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Single-Port Thoracoscopic Lobectomy or Segmentectomy with Flexible 3D Endoscope Used

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Abstract

Introduction: Uniportal thoracoscopic surgery is a popular issue recently, but it is still not widespread worldwide due to limitations of the surgical technique. In most studies, Uniportal thoracoscopic surgery usually uses a 2D 30º endoscope as a camera. We use a flexible 3D endoscope system as a camera while performing single-port lobectomy or segmentectomy and compare it with double-port 2D and double-port 3D surgery.

Methods: The data of consecutive patients diagnosed with lung cancer that underwent 2D or 3D thoracoscopic lobectomy or segmentectomy in Changhua Christian Hospital from December 2015 to May 2018 were retrospectively analyzed. Tumor characteristics, perioperative and postoperative data and postoperative complications were all recorded for every patient.

Results: A total of 257 patients were enrolled in this study and were allocated to 3 groups: 1 (85 patients who underwent double-port surgery with a 2D system), 2 (95 patients who underwent double-port surgery with a 3D system) and 3 (77 patients who underwent single-port surgery with a 3D system). The 3 groups revealed similar patient demographics and tumor characteristics. The mean operative time, duration of chest drainage, ICU days and total length of stay were all the shortest in group 3 with significant difference (all p-values <0.05).

Conclusion: Single-port thoracoscopic lobectomy or segmentectomy under a 3D endoscopic system is safe and feasible. In our study, it has shorter operative time, duration of chest drainage, ICU days, and total length of stay compared to the other two groups. But its complication rate is similar to the other two groups.

Keywords: 3D endoscope; Single-port; Uniportal; Thoracoscopic lobectomy; Thoracoscopic segmentectomy

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Introduction

According to guidelines of the National Comprehensive Cancer Network, anatomic resection including lobectomy or segmentectomy is currently a standard treatment of early non-small cell lung cancer. Open thoracotomy has been almost replaced with thoracoscopic surgery in this decade. Thoracoscopic surgery has been proven to have a similar survival outcome compared to open thoracotomy but less morbidity, such as lower pain score, shorter admission stay, and earlier back to normal daily activity [1-5]. With the increasing frequency of thoracoscopic surgery, incisions decreased from the conventional 3 or 4 ports to double -port or even single -port. There have been many recent published studies discussing Uniportal thoracoscopic surgery recently [6-12]. But owing to the limitations of the surgical technique, Uniportal thoracoscopic surgery is still not widespread worldwide. Traditional thoracoscopic surgery uses a 30º thoracoscopy with a 2D system. But there are some disadvantages of 2D systems, such as lack of depth of field and more risk during pulmonary vessel dissection, especially in inexperienced surgeons. Robotic systems solved these problems but still have drawbacks, such as being too expensive for most patients to afford, the

3D image being only under the operator's view but not the assistant's or scrub nurse's and being almost impossible for junior surgeons to use. 3D endoscopic system development resolves the above problems and improves safety for thoracoscopic surgery [13-15]. We combined a single-port method and a 3D system to perform thoracoscopic lobectomy and segmentectomy in our hospital. The purpose of this study is to compare 3D single-port with 3D double-port and 2D double-portal thoracoscopic lobectomy or segmentectomy in non-small cell lung cancer patients, by examining perioperative outcomes, complications and other short-term outcomes.

Patients and Methods

This is a retrospective and single-center observational study in Changhua Christian Hospital. A total of 454 patients underwent surgical treatment for non-small cell lung cancer from December 2015 to May 2018 (Figure 1).

Exclusion criteria included

- Open thoracotomy
- Thoracoscopic wedge resection
- Double procedure at the same time (lobectomy + segmentectomy or segmentectomy in different lobes)
- The same patient underwent thoracoscopic surgery twice
- Clinical or pathological stage M1
- Received neoadjuvant chemotherapy before lobectomy

