Original Article

A Comparison of Operative Outcomes between Single-Port and Multi-Port Video-Assisted Thoracoscopic Surgery (VATS) in Pulmonary Lobectomy

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Background: Single-port video-assisted thoracoscopic surgery (VATS) have been performed in Southeast Asian countries for several years. However, the outcomes of the single-port VATS are still under investigation.

Objective: To compare the surgical outcomes between single-port VATS and multi-port VATS in pulmonary lobectomy and to validate its efficacy and safety.

Materials and Methods: The outcomes of 130 patients that underwent VATS at the Central Chest Institute of Thailand between January 2015 and May 2018, were reviewed. Patients were classified into two groups, single-port, and multi-port VATS with 68 as single-port and 62 as multi-port cases. Patient characteristics and perioperative outcomes were analyzed and compared.

Results: There were no significant differences in patient characteristics between the two groups. The single-port group had a lower Pain Numeric Rating Scale at 24 hours (p=0.022) and shorter length of hospital stay (p=0.044) than the multi-port group. The number of N2 lymph nodes retrieved in the single-port group was significantly higher than in the multi-port group (p=0.022) while other surgical outcomes were not significantly different. There were no significant differences in intraoperative and post-operative complications (p=0.338 and p=0.142, respectively) and no perioperative mortality in both groups.

Conclusion: The authors' experience showed that single-port VATS is a practical technique and safe procedure when compared to multi-port VATS.

Keywords: Video-assisted thoracoscopic surgery (VATS), lobectomy, minimally invasive surgery

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Single-port Video-Assisted Thoracoscopic Surgery (VATS) is the new trend in thoracic surgery. It was reported for the first time in 2004 by Rocco et al[1] and has since been accepted to be performed in Asian countries[2,3], e.g., Taiwan, Korea, Hong Kong, Singapore, China, and Japan. However, the outcomes of the single-port VATS for anatomical resection of the lung are still under investigation. Some advantages have been reported, including a significant reduction of post-operative pain[4] and shorter hospital stays[5] when compared to multi-port VATS anatomical resection. In the Central Chest Institute of Thailand, single-port VATS has been routinely performed since January 2015. The study compared the outcomes of single-port VATS with multi-port VATS in lobectomy to validate its efficacy and safety.

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Materials and Methods

One hundred sixty-two patients underwent VATS for lobectomy between January 2015 and May 2018 at the Central Chest Institute of Thailand. Thirty-two patients were excluded because of conversion and missing medical data. Because the primary outcome in the present study was to compare post-operative pain between VATS procedure, the authors decided to exclude minithoracotomy and thoracotomy wound from conversion. Therefore, 130 patients were retrospectively reviewed. There were 68 cases in the

single port group and 62 cases in the multi-port group.

Patient characteristics included age, gender, the American Society of Anesthesiologists (ASA) physical status classification, smoking history, lobectomy position, forced expiratory volume (FEV) in one second, percentage of FEV in one second ($\%FEV_1$), and diagnosis. In lung cancer patients, the cancer stage and histological type were recorded.

The surgical outcomes were recorded and included operative time, blood loss, duration of chest drain, length of hospital stay, intraoperative and post-operative complications, lymph node staging (number of lymph nodes retrieved and number of nodal stations explored), and pain numeric rating scale (NRS). The variables were analyzed and compared among the two groups.

Surgical technique

In 2013, the present study institute has started a video-assisted thoracoscopic program employing three-port and two-port VATS techniques for pulmonary lobectomy.

In the three-port technique, the surgeon used the standard three-port anterior approach, performed with a 5 or 10 mm, 30-degree angled high-definition (HD) video-thoracoscope. The surgeon and the assistant were positioned on the anterior side of the patient, with the surgeon cranially. Initially, the camera was inserted via the seventh intercostal space anterior to the mid-axillary line, and then a 4 to 5 cm anterior utility incision was made without rib spreading at the fourth or fifth intercostal space (depending on the lobe where the lobectomy was performed), just anterior to the latissimus dorsi muscle. The wound was protected by a plastic soft tissue retractor kept in place by a ring in the chest cavity and one outside the skin. The third port was inserted via the sixth intercostal space just posterior to the posterior axillary line for retraction of the lung. In the two-port technique, the surgeon performed in the same manner as the three-port approach but did not create the third port at the sixth intercostal space.

In January 2015, the surgeon began performing the single-port VATS technique for lobectomy. A single incision of approximately 3 to 4 cm was made in the fifth intercostal space at the anterior axillary line. The wound was protected by a plastic soft tissue retractor kept in place by a ring in the chest cavity and one outside the skin. The 5 mm thoracoscope with 30-degree angle HD was usually placed through the lower channel with the instruments in the upper channel.

