Original Article

The feasibility and efficacy of two micro-portal video-assisted thoracic surgery in pulmonary lobectomy for lung cancer

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Background: Conventional three-port video-assisted thoracic surgery (VATS) is well established internationally. Meanwhile, uniportal VATS technique has been become more and more popular in the past two decades. However, both methods have their merits and drawbacks. The purpose of this paper is to compare the surgical outcome of patients with lung cancer between traditional three-port VATS and our new two micro-portal VATS technique in an attempt to validate the safety, feasibility and efficacy of the latter procedure.

Methods: We retrospectively analyzed the perioperative data of two hundred and eight patients with primary lung cancer who underwent successful VATS lobectomy between September 2016 and December 2017 at our unit.

Results: Comparing to conventional three-port VATS group, the numeral analogue scale (NAS) pain scores were significantly lower in the two micro-portal VATS group. There were no surgery related mortality and no significant differences in operative time, blood loss, number of lymph nodes dissected, chest tube duration, length of stay or postoperative complications between the two group.

Conclusions: The two micro-portal VATS procedure is a safe and effective strategy for patients with lung cancer, which is associated with decreased surgical trauma and less postoperative pain. This emerging technology may benefit patients by enhancing comfort during their postoperative hospitalization.

Keywords: Two micro-portal; video-assisted thoracic surgery (VATS); lung cancer; postoperative pain

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Introduction

Malignant tumors which lead to lung cancer, is the leading contributor to the high mortality and morbidity in China (1). Although chemotherapy, radiotherapy, specific immunotherapy and molecular target therapy have had great progress in the past decades, radical surgery is still the primary option for relatively early stage of lung cancer. With the advent of rapid technological progress and constant renewal of ideas, thoracic surgery is becoming more and more minimally invasive.

Conventional three-port video-assisted thoracic surgery (VATS) has thought as the main standard technique in treating lung cancer for many units around the world (2). Many studies have demonstrated that VATS lobectomy showed decreased hospitalization time, less loss of respiratory function, shorter chest tube drainage time and fewer postoperative complications (3). Besides, four-port (4) and two-port (5) VATS are also reported by several centers. Since 2010, uniportal VATS which is firstly performed

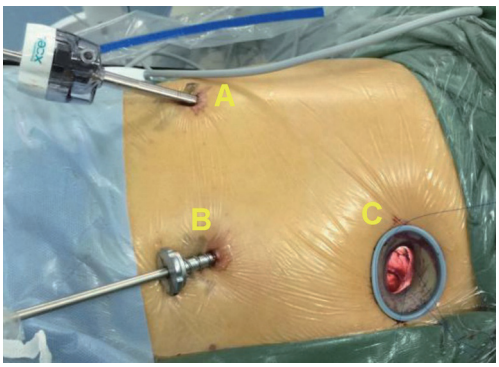

Figure 1 The incision of right superior lobectomy. "A" stands for secondary operating port in the ninth intercostal space at the scapular line with a 5-mm trocar. "B" stands for viewing port in the seventh intercostal space at the midaxillary line with a 5-mm trocar. "C" stands for main operating port in the fourth intercostal space of the anterior axillary line with a length of 20 mm incision that was attaching with a wound protector.

by Gonzalez *et al* (6,7) through a small incision of about 4 cm has expanded an area of exploration in minimally invasive approach. A recent meta-analysis revealed better outcomes of uniportal VATS regarding to postoperative hospitalization, chest tube drainage time and pain score (8).

The aim of this study is to optimize two important aspects of VATS, that are cutting length and technique procedure. The most currently popular and matured option for incision selection of VATS include traditional three port and uniportal methods. The three-port procedure is not restricted by the operation angle, the resection is more convenient and the operation speed is faster. Single port procedure is operated through a single intercostal, which has beautiful incision, less pain (9). However, because of the limited internal angle, the operation is more complex, the operation speed is slow. Therefore, we designed a new procedure named two micro-portal VATS technique which shortened the length of viewing port and secondary operating port. So, the wound becomes smaller both outside and inside. In order to make the operation more reasonable and simpler, we designed different surgical procedures of hilar dissection for different lobectomy, which we called tangent line single-direct VATS lobectomy. There is no need to turn over the lobes too many times during the operation, which avoiding tumor cells entering the circulatory system as a result of turning and squeezing the lungs.

