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Uniportal video-assisted thoracoscopic lobectomy: an alternative to conventional thoracoscopic lobectomy in lung cancer surgery?

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Abstract

OBJECTIVES: Although the standard video-assisted thoracoscopic surgery (VATS) approach is generally performed through two to four incisions, uniportal VATS pulmonary resection has recently been reported to be a promising, less invasive alternative. To evaluate the adequacy of uniportal VATS lobectomy as an alternative to conventional VATS lobectomy in lung cancer, we analysed and compared the outcomes of uniportal and conventional VATS lobectomies.

METHODS: Retrospective observational data for patients who underwent VATS lobectomy at Samsung Medical Center between January 2013 and February 2014 due to a diagnosis of lung cancer were collected. Perioperative factors such as operative time, postoperative chest tube duration, postoperative hospital stay, complication rate, conversion rate, reoperation rate and mortality were compared between the uniportal and conventional VATS groups.

RESULTS: A total of 90 uniportal VATS lobectomies and 60 conventional VATS lobectomies were attempted. Fifty-eight (64.5%) cases were completed as uniportal VATS lobectomies, and 51 (85%) cases as conventional VATS lobectomies. There were 32 (35.5%) conversions of uniportal VATS lobectomy cases, including four conversions to three-port VATS, 18 to two-port VATS and 10 to open thoracotomy. No differences in postoperative complications, postoperative 30-day mortality or reoperation rate were noted between the two groups. There was no difference in operative time, number of removed lymph nodes, chest tube duration or length of postoperative hospital stay between the uniportal VATS group and conventional VATS group.

CONCLUSIONS: The similar perioperative results of uniportal VATS lobectomy compared with conventional VATS lobectomy suggest that uniportal VATS is a viable alternative approach to the conventional VATS approach in selected patients, especially in patients with early peripheral lung cancer with good anatomy and in good general condition.

Keywords: Thoracoscopy/video-assisted thoracoscopic surgery • Lung cancer • Lobectomy

INTRODUCTION

With the worldwide trend towards minimally invasive surgical techniques, video-assisted thoracoscopic surgery (VATS) has become the standard approach for treating early lung cancer [1]; it was recently even attempted in advanced lung cancer patients [2, 3]. Although there is no clear definition or standard for VATS lobectomy, it is generally performed through two to four incisions [4, 5]. This allows multiple different angles of approach to the hilar structures and lymphatic tissues during VATS lobectomy.

Recent uniportal VATS pulmonary resection studies have reported that this approach has several advantages, such as improved geometry for instrumentation and exposure during surgery, in addition to reduction in postoperative pain and paraesthesias [6–8]. According to some surgeons, it is even useful in more advanced lung cancers or complex pulmonary resections such as pneumonectomy or sleeve resection [9, 10].

Considering its advantages with regard to postoperative pain, comparable perioperative results and improved cosmetic effects, we have initiated the use of uniportal VATS approach in lobectomies for early lung cancer patients at our institution. To evaluate whether uniportal VATS lobectomy is a feasible alternative to conventional VATS lobectomy in lung cancer, we reviewed perioperative clinical data, and compared the uniportal VATS lobectomy results with those obtained using conventional VATS lobectomy.

MATERIALS AND METHODS

This was a retrospective, observational study of patients who underwent VATS lobectomy for the diagnosis of lung cancer at

Samsung Medical Center between January 2013 and February 2014. The Institutional Review Board of Samsung Medical Center approved this study, and waived the requirement for informed consent.

Inclusion and exclusion criteria

All surgically resectable lung cancer patients, including those with primary and metastatic disease, who were initially treated with VATS were included in our study regardless of stage or surgical complexity. To avoid selection bias, only those patients who were treated by a single surgeon were included in the uniportal and conventional VATS groups. Patients who had another separate operation at the same time that required an additional extrathoracic incision were excluded. Furthermore, patients who were initially treated with open thoracotomy were also excluded.