Both multi-port and single-port techniques were performed under general anesthesia with single-lung ventilation via a double lumen endotracheal tube. The surgical steps were similar in both groups, including individual dissection of the veins, arteries, bronchus, and fissure of the lobe by using the same staple, energy device, and endoscopic instrument.

In lung cancer patients, the surgeon performed systematic lymph node sampling in early-stage lung cancer and lymph node dissection in the later stages of lung cancer.

At the end of the operation, the surgeon used 20 or 24 Fr sized chest drains. In the single-port VATS, a chest drain was inserted at the same place as the surgical wound but in multi-port VATS, a chest drain was inserted in the camera port wound. The wound was infiltrated with 10 ml of 0.5% Marcain at the end of the operation.

For pain control in the post-operative period, all the patients received 3 mg morphine intravenously prn every four hours on the first day, followed by non-steroidal anti-inflammatory drug (NSAID) three times daily and 500 mg acetaminophen orally prn every six hours on the second and third days, then finally only 500 mg acetaminophen orally prn every six hours was used for pain control after three days.

The technique of VATS for each patient was selected according to the surgeon's preference.

Numeric rating scale pain scores

The NRS is a segmented numeric version of the visual analogue scale (VAS). Similar to the VAS, the NRS is anchored by terms describing pain severity extremes[6]. The 11-point numeric scale ranges from '0' representing no pain, to '10' representing another pain extreme[7].

The pain scores in the present study were assessed at 24, 48, and 72 hours post-operatively and at one week and one month after surgery[8].

Statistical analysis

Descriptive analysis was performed and expressed as the mean ± standard deviation for continuous variables, and as frequencies and percentages for categorical variables. Quantitative data of both groups were compared using the independent t-test, while qualitative data of these groups were compared using the chi-squared test.

The IBM SPSS Statistics, version 25 (IBM Corp., Armonk, NY, USA) was used to analyze the data. A p-value of less than 0.05 were considered statistically significant.

Table 1. Patient characteristics

Characteristics	Single-port (n=68) n (%)	Multi-port (n=62) n (%)	p-value
Age (years); mean±SD	60.06±13.74	60.65±11.03	0.790
Sex			0.854
Male	34 (50.0)	30 (48.4)	
Female	34 (50.0)	32 (51.6)	
ASA classification			0.250
1	30 (44.1)	22 (35.5)	
2	33 (48.5)	30 (48.4)	
3	5 (7.4)	10 (16.1)	
Smoking			0.515
Never	44 (64.7)	36 (58.1)	
Stop	18 (26.5)	22 (35.5)	
Present	6 (8.8)	4 (6.5)	
Lobectomy position			0.455
Left lower	7 (10.3)	12 (19.4)	
Left upper	17 (25.0)	12 (19.4)	
Right lower	16 (23.5)	10 (16.1)	
Right middle and lower	0 (0.0)	1 (1.6)	
Right middle	5 (7.4)	7 (11.3)	
Right middle and upper	1 (1.5)	0 (0.0)	
Right upper	22 (32.4)	20 (32.3)	
Pulmonary function; mean±SD			
FEV_1 (Liters)	2.25±0.66	2.16±0.55	0.392
$\%FEV_1$	97.66±20.63	96.85±19.93	0.821

ASA=American Society for Anesthesiologists physical status; FEV_1=the first second forced expiratory volume; $\%FEV_1$=ratio of the first second of forced expiration to the full forced vital capacity express in percent; SD=standard deviation

Table 2. Proportions of diagnoses

Diagnosis	Single-port (n=68) n (%)	Multi-port (n=62) n (%)	p-value
Aspergilloma	0 (0.0)	3 (4.8)	0.182
Arteriovenous malformation	1 (1.5)	0 (0.0)	
Bronchogenic cyst	0 (0.0)	1 (1.6)	
Lung cancer	55 (80.9)	46 (74.2)	
Fibrogranuloma	1 (1.5)	0 (0.0)	
Hamatoma	1 (1.5)	1 (1.6)	
Interstitial fibrosis	1 (1.5)	0 (0.0)	
Lung abscess	2 (2.9)	0 (0.0)	
Metastatic cancer	0 (0.0)	4 (6.5)	
Organizing pneumonia	0 (0.0)	1 (1.6)	
Pulmonary sequestration	0 (0.0)	1 (1.6)	
Pulmonary vasculitis	1 (1.5)	0 (0.0)	
Sclerosing pneumocytoma	1 (1.5)	2 (3.2)	
Tuberculosis	5 (7.4)	3 (4.8)	