Methods

Patients

We retrospectively analyzed clinical outcomes of 208 patients who underwent VATS lobectomy by a single surgeon at our department. All patients were pathologically diagnosed as primary lung cancer postoperatively. One hundred and four patients achieved traditional three port VATS lobectomy between June 2016 and December 2016. From January 2017, we started the two micro-portal VATS lobectomy, and 104 patients were analyzed until December 2017. None patient received neoadjuvant therapy before surgery. Institutional review approval and written informed consent for each patient were obtained. Routine preoperative research including complete blood count, serum biochemistry tests, arterial blood gas analysis, pulmonary function test, transthoracic echocardiogram, abdominal ultrasonography, computed tomographic scan of the chest and brain, whole-body bone scanning and bronchoscopy were undergoing before every surgery.

The characteristic data studied in each patient include age, body mass index (BMI), gender, smoking status, tumor location, tumor maximum diameter, histologic type, lymph node staging, tumor staging, operative time (from the beginning of general anaesthetic to extubation), blood loss, number of lymph node retrieved, pain score on day 1, 2, 3, 7 after surgery, duration of chest tube in place, length of hospital stay and postoperative complications regarding to pulmonary infection, gas leak over 5 days and death. Patients who were older than 75 or younger than 18 were excluded. The tumor stage was determined according to the seventh edition of American Joint Committee on Cancer staging system.

Operative procedure and postoperative care

All patients were delivered general anesthesia with two lumen tube intubation and operated in a lateral decubitus position with the operating table flexed to increase the intercostal space.

For traditional three port VATS lobectomy, two 10–20 mm incisions were made in the seventh intercostal space at the midaxillary line and the ninth intercostal space at the scapular line, as viewing port and secondary operating port separately. Then, a main operating port was made on the third or fourth intercostal space of the anterior axillary line,

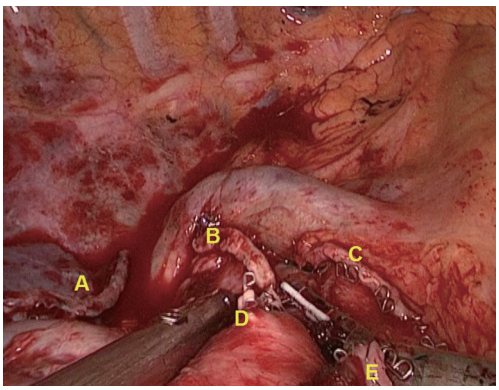

Figure 2 The postoperational view of right superior lobectomy. "A" stands for the stump of back part of oblique fissure. "B" stands for stump of the right superior lobar bronchus. "C" stands for stump of the apical posterior and anterior branch of right pulmonary artery. "D" stands for stump of the superior branch of right pulmonary artery. "E" stands for stump of the right superior pulmonary vein.

with a length of 20–25 mm incision that was attaching with a wound protector. After that, a 10 mm 30° oblique-viewing thoracoscope was used in the operation. The dissections were mainly done using endoscopic ultrasonic scalpel and occasionally using endoscopic hook electrocautery. The resection was performed using flexible curved-tip endoscopic staplers in the order of pulmonary vein, lobar bronchus, pulmonary artery and interlobar fissure. This procedure was learned from Prof. Liu, that he called single-direction thoracoscopic lobectomy (10). Subsequently, the resected lobe was removed using a protective specimen bag through the main operating hole. Afterwards, systemic mediastinal lymph node dissection was performed in a standard way, which included group 2, 3, 4, 7, 9 lymph nodes in the right side and group 5, 6, 7, 9 lymph nodes in the left side. Finally, a 10-mm rubber chest tube was placed through the secondary operating port for the middle and lower lobectomy. For upper lobectomy, another tube was placed through the viewing port to the cupula pleurae. At the end of operation, the tube was secured with a U-shaped suture to allow proper closure of the wound when removing the tube.

For two micro-portal VATS lobectomy, the viewing port and secondary operating port were replaced by a 5-mm trocar comparing with traditional three-port VATS lobectomy (*Figure 1*). Accordingly, the new procedure was performed using a 5-mm 30° oblique-viewing thoracoscope. The resection order was followed by the principle of "from back down to front up" way. In detail, for upper lobectomy (*Figure 2*), the resection was made in the order of pulmonary artery and its branches, lobar bronchus and pulmonary vein. For right middle lobectomy, we chose the main operating port in the third intercostal space of the anterior axillary line and followed the resectional order of vein-bronchus-artery. For lower lobectomy, the resection was performed in the order of vein-bronchus-artery or artery-bronchus-vein. In the end, the chest tube was changed to thinner and softer latex material.