257 patients were allocated to 3 groups: 1 (85 patients underwent double-port surgery with a 2D system), 2 (95 patients underwent double-port surgery with a 3D system) and 3 (77 patients underwent single-port surgery with a 3D system). Single-port thoracoscopic lobectomy or segmentectomy was performed with patients under general anesthesia with single-lung ventilation via a double-lumen endotracheal tube or single-lumen endotracheal tube and the use of an endobronchial blocker. The patients were placed in a full lateral decubitus position with the operating table flexed to increase the intercostal spacing. One 3.5 cm to cm or 4 cm incision was created in the 5th intercostal space between the anterior axillary line and the mid axillary line and protected with wound protector without rib spreading (Figure 2A). Black silk was sutured on the wound protector to divide the camera from other working instruments (Figure 2B). A flexible 3D endoscope (Olympus) was used as our camera in our surgery and was put in the posterior site of the wound. The operator and the camera holder stood at the patient's anterior site and the first assistant stood at the patient's posterior site. The operator stood at the patient's caudal site while the camera holder stood at the patient's cranial site (Figure 3). The step of lobectomy or segmentectomy was similar to traditional double-port thoracoscopic surgery. After surgery, we set one 24FR. Straight chest tube as chest drainage at the posterior site of the incision. The chest tube was fixed with 2-0 Stratafix (knotless suture) and 2-0 nylon sutures (Figure 2C,2D).

Statistical analysis

Continuous variables were compared by using the 2-tailed t test. Categorical variables were compared using the χ^2 or Fisher exact test. Statistical analysis was considered to be significant when the probability value was below 0.05. Data analysis was performed using Statistical Package for the Social Sciences software (version 17.0; SPSS, Chicago, IL).

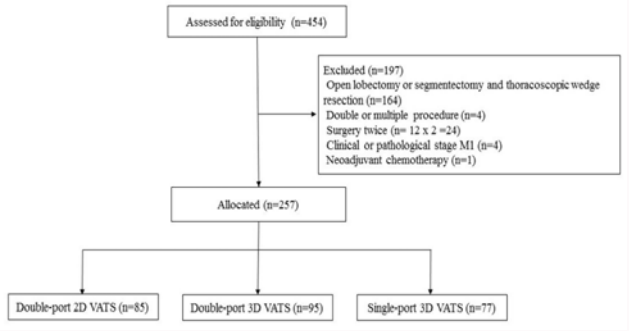

Figure 1: Flow chart of the study. Lung cancer patients underwent thoracoscopic lobectomy or segmentectomy between December 2015 and May 2018.
VATS: Video-Assisted Thoracoscopic Surgery; 3D: Three Dimensional; 2D: Two Dimensional

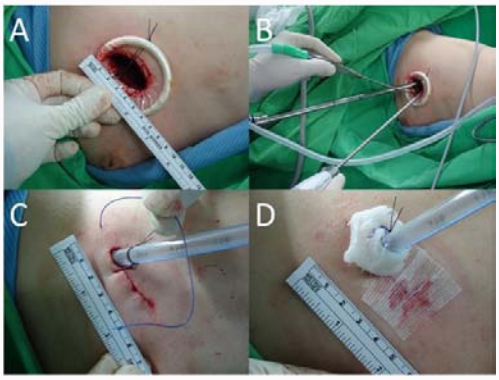

Figure 2: A) One 3.5 cm or 4 cm incision was created in the 5th inter costal space between the anterior axillary line and the mid-axillary line and was protected with wound protector without rib spreading. B) Black silk was sutured on the wound protector to divide the camera from other working instruments. C) One 24Fr. straight chest tube for chest drainage was inserted at the posterior site of the incision. D) The chest tube was fixed with 2-0 Stratafix (knotless suture) and 2-0 nylon sutures.

Results

During December 2015 to May 2018, 454 patients with non-small cell lung cancer underwent surgical treatment. We excluded 164 patients due to open thoracotomy or thoracoscopic wedge resection. Four patients who underwent a double procedure were excluded. Twelve patients were excluded because they underwent thoracoscopic surgery twice. Four patients were excluded due to clinical or pathological stage M1. One patient was excluded due to receiving neoadjuvant chemotherapy before lobectomy. Group 1 consisted of 84 patients who underwent double-port surgery with a 2D system, and group 2 consisted of 92 patients who underwent double-port surgery with a 3D system. Group 3 consisted of 44 patients who underwent single-port surgery with a 3D system. The clinical parameters of the three groups are displayed in Table 1. Mean age, smoking status, pulmonary function and most comorbidity were similar in the 3 groups. Only a higher proportion of females and lower chronic kidney disease in group 3 are significantly different from the other 2 groups (p-value <0.05). Tumor characteristics including size, location, cell types and clinical staging are displayed in Table 2. Almost all data are similar in the 3 groups and reveal no significant difference. Only a higher proportion of adenocarcinoma in group 3 is significantly different from the other 2 groups (p-value <0.05). Perioperative and postoperative data are all displayed in Table

Figure 3: The operator stands at patient's caudal site while the camera holder stands at patient's cranial site.