Surgical strategy and technique

Since the introduction of uniportal VATS in May 2013, our surgical strategy for lobectomy has included initial exploration of the pleural cavity with a 5-mm 30-degree thoracoscope through the mid-axillary fifth intercostal space in all patients. Uniportal VATS was initially attempted in all patients except those with pleural seeding or diffuse, thick pleural adhesions; however, we did not hesitate to convert to two-port, three-port or open lobectomy when we encountered complex anatomy such as incomplete fissure, perivascular calcified lymph nodes, diffuse thick pleural adhesions or patients with poor pulmonary function that did not tolerate single-lung ventilation.

After confirmation of resectability through VATS exploration, the 5-mm incision at the fifth intercostal space was extended to a 3.5–5 cm incision (mean: 3.96 ± 0.40, range: 3–5) at the area of the mid-axillary line. An incision of the same length at the same area was also used in the conventional VATS procedure as the utility port. A wound protector (Endo Keeper, medium, Nelis) was applied in both groups. A routine lobectomy procedure using hook-type monopolar electrocautery, suction devices, vascular clips, energy devices and endostaplers with the guidance of a 5-mm 30-degree angled thoracoscope was performed in both groups. The difference in surgical technique between the two groups was that two 5-mm and 12-mm incisions for ports at the fourth and seventh intercostal spaces in the midaxillary line were added during the conventional VATS lobectomy (Figure 1). Also, longer, curved hook-type monopolar electrocauterizer, suction devices and instruments with proximal and distal articulation for an easier handling of vessels from different angles were selectively used in uniportal VATS lobectomy. Anatomical resection of veins, arteries, bronchi and mediastinal lymph nodes was performed in the same manner in both groups.

Intraoperative conversion to two- or three-port VATS was performed by adding another 12-mm sized port at the seventh intercostal space followed by another 5-mm port at the fourth intercostal space as needed. If conversion to thoracotomy was required, anterior and posterior extension of the uniportal incision at the fifth intercostal space was performed.

Once the operation was completed, a single chest tube was inserted in the anterior part of the incision for uniportal VATS and through the port at the seventh intercostal space for conventional VATS.

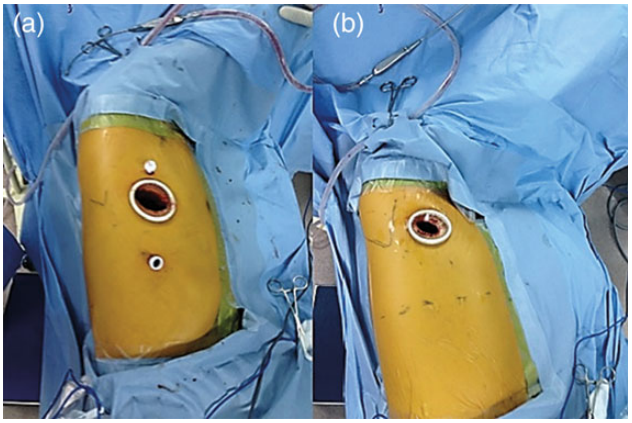

Figure 1: Port placements in (a) conventional VATS lobectomy and (b) uniportal VATS lobectomy.

Chest tubes were removed postoperatively when the daily chest tube drainage was <150 cc with no air leakage and sufficient lung expansion on chest X-rays. Patients were usually discharged the day after the chest tube removal and they were routinely followed up after 1 week, and every 3 months until the first 2 years postoperatively and every 6 months thereafter.

Groups and outcome measurements

Patients were divided into two groups based on the type of surgical procedure initially attempted. The uniportal VATS group included those patients in whom a lobectomy procedure was initially attempted through a single incision. Conventional VATS groups included those patients for whom the procedure was initially attempted with two or three incisions. Considering the purpose of this study was to compare the results of uniportal VATS lobectomy and conventional VATS lobectomy, patients who required an open thoracotomy initially were excluded from the study. Because the uniportal VATS approach was initiated in May 2013, the conventional VATS group included patients treated between January and April 2013, whereas the uniportal VATS group included patients who were treated between May 2013 and February 2014.