All patients were observed in our intense care unit for six hours at least. The same dose of disposable self-control PCA (sulfentanyl and dezocine) and prophylactic antibiotics were used routinely. The intensity of postoperative pain was scored with a 0–10 numerical analogue scale. Pain scores were assessed at 24, 48, and 72 h after surgery and at 1 week postoperatively. The chest drain was removed when the amount of chest draining was less than 100 mL per day, without air leakage, no pneumothorax or localized pleural effusion on chest X-rays. Patients were usually discharged from the hospital 1 day after the chest tube was removed.

Ethical approval was not required by the Tangdu Hospital. The procedure had standard indications and oncological principles. Meanwhile, all patients were signed written informed consent and not involved in a formal trial.

Statistical analysis

A database was obtained from online service of Linkdoc. Continuous variables were presented as means with standard deviations and categorical variables were presented as frequencies. Variables were compared using Student's *t*-test, the χ^2 test and variance analysis or Fisher's exact test. Data were analyzed using SPSS 22.0 software (SPSS, Inc., Chicago, IL, USA), p-value less than 0.05 was considered statistically significant.

Results

There were 208 patients who underwent VATS lobectomy between June 2016 and December 2017 by Prof. Yan at our department. One hundred and four patients underwent traditional three port VATS and 104 patients underwent two micro-portal VATS lobectomy. All patients were confirmed to be primary lung cancer in postoperative pathological diagnoses and classified by pathologic stage. As demonstrated in *Table 1*, the two groups were well matched in regarding to age, body weight index (BMI), gender, smoking status, tumor

Table 1 Comparison of clinical characteristics in two groups

Characteristics	Three-port	Two micro-port	P
Age (year)	59.49±9.53	62.37±8.11	0.275
BMI (kg/m^2)	23.63±2.98	23.25±2.73	0.365
Gender			0.565
Male	64	68	
Female	40	36	
Smoking status			0.684
Never	54	43	
Now	17	34	
Was	33	27	
Tumor site			0.884
Right upper lobe	36	29	
Right lower lobe	19	22	
Right middle lobe	6	7	
Left upper lobe	20	22	
Left lower lobe	30	24	
T stage			0.449
T1a	6	10	
T1b	26	25	
T1c	21	2	
T2a	36	48	
T2b	9	10	
T3	5	8	
T4	1	1	
N stage			0.649
N0	68	71	
N1	15	17	
N2	21	16	
TNM stage			0.420
IA	39	25	
IB	20	34	
IIA	13	20	
IIB	12	7	
IIIA	20	18	
Histological type			0.342
Big cell	2	2	
Squamous cell	23	35	
Adenocarcinoma	72	59	
Adenosquamous carcinoma	4	3	
Small cell	3	5	

Table 2 Comparison of surgical outcomes in two groups

Group	Three port	Two micro-port	P
Operative time (min)	145.05±4.18	149.76±35.96	0.601
Bleeding	202.60±224.30	275.38±444.96	0.141
Number of lymph node retrieved	15.36±3.06	16.32±3.47	0.116
Numeral pain score			
Day 1	6.92±1.08	4.23±1.37	0.008
Day 2	5.61±1.17	3.43±1.01	0.000
Day 3	5.04±1.09	3.37±0.92	0.000
Day 7	2.66±0.95	1.71±0.87	0.000
Chest tube duration	5.10±3.59	5.63±2.65	0.659
Postoperative hospital stay	7.63±4.72	8.32±3.43	0.989
Pulmonary infection after lobectomy	4	5	0.749
Air leak over 5 days	10	13	0.659
Conversion to thoracotomy	6	6	1
Postoperative 30-day mortality	0	0	1

site, TNM stage and histological type.

