantly fewer total lymph nodes and groups of lymph nodes were dissected in the segmentectomy than lobectomy group (P<0.05). In the segmentectomy group, only conventional lymph node sampling was performed for the hilar node, interlobar node and lobar node stations (134 lymph nodes in total; mean per case, 4.2), whereas conventional lymph node dissection was performed in the lobectomy group (271 lymph nodes in total; mean per case, 5.8).

In this study, according to postoperative measurement, the tumors resected in the segmentectomy group had smaller diameters than those in the lobectomy group; similar findings have been reported by others both in China and other countries (18,19). Because this study was retrospective and there were no standardized guidelines for selecting the procedure, individual surgeons decided which patients would undergo anatomic segmentectomy, which may have skewed the results. In any case, anatomic segmentectomy results in a larger pulmonary surface and greater trauma than lobectomy. However, in our study, the groups did not differ significantly in terms of intraoperative blood loss and incidence of postoperative complications. In terms of the absolute data, the segmentectomy group (6.3%) had fewer postoperative complications than the lobectomy group (17.0%). Therefore, we consider that the influence of tumor size was minimal and did not determine the outcomes. Prospective studies are required to verify this contention.

Two patients in the lobectomy group required thoracocentesis and catheterization because of postoperative pleural effusion; the drainage volume and duration in these two cases is included in the total drainage duration and volume. Drainage duration was shorter and the volume less in the segmentectomy than lobectomy group (both significant at P<0.05). Because less lung tissue is removed when anatomic segmentectomy is performed, the residual cavity is smaller. Additionally, only few inter-lobar fissures need to be incised to provide an adequate field of vision, the lung lobe structure and position do not change markedly, more of the tissue in the affected lung lobe can be left *in situ*, and the recruitment maneuver is unnecessary: unlike lobectomy, anatomic segmentectomy does not require a maneuver to recruit other lung lobes on the affected side to fill the residual cavity. Other studies (19,20) have reported that S-VATS anatomic segmentectomy is associated with a more rapid postoperative recovery.

More staples were used in the segmentectomy than the lobectomy group; however, this difference was not statistically significant. This finding is not in agreement with previous reports concerning non-S-VATS (21). We believe the following points are important regarding number of staples required. (I) In some patients in the lobectomy group, an adequate inter-lobar fissure did not develop and a linear stapling device was required to seal the deficiency, increasing the number of staples used; (II) because the arteries and veins of segments are thinner than those of lobes, silk ligation could be substituted for linear stapling in some patients in the segmentectomy group, decreasing the number of staples required; (III) in some

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patients in the segmentectomy group who had peripheral pulmonary nodules, wedge resection for lesions that were not close to the visceral pleura would have resulted in a similar functional loss to that caused by direct pulmonary segment dissection; the latter was therefore performed.

Previous studies (19,20) comparing the treatment outcomes of anatomic segmentectomy and lobectomy have reported that anatomic segmentectomy involves a longer operation time, fewer lymph node groups and mediastinal lymph nodes dissected, smaller postoperative drainage volume, shorter duration of postoperative drainage, and use of more staples than lobectomy. However, in our study, we found no statistically significant differences between S-VATS anatomic segmentectomy and S-VATS lobectomy in operation time, intraoperative blood loss, or number of staples used ($P>0.05$); S-VATS anatomic segmentectomy did not increase the number of staples used or the cost. Additionally, we found significantly fewer groups of lymph nodes and number of mediastinal lymph nodes dissected, a smaller volume of postoperative drainage, and shorter duration postoperative drainage than in the lobectomy group (all $P<0.05$). Therefore, segmentectomy does facilitate rapid postoperative recovery. Because S-VATS requires fewer ports for instruments, provides a smaller operation space, and is a more difficult procedure requiring greater technical competence than lobectomy, S-VATS anatomic segmentectomy should be performed only by surgeons who have mastered S-VATS lobectomy. S-VATS conforms with the modern concept that surgical procedures should guarantee safety and be minimally invasive. Because we did not have data about comparison with non-single-port segmentectomy, considering S-VATS segmentectomy superior to non- S-VATS segmentectomy would be not enough evidence and needed more related research in the future.

Chest wall pain after S-VATS is clearly milder than that after traditional multi-port VATS (22). Patients are therefore generally less fearful and stressed about undergoing the former procedure. Because the incision is located posterior to the breast, it can readily be covered and putting on clothes is easier. In conclusion, S-VATS lobectomy and segmentectomy are safe and have similar effect. Segmentectomy better facilitates rapid postoperative recovery and can be performed in patients with early-stage NSCLC.

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Footnote

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

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