Preoperative findings such as sex, age, clinical stage, histology and comorbidities including hypertension, diabetes mellitus, pulmonary tuberculosis, pneumonia, chronic obstructive lung disease, cardiac disease (coronary disease, atrial fibrillation or congestive heart failure), renal disease (acute or chronic renal injury), liver disease (alcoholic liver disease or liver cirrhosis), previously treated cancers, past history of surgical chemotherapy and radiotherapy were analysed (Table 1). To analyse perioperative surgical outcomes, operative time, postoperative chest tube duration, postoperative hospital stay, completeness of resection, total number of removed lymph nodes, conversion rate, complication rate, reoperation rate and 30-day mortality rate were reviewed and compared.

In addition to the overall comparison between the uniportal VATS group and the conventional VATS group, patients in the uniportal VATS group and the conventional VATS group were divided into separate subgroups depending on their clinical stage (clinical stage I, II, III, metastatic lung cancer). To compare uniportal VATS and conventional VATS lobectomy in early lung cancer patients, subgroup analysis of clinical stage I patients was also performed in both groups. And also, to further analyse the

Table 1: Baseline clinical characteristics of the study subjects

Variables	Uniportal VATS lobectomy *n* (%)	Conventional VATS lobectomy *n* (%)	*P*-values
Patients, *n*	90 (60)	60 (40)	
Mean age, years (range)	60.54 ± 11.38 (9–80)	63.30 ± 9.29 (40–82)	0.121
Male: female	50 (56): 40 (44)	34 (56.7): 26 (43.3)	0.893
Right: left	46 (51.1): 44 (48.9)	29 (48.3): 31 (51.7)	0.739
Clinical stage			0.748
I	60 (66.7)	39 (65)	
II	11 (12.2)	10 (16.7)	
III	6 (6.7)	5 (8.3)	
Metastasis	13 (14.4)	6 (10)	
Pathological stage			0.503
aCR	0	2 (3.3)	
I	53 (58.9)	36 (60)	
II	10 (11.1)	8 (13.3)	
III	14 (15.6)	8 (13.3)	
IV	13 (14.4)	6 (10)	
Histology			0.307
ADC	55 (61.1)	45 (75)	
SCC	15 (16.7)	8 (13.3)	
Other malignancy	7 (7.8)	2 (3.3)	
Metastasis	13 (14.4)	5 (8.3)	
Hypertension	24 (26.7)	24 (40)	0.086
Diabetes mellitus	11 (12.2)	11 (18.3)	0.300
COPD/asthma	5 (5.6)	4 (6.7)	1.000
Pneumonia	0	2 (3.3)	0.158
Pulmonary tuberculosis	6 (6.7)	6 (10)	0.544
Coronary arterial disease	4 (4.4)	3 (5)	1.000
Heart failure/valvular heart disease	1 (1.1)	0	1.000
Atrial fibrillation	1 (1.1)	4 (6.7)	0.083
Liver disease	4 (4.4)	1 (1.7)	0.649
Renal disease	1 (1.1)	1 (1.7)	1.000
Other cancer	27 (30)	13 (21.7)	0.258
Previous thoracic operation	3 (3.3)	1 (1.7)	0.650
Previous chemotherapy	10 (11.1)	9 (15)	0.483
Previous radiotherapy at thorax	4 (4.4)	5 (8.3)	0.485

VATS: video-assisted thoracoscopic surgery; ADC: adenocarcinoma; SCC: squamous cell carcinoma; COPD: chronic obstructive pulmonary disease.

differences between the uniportal VATS and conventional VATS approaches, we have compared the outcomes of those who underwent conventional VATS initially versus those who were converted from uniportal to conventional VATS due to intraoperative complications or difficulties.