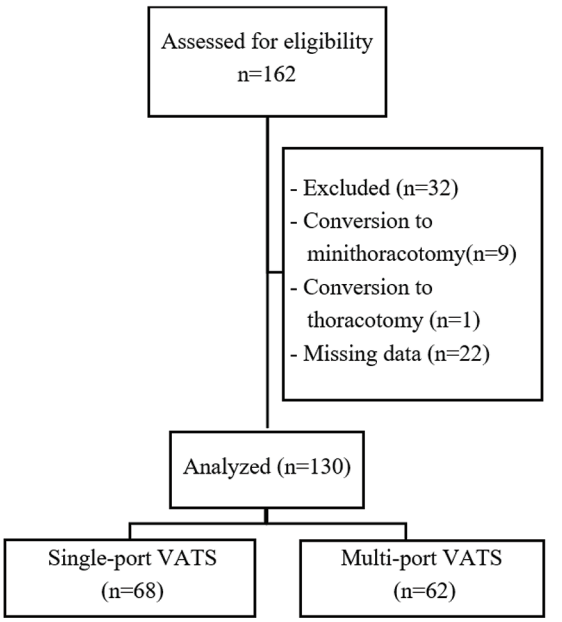

Figure 1. Number of patients.

Ethical approval

The present study was approved by the Ethics Committee of Central Chest Institute of Thailand (no.003/2562).

Results

Patient characteristics

One hundred sixty-two patients underwent VATS for lobectomy between January 2015 and May 2018 at the Central Chest Institute of Thailand. Thirty-two patients were excluded because of conversion and missing medical data (Figure 1). Eight patients and one patient respectively (9.5% and 1.3%) were converted from single-port and multi-port VATS to minithoracotomy. One patient was converted to open surgery in the form of thoracotomy. Therefore, 130 were patients included in the present study. The patients were divided into two groups, patients that underwent single-port VATS (n=68) and patients that underwent two- or three-port VATS (multi-port) (n=62).

There were no significant differences in age, gender, ASA classification, smoking history, lobectomy position, lung function (Table 1), diagnosis (Table 2) and stage of lung cancer, and histology type

Table 3. Proportions of diagnoses (lung cancer subgroup)

Diagnosis	Single-port (n=55) n (%)	Multi-port (n=46) n (%)	p-value
Adenocarcinoma	48 (87.3)	38 (82.6)	0.325
Carcinoid tumor	1 (1.8)	0 (0.0)	
Large cell carcinoma	0 (0.0)	2 (4.3)	
Lymphoepithelioma carcinoma	0 (0.0)	1 (2.2)	
Sarcomatoid carcinoma	0 (0.0)	1 (2.2)	
Squamous cell carcinoma	6 (10.9)	4 (8.7)	

Table 4. Distribution of lung cancer

Pathologic stage	Single-port (n=55) n (%)	Multi-port (n=46) n (%)	p-value
Stage I-IV			0.082
Stage I			
• IA1	0 (0.0)	1 (2.2)	
• IA2	7 (12.7)	7 (15.2)	
• IA3	10 (18.2)	10 (21.7)	
• IB	19 (34.5)	8 (17.4)	
Stage II			
• IIA	3 (5.5)	5 (10.9)	
• IIB	5 (9.1)	9 (19.6)	
Stage III and above			
• IIIA	11 (20.0)	3 (6.5)	
• IIIB	0 (0.0)	2 (4.3)	
• IV	0 (0.0)	1 (2.2)	

in the lung cancer groups (Table 3, 4).

Surgical outcomes

There were no significant differences in operative times, blood loss, or duration of chest draining among the two groups (Table 5). Length of stay was significantly lower in the single-port group (7.97±3.38 versus 9.31±4.09 days, p=0.044). The number of N1 lymph nodes retrieved was not significantly different between the two groups, while the number of N2 lymph nodes retrieved in the single-port group was higher than that for the multi-port groups (p=0.012). There was one patient (1.5%) who had an intraoperative complication (tracheal tear) in the single-port group while seven patients (10.3%) and six patients (9.6%) respectively had post-operative complications in the single- and multi-port groups. However, there was no statistically significant difference between the two groups (Table 6).

Pain numeric rating scale

The mean pain NRS (Table 7) at 24 hours after surgery in the single-port group was significantly lower than the reported value in the multi-port group (2.75±1.44 versus 3.44±1.88, p=0.022). The mean pain NRS values at 48 hours, 72 hours, one week and one month after surgery were not significantly different between the two groups.

