Does Division of the Pulmonary Ligaments Affect the Outcomes after Thoracoscopic Lobectomy: A Retrospective Study of 72 Cases

L Bu[1, 2], L Zhang[1], X Mao[1], P Wang[1]

ABSTRACT

Background: Whether dissecting or not the inferior pulmonary ligaments (IPLs) during superior video-assisted thoracoscopic (VATS) lobectomy for early stage lung cancer remains controversial.

Objective: To evaluate the influence of dissecting the IPLs in VATS superior lobectomy on bronchial distortion and recovery of pulmonary function.

Methods: This was a retrospective study of 72 patients who underwent VATS superior lobectomy from March 2012 to August 2013 at the First People's Hospital of Yunnan Province. Patients were grouped according to IPLs preservation (group P) or dissection (group D). The preoperative and postoperative pulmonary function and the postoperative complications were analyzed. The change in bronchi angles and pulmonary capacity were measured using computed tomography (CT).

Results: There was no significant difference in the complication rate and volume of chest drainage between the two groups. The change in bronchus angle in group P was significantly smaller than in group D after left lung operation (P=0.046 at 3 months; P=0.038 at 6 months). In the right lung, the angle change was greater in group D than in group P at 3 months (P=0.057) but not at 6 months (P=0.541). In terms of pulmonary function, the FEV2% and FEV1 were significantly better in group P than in group D at 3 and 6 months (P<0.05). The pulmonary capacity in group P was significantly larger than in group D at 6 months (P=0.002).

Conclusion: Preservation of IPLs during VATS lobectomy might have an impact on the bronchus angle, and lung function and volume.

Keywords: Bronchial distortion, inferior pulmonary ligaments, pulmonary function, VATS upper lobectomy

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From: [1]Department of Thoracic Surgery, First People's Hospital of Yunnan Province, Kunhua Hospital Affiliated to Kunming University of Science and Technology, Kunming 650031, China and [2]Medical Faculty of Science, Kunming University of Science and Technology, Kunming 650031, Yunnan Province, China.

Correspondence: Dr P Wang, Department of Thoracic Surgery, First People's Hospital of Yunnan Province, Kunhua Hospital Affiliated to Kunming, University of Science and Technology, No.157 Jinbi Road, Xishan District, Kunming 650031, Yunnan Province, China. E-mail: pingwangchn@yeah.net

INTRODUCTION

When the pretreatment evaluation suggests no lymph node involvement, lobectomy is recommended for stage I or II lung cancer in patients who are medically fit (1, 2). In addition, in experienced center, minimally invasive resection is recommended for patients with stage I disease. Indeed, video-assisted thoracoscopic (VATS) lobectomy has been suggested to reduce the likelihood of systemic recurrence and the 5-year overall survival compared with open lobectomy (3, 4). In addition, VATS lobectomy is associated with fewer complications compared with thoracotomy (5, 6).

When considering all types of lung cancers, nearly two thirds of the patients have lesions in the right or left superior lobe (7). During superior lobectomy, thoracic surgeons routinely dissect the inferior pulmonary ligaments (IPLs), which can reduce the limitation on the range of motion of the inferior lobe, and improve the re-expansion of the inferior lobe and the filling of the residual cavity of the superior lobe. Theoretically, dissecting the IPLs can avoid the occurrence of atelectasis and pleural effusion (8). However, IPLs are important to fix the lobes in the thoracic cavity (9).

Currently, there is no evidence confirming that dissecting IPLs can improve the prognosis and reduce the complication rate, and whether to cut off the IPLs or not remains controversial (9). Using 3D imaging techniques, Ueda et al. (10) found that 41% of the patients were suffering from varying degrees of bronchial distortion and stenosis after superior lobectomy, and found that there were correlations with chronic dry cough and shortness of breath, as well as significantly decreased pulmonary function. On the other hand, dissecting the IPLs may lead to bronchial stenosis, distortion and even pulmonary torsion,

and patients may present with refractory dry cough and progressive shortness of breath, which can be confirmed by CT scan, X-ray and bronchoscopy. Seok et al. (11) consider that bronchial distortion can affect the postoperative recovery of pulmonary function. Many authors observed that dissecting IPLs during superior lobectomy caused bronchial distortion, but failed to find methods to prevent or reduce the incidence rate (9, 12).

How to relieve the impact of bronchial distortion on postoperative pulmonary function and quality of life is an important subject. Therefore, the main purpose of this study was to compare outcomes between patients in whom IPLs were preserved or not during superior lobectomy.

METHODS

Subjects

This was a retrospective study of patients admitted from March 2012 to August 2013 at the First People's Hospital of Yunnan Province. The inclusion criteria were: 1) patients with non-small cell lung cancer (NSCLC) (Stage I-III); 2) candidate for superior lobectomy (no severe pleural adhesion according to CT scan and all other examinations before operation, no COPD history); and 3) patients who received scheduled and deadline VATS lobectomy. The exclusion criterion was being lost to follow-up.