Statistics

All data were entered into an excel spreadsheet (Microsoft, Bellevue, WA, USA). Data were analysed using the IBM SPSS Statistics Version 19 (IBM SPSS Software, Armonk, NY, USA) to compare the qualitative and quantitative results of uniportal VATS and conventional VATS such as age, sex, operative time, postoperative chest tube duration, postoperative hospital stay, completeness of resection, total number of removed lymph nodes, number of removed lymph node stations, conversion rate, complication rate, reoperation rate and 30-day mortality rate. Univariate data analysis included independent sample *t*-tests or the Mann–Whitney test for quantitative variables and the χ^2 test or Fisher's exact test for qualitative variables. Data are reported as means ± standard errors of the mean. A value of $P < 0.05$ was considered statistically significant.

RESULTS

Between January 2013 and February 2014, 179 lobectomies were performed by a single surgeon (Y.S. Choi) at Samsung Medical Center due to a diagnosis of lung cancer. Twenty-nine cases that were performed together with other operations requiring additional incisions or in which an open thoracotomy was performed initially were excluded from the study. Among the 150 lobectomies, 90 lobectomies were attempted using the uniportal VATS approach and 60 lobectomies were attempted using the conventional three-port VATS approach. All lobectomies were performed with anatomical resection of veins, arteries and bronchi.

Of the 90 lobectomies attempted using the uniportal VATS approach, 58 (64.5%) were completed as uniportal VATS lobectomies, and 32 (35.5%) were converted, including four conversions to three-port VATS, 18 conversions to two-port VATS and 10 conversions to open thoracotomy. The reasons for conversion were diffuse tight pleural adhesions, anthracotic lymph nodes, extranodal invasion of lymph nodes, large tumour size, transfissural invasion of the tumour and bronchial injury due to stapling error (Table 2). There were nine conversions to open thoracotomy in three-port conventional VATS cases. Finally, 58 (38.6%) uniportal VATS lobectomies, 55 (36.7%) three-port conventional VATS lobectomies,

Table 2: Conversions from uniportal VATS lobectomy (32 cases, 35.5%)

To	Reason for conversion	*n* (%)
Two-port VATS lobectomy	Pleural adhesions	7 (21.9)
	Severe anthracotic lymph nodes	3 (9.4)
	Suspected extranodal invasion of the hilar lymph nodes	2 (6.2)
	Tumour abutting the pulmonary artery	2 (6.2)
	Suspected fissure invasion	1 (3.1)
	Post-neoadjuvant chemoradiation with diffuse pleural adhesions	1 (3.1)
	Intraoperative bleeding from the pulmonary artery	2 (6.2)
Three-port VATS lobectomy	Bronchial injury due to stapling error	1 (3.1)
	Conversion to sleeve lobectomy due to tumour location	1 (3.1)
	Large tumour with adhesion to the mediastinal pleura of the AP window	1 (3.1)
	Poor pulmonary function intolerant to one-lung ventilation	1 (3.1)
Open lobectomy	Diffuse, tight pleural adhesions	6 (6.2)
	Suspicious direct invasion to surrounding tissues (parietal pleura, transfissural invasion)	4 (12.5)
	Conversion to sleeve lobectomy	1 (3.1)
	Large tumour size	2 (6.2)

Table 3: Comparison of overall clinical outcomes between the two groups using univariate analysis

Variables	Uniportal VATS lobectomy *n* (%)	Conventional VATS lobectomy *n* (%)	*P*-values
Patients, *n*	90 (60)	60 (40)	
Operative time (min)	159.2 ± 53.14	166.15 ± 49.48	0.256
Chest tube duration (days)	5.04 ± 2.88	6.25 ± 5.74	0.321
Postoperative hospital stay (days)	6.78 ± 3.37	8.60 ± 8.29	0.289
Incomplete resection	0	1 (1.7)	0.400
Total number of removed lymph nodes	13.59 ± 7.18	15.82 ± 8.70	0.250
Total number of positive lymph nodes	1.01 ± 3.27	0.48 ± 1.28	0.444
Complications	18 (20)	17 (28.3)	0.237
Reoperation	1 (1.1)	1 (1.7)	1.000
Mortality	0	1 (1.7)	0.400

18 (12%) two-port conventional VATS lobectomies and 19 (12.7%) open lobectomies were performed in the study group.