3, including type of surgery, operative time, intraoperative blood loss, ICU duration, ventilator duration, chest drainage duration, length of stay, total lymph nodes dissected and number of positive lymph nodes. Only one patient converted to open thoracotomy in group 2; that patient had a centrally located tumor that made approaching the hilum under thoracoscopy difficult. Mean operative time in group 3 is 166.0 ± 53.5 min, which is significantly shorter than that of group 1 (236.3 ± 87.4 min) and group 2 (221.6 ± 83.3 min) (p-value =0.000). Mean intraoperative blood loss in group 3 is 31.5 ± 40.0 ml, which is significantly lower than that of group 1 (60.8 ± 58.8 ml) and group 2 (60.8 ± 58.8 ml) (p-value =0.003). Duration of chest drainage, ICU days and total length of stay are all significantly shorter in group 3 than in group 1 and group 2 (all p-values <0.05). Ventilator duration seems also shorter in group 3 but is not significantly different. The numbers of total lymph nodes dissected and positive lymph nodes are similar in the 3 groups. Postoperative complications are displayed in Table 4. The only mortality was in group 1, and it was due to postoperative pulmonary embolism with a large area of stroke. The most common complications are subcutaneous emphysema and pneumonia, and the occurrences of complications are similar in all groups. Other complications include urinary tract infections, drug allergies, and electrocautery related scald burns. All 3 groups have no reoperations.

Discussion

The initial study about thoracoscopic lobectomy was published in 1992 [16,17]. Since then, the technique of thoracoscopy developed rapidly worldwide with a 3-port or 4-port approach. The first case report of a single-port thoracoscopic lobectomy was published in 2011 [6]. More studies displayed the potential advantages of reduced access trauma, less pain and better cosmetics [11,12]. 3D endoscopic systems were developed in recent years and provide a clearer operative view, the distance between an instrument and tissue and easier hand-eye coordination. Two kinds of 3D endoscopic systems make up a majority of the current market. One is a 30º thoracoscopy (Karl Storz) and another is a flexible 0º thoracoscopy (Olympus). Traditional single-port lobectomy and segmentectomy use a 30º thoracoscopy with a 2D endoscopic system. In our study, we used a flexible 3D endoscope to perform lobectomy and segmentectomy. There is only one case report using a similar method; it involved a left upper lobe tri-segmentectomy [18]. The current article is the only original article that reports the use of a flexible 3D endoscope as a camera to perform lobectomy and segmentectomy and compares it with 2D double-port and 3D double-port thoracoscopic surgery in the same hospital. A flexible 3D system not only offered better surgical vision than a traditional or 3D 30º endoscope, but it also decreased conflict between instruments and the endoscope, especially in single-incision thoracoscopic surgery. In our hospital, we performed thoracoscopic lobectomy and segmentectomy with a double-port approach 7 years ago. We started using a flexible 3D endoscopic system in June 2016. Initially, thoracoscopic lobectomy and segmentectomy was still undergone with a double-port approach, and the camera holder was not familiar with its flexible feature. After one year of using a flexible 3D endoscope, we shifted our surgery from a double-port to a single-port approach. Owing to experience of both the surgeon and camera holder, we accustomed to the single-port approach from double-

Table 1: Patient demographics.

Variables	Group 1 (n=85)	Group 2 (n=95)	Group 3 (n=77)	P-value
Age (mean, years)	63.8 ± 11.8	63.9 ± 13.5	61.4 ± 10.0	0.316
Gender				0.027
Male	n=42 (49.4%)	n=49 (51.6%)	n=25 (32.5)	
Female	n=43 (50.6%)	n=46 (48.4%)	n=52 (67.5%)	
Smoking	n=13 (15.3%)	n=12 (12.6%)	n=5 (6.5%)	0.205
FEV1 (L)	2.13 ± 0.64	2.12 ± 0.63	2.11 ± 0.65	0.98
FEV1 (%)	88.32 ± 16.70	88.39 ± 19.57	90.05 ± 16.52	0.828
FEV1/FVC (%)	80.83 ± 10.87	79.25 ± 9.41	79.70 ± 8.92	0.559
Comorbidity (%)				
Hypertension	n=41 (48.2%)	n=44 (46.3%)	n=28 (36.4%)	0.266
Diabetes	n=26 (30.6%)	n=22 (23.2%)	n=17 (22.1%)	0.384
Coronary artery disease	n=10 (11.8%)	n=9 (9.5%)	n=4 (5.2%)	0.334
Chronic kidney disease	n=13 (15.3%)	n=9 (9.5%)	n=3 (3.9%)	0.05
Peptic ulcer	n=9 (10.6%)	n=8 (8.4%)	n=7 (9.1%)	0.879
Liver cirrhosis or hepatitis	n=14 (16.5%)	n=16 (16.8%)	n=10 (13%)	0.756
Other pulmonary disease (Chronic obstructive pulmonary disease/Asthma/ Pulmonary tuberculosis)	n=23 (27.1%)	n=27 (28.4%)	n=11 (14.3%)	0.065
Other cancers	n=14 (16.5%)	n=11 (11.6%)	n=9 (11.7%)	0.559

Table 2: Tumor characteristics.