The present study was approved by the ethical committee of the First People's Hospital of Yunnan Province. The need for individual consent was waived by the committee because of the retrospective nature of the study.

Operative method

All operations were performed by the same team (including one professor, one associate professor and a resident) at the First People's Hospital of Yunnan Province. Patients were placed in the standard lateral position and were given general anesthesia. A thoracoscope (Karl Storz, Germany, 10mm HD, 1080P Thoracoscope system) was deployed through three incisions along the affected side: one in the 7^{th} midaxillary intercostal space as observation port, one in the 4^{th} intercostal space in the anterior line as the main operation port, and the other in the 7^{th} intercostal space in the shoulder angle line as assistant operation port. Patients were classified in group D (IPLs were dissected) or in group P (IPLs were preserved).

A chest tube was placed in all patients during and after the operation, and the 24-h postoperative drainage was no more than 100 ml. There was no air overflow in the chest tube even when patients got severe continuous cough. The chest tube was removed when the residual cavity was less than two intercostal spaces on thoracic X-ray.

Angle measurement

All patients underwent thin slice scan (supine position, 2.5-mm thickness) using a 64 multi-detector helical CT before the operation and at 3 and 6 month postoperatively. Raw data were transferred to the central database and converted into 3-dimension (3D) reconstruction image of the bronchi. The change in bronchus angle was measured according to the following principles. 1) For patients who underwent left superior lobectomy, the long axis of the left proximal primary bronchus was considered as the baseline on the coronal plane, and came into an angle with the axis of the inferior pulmonary bronchus. 2) For

patients who underwent right superior lobectomy, the baseline came into an angle with the axis of the middle pulmonary bronchus. The increased angle was the pre-operative angle minus the postoperative angle **(Figure 1)**. The axes were drawn by a resident of radiology, and examined and adjusted by a professor of radiology.

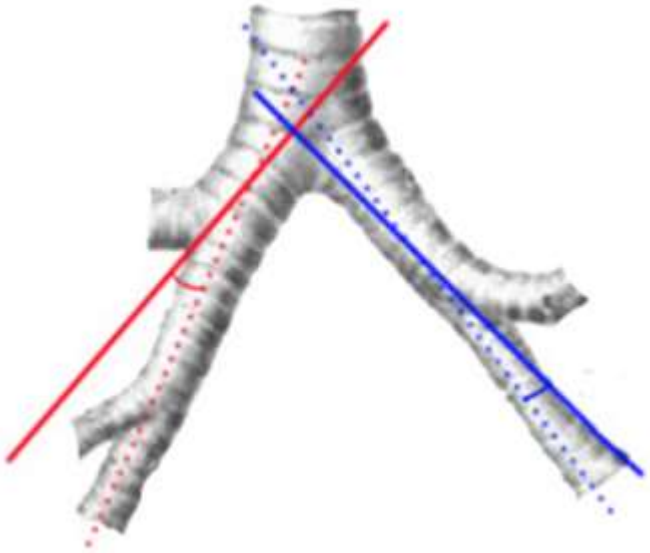

Figure: The change in bronchus angle was defined as the pre-operative angle minus the postoperative angle. The red dotted line is the axis of the right primary pulmonary bronchus before the operation, and the red full line is the axis after the operation. The angle between the red dotted and full lines is the difference before and after the operation. The same applies for the blue lines (left bronchus).

Pulmonary function test

Pulmonary function was examined in all patients using a pulmonary function test apparatus (Minato, Japan) before the operation, and at 3 and 6 month postoperatively. Pulmonary function tests included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), and maximal ventilator volume (MVV).

Pulmonary capacity

The pulmonary capacity was measured 6 months postoperatively using a 64 multi-detector CT from top to bottom of the lung after patients were trained to hold their breath. Volume was calculated using the Siemens Pulmo pulmonary quantitative automatic analysis software.

Statistical analyses

Data were processed using SPSS 17.0 (IBM, Armonk, NY, USA). Continuous data are presented as mean ± standard deviation (SD), and were analyzed using the Student's t test. Categorical data are presented as frequencies and were analyzed using the chi-square test. $P < 0.05$ was considered to be statistically significant.

RESULTS

General data

Seventy-two patients were included. There were 18 males and 15 females in group D, with a mean age of 52.34±7.42 years. There were 21 males and 18 females in group P, with a mean age of 51.58±7.08 years. There was no significant difference in gender distribution, age, and dissected area **(Table 1)**.