Discussion

VATS has been used as conventional treatment. The multi-port VATS approach was introduced earlier but the use of single-port VATS is increasing due to its potential benefits, which include lower operating times, reduced blood loss, lower post-operative pain, and shorter hospital stays[4,9-11]. However, the

Table 5. Surgical outcomes

Characteristic	Single-port (n=68) Mean±SD	Multi-port (n=62) Mean±SD	p-value
Operative time (minutes)	191.10±40.88	204.68±65.93	0.166
Length of hospital stay (days)	7.97±3.38	9.31±4.09	0.044
Duration of intercostal drainage insertion (days)	5.97±3.36	6.63±3.34	0.265
Blood loss (mL)	153.97±140.34	190.32±164.86	0.177
N1 lymph nodes retrieved (lung cancer patients only)	5.27±4.65	5.87±4.86	0.532
N2 lymph nodes retrieved (lung cancer patients only)	15.64±8.42	10.28±11.04	0.007
Margin (lung cancer patients only); n (%)			0.898
Negative	54 (98.2)	45 (97.8)	
Positive	1 (1.8)	1 (2.2)	

SD=standard deviation

Table 6. Post-operative complications

Complication	Single-port (n=68) n (%)	Multi-port (n=62) n (%)	p-value
Intraoperative complication			0.338
Tracheal tear	1 (1.5)	0 (0.0)	
Post-operative complication			0.142
Chylothorax	2 (2.9)	0 (0.0)	
Infected wound	0 (0.0)	3 (4.8)	
Prolong air leak (over 7 days post-operative)	5 (7.4)	3 (4.8)	

Table 7. Pain numeric rating scale after surgery

Characteristic	Single port (n=68) Mean±SD	Multi-port (n=62) Mean±SD	p-value
24 hours	2.75±1.44	3.44±1.88	0.022
48 hours	1.84±1.10	2.13±1.08	0.131
72 hours	1.29±0.98	1.52±0.95	0.193
7 days	0.38±0.57	0.44±0.78	0.657
30 days	0.03±0.17	0.03±0.18	0.926

SD=standard deviation

evidence regarding the outcomes and advantages of a single incision in lobectomy is limited and the results remain controversial, particularly in terms of efficacy and safety.

The present study demonstrated that the single-port VATS surgery had a lower post-operative pain score after the first 24 hours than the multi-port VATS, although the patients received similar medication post-operatively. The pain in both groups decreased over time and had almost completely gone after one month. The authors found the single-port group had a shortened length of stay in the hospital, as reported in other studies[10-12], while the median hospitalization period was longer compared to other hospitals because the hospital stay duration of the authors' patients was delayed according to the authors' customary practices. Finally, the present study showed that the single-port approach generated a significantly higher number of N2 lymph nodes retrieved than the multi-port approach and this finding differed from other studies, possibly because the learning curve for managing mediastinal lymph nodes and the technique to retrieve the lymph nodes differed among surgeons. However, the present study can prove that the single-port technique was practical for managing mediastinal lymph nodes in lung cancer.

The conversion rates from multi-port and single-port VATS were 1.3% and 9.5%, respectively, but another study had reported conversion rates between 2.1% to 4.6%. Most of the conversion were caused by bleeding that cannot be corrected by VATS procedure, possibly because the first year and the first 30 cases of the single-port technique formed the learning curve of that procedure[12,13]. This was the cause of the conversion rate being higher in the single-port group than in the multi-port group.

For safety, complications did occur intraoperatively and post-operatively, but the incidences were not statistically significantly different between the two groups. In the tracheal injury complication, it was a 0.2 mm tear from cautery burn. The authors corrected it by suture with non-absorbable suture 4-0 one stitch without conversion. For the chylothorax complication, the surgeon treated by conservative treatment and chylothorax was solved within seven days. In the infected wound complication, they were classified as superficial infected wound and were treated by debridement and oral antibiotic. The wound infections were resolved within seven days. Prolong air leakage complication were corrected by conservative treatment and were solved not longer than two weeks post-operative.

One limitation of the present study was the retrospective data in patients with various diseases who underwent VATS. Furthermore, a randomized control trial should be conducted in the same conditions with a similar position to validate the efficacy and safety for the single-port versus the multi-port VATS.

Conclusion

The author' experience showed that single-port VATS is a practical technique, has lower post-operative pain and shorter hospital stay, and is safe when compared to multi-port VATS. However, the single-port technique is a relatively complex procedure and its performance requires the skills of an experienced surgeon.

What is already known on this topic?

Single-port VATS is one of the newly minimally operative procedures for thoracic surgery and is already established in Asia. It has few reports for efficacy and safety of this procedure when compared to conventional VATS. The advantages of the single-port were less post-operative pain and shorter hospital stay in some studies.

What this study adds?

This study is the first report from Thailand for efficacy and safety in single-port VATS lobectomy compared with conventional multi-port VATS lobectomy. This study confirmed the advantage of the single-port VATs lobectomy that the procedure had less post-operative pain and shorter hospital stay than the multiport VATS, even though they have the same standard of treatment.

Conflicts of interest

The authors declare no conflict of interest.

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