In terms of surgical outcomes, as shown in *Table 2*, there was no intraoperative or 30-day mortality in both groups. In the traditional three port group, there were 6 patients who needed conversion to thoracotomy, due to severe pleural adhesion (n=2), bleeding at pulmonary arterial branch (n=1), and anthracofibrotic lymph nodes around pulmonary artery (n=3). Similarly, there were 7 patients who converted to thoracotomy, due to severe pleural adhesion (n=1), bleeding at pulmonary arterial branch (n=2), and anthracofibrotic lymph nodes around pulmonary artery (n=3). The operative time and intraoperative bleeding in the traditional three port group and two micro-port group were similar (145.05±4.18 *vs.* 149.76±35.96 min, P=0.601; 202.60±224.30 *vs.* 275.38±444.96 mL, P=0.141). The number of lymph node retrieved in the traditional three port group and two micro-port group were 15.36±3.06 and 16.32±3.47, respectively (P=0.116). Postoperative air leak over 5 days was developed in 10 patients in the traditional three port group and 13 patients in the two micro-port group (P=0.659). The rate of pulmonary infection after lobectomy

was also similar in either group (4/104 *vs.* 5/104, P=0.749). The chest tube duration and postoperative hospital stay in the two micro-port group were shorter than that in the traditional three port group (5.10±3.59 *vs.* 5.63±2.65 days, P=0.659; 7.63±4.72 *vs.* 8.32±3.43 days, P=0.989). However, the differences were not statistically significant.

In the traditional three port VATS group, the mean pain scores at day 1, 2, 3 and 7 after surgery were 6.92±1.08, 5.61±1.17, 5.04±1.09 and 2.66±0.95. In the two micro-port VATS group, the pain scores were 4.23±1.37, 3.43±1.01, 3.37±0.92 and 1.71±0.87, which were significantly lower than the traditional three port VATS group. The result was confirmed an advantage for our two micro-port VATS regarding to reduced pain in the early postoperative period. We attributed this to reduced trauma and intercostal nerve injury.

Discussion

VATS lobectomy was widely practiced using 1 to 4 port incisions in China. The most representative procedure includes the single-direction thoracoscopic lobectomy of West China Hospital (10) and the single port thoracoscopic lobectomy of Shanghai Pulmonary Hospital (11). Several studies demonstrated that uniportal VATS minimized the amount of surgical trauma and had many advantages including decreased postoperative pain, shorter hospital stay, preservation of pulmonary function and so forth when compared with traditional three port VATS. Wang *et al.* (12) noted that uniportal VATS was geometrically favorable to multiportal techniques, which provided more anatomic and direct in-plane view of the target tissue, and made it easier for the surgeon to judge distances and improve the accuracy of the surgical maneuvers. However, due to its technical difficulty such as instrumentation impeding with each other and exclusive need of endoscopic instruments with two articulation, uniportal VATS was performed only in a limited number of hospitals. We considered that our method made best use of the advantages of traditional three port VATS and bypassed the disadvantages of uniportal VATS.

The result of this study revealed that there were no surgery related mortality and no significant differences in operative time, blood loss, number of lymph nodes dissected, chest tube duration, length of stay or postoperative complications between the two group. These results indicated that the safety and efficacy of two micro-port and three port VATS were similar. Moreover, our results showed that the numeral pain scores were significantly lower in the two micro-portal VATS group, which might be attributed to less incision trauma and reduced intercostal nerve injury. The total length of incision was 3–3.5 cm which was even shorter than the single port. Meanwhile, the use of 5 mm trocar and wound protector successfully avoided the injury to the chest wall from the instruments. A recent study by Nardini *et al* (13) also demonstrate that microlobectomy using 5 mm trocar and instrument is a valid alternative to traditional VATS techniques.

This study has several limitations. First of all, the retrospective nature of data lends themselves to inherent bias, even though the patients have received the standardized perioperative care. Secondly, we didn't compare the intraoperative and postoperative outcomes of a specific lobectomy between the two groups due to limited sample size. In addition, the study had no long-term follow-up data on oncologic factors such as tumor recurrence rate and overall survival rate. This will be our further work to be on going.

Conclusions

In conclusion, our experience showed that the two micro-port VATS lobectomy had similar results in safety and efficacy comparing with the traditional three-port VATS lobectomy. Besides, patients who had two micro-port VATS lobectomy suffered from less pain, which might improve their satisfaction rate. This indicates that the two micro-port VATS remain an exciting new development in the field of minimally invasive thoracic surgery.

Acknowledgements

None.

Footnote

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

Ethical Statement: Ethical approval was not required by the Tangdu Hospital. Meanwhile, all patients were signed written informed consent and not involved in a formal trial.

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