Table 1: Characteristics of the patients

Variables	**Group D (n=33)**	**Group P (n=39)**	**P-value**
Gender			0.953
Male	18, 4.5%	21, 53.8%	
Female	15, 45.5%	18, 46.2%	
Age	52.34±7.42	51.58±7.08	0.761
Operative site			0.855
Left	12, 36.4%	15, 38.5%	
Right	21, 63.6%	24, 61.5%	
Staging			0.958
Stage I	16, 48.5%	21, 53.8%	
Stage II	12, 36.4%	15, 38.5%	
Stage III	5, 15.2%	3, 7.7%	
Comorbidities	7, 21.2%	9, 23.1%	0.949
Complications			
Arrhythmia	3, 9.1%	1, 2.6%	0.288
Pulmonary infection	1, 3.0%	2, 5.1%	0.657
Delayed postoperative complication	2, 6.1%	0	0.119
Atelectasis	0	1, 2.6%	0.354
Drainage volume (ml)	1433±405	1302±454	0.115
Drainage time (d)	4.3±3.1	5.0±3.9	0.528

Complications

All subjects survived the perioperative period. No procedure was converted to open surgery. In group D, there were three patients suffering from arrhythmia, one from pneumonia and two from air leak. The mean drainage volume and time were 1433±405 ml and 4.26±3.05 days, respectively. In group P, there were one case of arrhythmia, two with pneumonia, and

one with atelectasis who got better after aspiring sputum with a bronchofibroscope. The mean drainage volume and time were 1302±454 ml and 5.04±3.88 days, respectively. There was no significant difference between the two groups in complication rate and drainage volume (P>0.05) (Table 2). Within 6 months after the operation, there were three patients (2 males, 1 female) who suffered from refractory dry cough and anhelation in group D, and four (all females) in group P. Regular antitussive could not relieve the symptoms except for compound codeine solution. Symptoms were relieved 6 months after the operation (no greater bronchus angle was seen in these patients according to CT scan).

Pulmonary function

There was no significant difference in terms of FVC and MVV. The FEV_1% was significantly higher in group P than in group D at 3 months (91.1±12.4 vs. 79.4±13.1, P=0.015), and the FEV_1 was significantly higher in group P than in group D (1.92±0.58 vs. 1.76±0.55 L, P=0.040). The pulmonary capacity in group P was significantly larger than in group D at 6 months [3898±913 vs. 2810±372 ml, P=0.002] (Table 2).

Table 2: Comparison of pulmonary function and angle between primary bronchi

Items	Group D	Group P	P-value
Lung capacity (ml)			
Pre-operative	3902±760	4248±1257	0.429
3 mo postoperative	3102±415	3553±1107	0.218
6 mo postoperative	2810±372	3898±913	0.002*
Primary bronchus angle			
Pre-operative	-20.21±8.20	-20.54±8.09	0.905
3 mo postoperative	64.00±16.80	56.85±11.88	0.144
6 mo postoperative	65.98±18.61	57.37±14.33	0.126
FVC (L)			
Pre-operative	2.27±0.73	2.40±0.78	0.639
3 mo postoperative	2.20±0.64	1.91±0.43	0.117
6 mo postoperative	2.28±0.63	2.04±0.59	0.261
FEV1 (L)			
Pre-operative	2.11±0.95	2.01±0.59	0.594
3 mo postoperative	1.73±0.46	1.89±0.52	0.917
6 mo postoperative	1.76±0.55	1.92±0.58	0.040*
FEV1%			
Pre-operative	88.71±14.60	93.28±7.58	0.319
3 mo postoperative	79.43±13.13	91.06±12.35	0.015*
6 mo postoperative	82.38±12.93	90.49±11.26	0.073
MVV (L)			
Pre-operative	73.04±23.35	69.87±20.63	0.469
3 mo postoperative	61.97±12.24	54.69±22.42	0.321
6 mo postoperative	67.82±13.54	56.24±20.40	0.085

Different outcomes between left and right superior lobectomies

The change in bronchus angle in group P was significantly smaller than in group D after left lung operation (68.8±9.1° vs. 78.1±7.8°, P=0.046 at 3 months; 72.0±8.2 vs. 82.5±9.9°, P=0.038 at 6 months) (Table 3). However, in the right lung, the change in angle was greater in group D than in group P at 3 months (48.9±4.1 vs. 54.0±7.3, P=0.057), but not at 6 months (47.6±7.1° vs. 48.9±9.4°, P=0.541) **(Table 3)**.