Variable	Group 1 (n=85)	Group 2 (n=95)	Group 3 (n=77)	P-value
Tumor site				0.63
Right upper lobe	n=28 (32.9%)	n=30 (31.6%)	n=28 (36.4%)	
Right middle lobe	n=3 (3.5%)	n=6 (6.3%)	n=9 (11.7%)	
Right lower lobe	n=21 (24.7%)	n=21 (22.1%)	n=13 (16.9%)	
Left upper lobe	n=19 (22.4%)	n=24 (25.3%)	n=15 (19.5%)	
Left lower lobe	n=14 (16.5%)	n=14 (14.7%)	n=12 (15.6%)	
Tumor size (cm)	2.97 ± 2.35	2.68 ± 1.72	2.26 ± 1.69	0.07
Clinical stage				0.526
0	n=4 (4.4%)	n=4 (4.2%)	n=4 (5.2%)	
IA	n=49 (57.6%)	n=50 (52.6%)	n=52 (67.5%)	
IB	n=12 (14.1%)	n=21 (22.1%)	n=9 (11.7%)	
IIA	n=8 (9.4%)	n=5 (5.3%)	n=4 (5.2%)	
IIB	n=6 (7.1%)	n=4 (4.2%)	n=3 (3.9%)	
IIIA	n=6 (7.1%)	n=11 (11.6%)	n=5 (6.5%)	
Cell type				0.03
Adenocarcinoma	n=64 (75.3%)	n=78 (82.1%)	n=71 (92.2%)	
Squamous cell carcinoma	n=16 (18.8%)	n=12 (12.6%)	n=2 (2.6%)	
Others	n=5 (5.9%)	n=5 (5.3%)	n=4 (5.2%)	

Table 3: Perioperative and postoperative data.

Variable	Group 1 (n=85)	Group 2 (n=95)	Group 3 (n=77)	P-value
Surgery				0.047
Lobectomy	n=61 (71.8%)	n=68 (71.6%)	n=43 (55.8%)	
Segmentectomy	n=24 (28.2%)	n=27 (28.4%)	n=34 (44.2%)	
Convert to thoracotomy	n=1 (1.2%)	0	0	0.362
Operative time (min)	236.3 ± 87.4	221.6 ± 83.3	166.0 ± 53.5	0
Intraoperative blood loss (ml)	60.8 ± 58.8	63.4 ± 84.3	31.5 ± 40.0	0.003
ICU duration (days)	2.45 ± 3.64	4.29 ± 13.37	1.03 ± 1.21	0.041
Ventilator duration (days)	0.99 ± 2.94	2.77 ± 13.06	0.05 ± 0.32	0.086
Chest tube duration (days)	6.94 ± 3.27	8.32 ± 6.65	5.34 ± 2.58	0
Length of stay (days)	10.13 ± 4.37	12.29 ± 14.78	7.94 ± 3.35	0.012
Total lymph nodes	18.28 ± 10.03	16.29 ± 9.40	15.79 ± 7.74	0.146
Positive lymph nodes	0.88 ± 3.32	0.76 ± 2.50	0.73 ± 2.19	0.18

port approach only in about one month. In our results, group 3 has significantly the shortest operative time, duration of chest drainage, ICU days, and total length of stay and the lowest intraoperative blood loss. Similar complication rates and numbers of lymph nodes dissected revealed no decrease in the quality of surgery. There are some limitations in our study, such as it being a single-center retrospective study, the small size, possibly some selection bias and the lack of long-term outcomes. Increasing experience and the familiarity between the surgeon and camera holder could be another bias in our study. However, a learning curve in group 3 was also involved in our study, but group 3's operative time was still the shortest.

Conclusion

Single-port thoracoscopic lobectomy or segmentectomy under the use of a 3D endoscopic system is safe and feasible. Comparing it to the other two surgery approaches in our study, it has shorter operative time, duration of chest drainage, ICU days, and total length of stay and also lower intraoperative blood loss but a similar complication rate.

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