Table 3: Different outcomes between left and right superior lobectomies

Primary bronchus angle	**Group D**	**Group P**	**P-value**
Left superior lobectomy	n=12	n=15	
Pre-operative	-12.8±3.2	-11.5±2.0	0.346
3 mo postoperative	78.1±7.8	68.8±9.1	0.046*
6 mo postoperative	82.5±9.9	72.0±8.2	0.038*
Right superior lobectomy	n=21	n=24	
Pre-operative	-27.7±2.6	-26.6±3.3	0.444
3 mo postoperative	54.0±7.3	48.9±4.1	0.057
6 mo postoperative	48.9±9.4	47.6±7.1	0.541

DISCUSSION

Currently, many thoracic surgeon dissect IPLs during superior lobectomy, which can reduce the residual cavity of the chest and prevent atelectasis, but which also induces risks of

bronchial distortion, stenosis, obstruction, and even ventilation dysfunction (9, 12). A study from Japan has shown that 69% of hospitals preserve IPLs during superior lobectomy, and that the doctors in these hospitals think that preservation of IPLs can reduce the incidence rate of bronchial distortion and stenosis, but will increase the risks of pleural effusion and infection (13). In the present study, there was no significant difference in terms of complication rate, chest drainage, drainage time, and delayed air leak. These results suggest that these factors are not affected by the dissection of IPLs.

After superior lobectomy, the re-expansion and filling of the remaining lung will pull the bronchus and lead to enlargement of the angle, especially for the left lung. A previous study found that the left inferior bronchus went severely upwards and even came to form a U shape in some cases (11). In the present study, the results showed that the change in bronchus angle in group D was significantly greater than in group P after left lung operation. However, in the right lung, the angle change was greater in group D than in group P at 3 months, but the difference disappeared at 6 months. This result can be explained by the fact that the left superior lobe takes a relatively larger portion in the chest compared with the right one, which provides sufficient space for re-expansion after surgery. The left primary bronchi are pulled upwards and distorted, and formed a relatively greater angle. Therefore, preservation of IPLs can fix the re-expanded lung after operation, reduce bronchial distortion, and prevent over-motion of the lung and pulmonary torsion. Matsuoka et al. (8) conducted a randomized clinical trial of 35 patients with adenocarcinoma in the superior lobe, and found that right lobectomy can form a greater angle than left lobectomy, and suggested that IPLs should be preserved because dissection of IPLs cannot prevent residual cavity in the chest.

Pulmonary function test is a common test for thoracic diseases, which is not only used to diagnose lung or pulmonary diseases, but also to evaluate the pre-operative risk and postoperative recovery and to predict the prognosis (14, 15). Due to the reduction of pulmonary parenchyma, lobectomy may cause a permanent loss of pulmonary function, which impairs the quality of life and prognosis (16, 17). Though there are multiple factors that affect recovery of pulmonary function, 90% of patients can restore their expected value of pulmonary function within 3 to 6 month postoperatively (18). However, superior lobectomy can cause significantly more loss of pulmonary function compared with other lobes (19). Though the volume of the inferior lobes is larger than that of the superior ones, the recovery of pulmonary function is no better than for superior lobes (20). This may be associated with the enlarged angle of primary bronchi caused by bronchial stenosis and distortion. Therefore, whether it is useful to preserve IPLs for the recovery of pulmonary function deserves further exploration.

In the present study, there was no significant difference in terms of FVC and MVV at 3 and 6 months between the two groups, but the FEV_1% was significantly higher in group P compared with group D at 3 months. In addition, the pulmonary capacity in group P was significantly larger than in group D at 6 months. The potential reasons are that the enlarged angle and distortion after dissecting the IPLs lead to bronchial stenosis, ventilation dysfunction and pulmonary function, and the inferior lobe and diaphragm elevate while the chest capacity and pulmonary capacity reduce. FEV_1 denotes whether there is restrictive ventilation dysfunction and evaluate the compensatory ability of the remaining lung and the quality of life. FEV_1 and FEV_1% are common pulmonary function parameters to evaluate

airway ventilation. Pulmonary capacity quantitative examination by multi-detector spiral CT can describe the exact lung capacity, and detect the early changes of pulmonary capacity and small airway.

No mortality or conversion to open surgery was observed in the present study, while previous series in which the IPLs were dissected observed a mortality rate of 0.5-3.7% and a conversion rate of 1.8-17.6% (21, 22). In these previous series, the most common complication was air leak, which was observed in two patients from group D. When preserving the IPLs, the most common complications are pleural effusion, insufficient lung expansion, atelectasis, empyema, pneumonia, pooling of sputum and fistula (13). In the present study, one case of arrhythmia, two with pneumonia, and one with atelectasis were observed.

The present study is not without limitations. Indeed, the sample size was small and from a single center. In addition, the retrospective nature of the study prevented to explore a wide array of variables since we had to limit ourselves to the standard data from the patients' charts.

CONCLUSION

Preserving the IPLs or not did not lead to differences in terms of complication rate, drainage volume and delayed air leak. However, preservation of IPLs could prevent bronchial distortion, reduce bronchial stenosis and ventilation dysfunction, and improve the recovery of pulmonary function and capacity. Preservation of IPLs during left lobectomy might reduce bronchial distortion and improve the recovery of pulmonary function and capacity.

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