No significant differences in sex, age, comorbidities or tumour location were noted between the uniportal and conventional VATS groups. Oncological factors such as clinical classification of malignant tumours (TNM) stage, pathological TNM stage and histology were not different between the two groups. Early lung cancer (clinical stage I) was the most common preoperative oncological status in both groups; 60 (66.7%) patients in the uniportal VATS group and 39 (65%) in the conventional VATS group had this diagnosis. Regarding cell types, adenocarcinoma was the most common type in both groups with 55 (61.1%) cases and 45 (75%) cases in each group, respectively (Table 1).

Univariate analysis revealed that the uniportal VATS group had a slightly shorter operative time, chest tube duration and length of postoperative hospital stay than the conventional VATS group, although without any statistical significance.

From an oncological perspective, no difference was noted regarding the completeness of resection or total number of lymph nodes removed between the two groups (Table 3).

There were 35 postoperative complications in total: 17 complications in the conventional VATS group (28.3%) and 18 complications in the uniportal VATS group (20%). Types of complications are given in Table 4. Most of these resolved without additional treatment.

There were two reoperations in total. One was in the uniportal VATS group, where uniportal VATS was initially attempted but was converted to three-port VATS for bronchial sleeve resection due to the central location of the tumour. The operation ended up as a VATS sleeve left upper lobectomy with successful lung expansion, which was confirmed intraoperatively. However, postoperative bronchial stenosis, probably caused by technical failure, resulted in unresolving postoperative atelectasis. Completion pneumonectomy was performed on postoperative day 2, and no additional complications were noted. Another reoperation was performed after a conventional VATS left upper lobectomy due to bronchial stenosis caused by external compression. Intraoperative findings showed that a folded fibrin mesh, which was previously applied at the lung surface, had migrated from its original position, and was externally compressing the bronchus. The mesh was removed and the problem was resolved without additional procedures.

There was a single in-hospital postoperative 30-day mortality due to postoperative pneumonia and acute lung injury after left lower lobectomy that was initially attempted as three-port conventional VATS and then converted to open thoracotomy.

For a more specific comparison of uniportal VATS lobectomy with conventional VATS lobectomy in early lung cancer patients, clinical stage I cases were selected separately from both groups and then compared. These results were not different from the

overall results. There were no differences in operative time, postoperative chest tube duration, postoperative length of hospital stay, total number of removed lymph nodes, postoperative complication rate, reoperation rate, or 30-day mortality rate between the uniportal VATS group and conventional VATS group (Table 5).

Together with the above mentioned results, the outcomes of those who underwent conventional VATS initially versus those who were converted from uniportal to conventional VATS, did not show any significant difference in operative time (154.13 vs 159.77 min, $P = 0.638$), chest tube duration (5.45 vs 5.91 days, $P = 0.538$), postoperative hospital day (6.95 vs 8.50 days, $P = 0.071$), complication rate (30.4 vs 36.4%, $P = 0.602$), reoperation rate (1.8 vs 4.5%, $P = 0.487$) and mortality (0 vs 0).

DISCUSSION

The feasibility and advantages of uniportal VATS in diverse fields of thoracic surgery have already been described in many studies [6, 7, 11–18]. Its minimally invasive nature, due to creation of only one incision through one intercostal space without rib spreading, results in less postoperative pain and fewer paraesthesias in addition to better cosmetic effects [7, 8, 19].

Although the feasibility of uniportal VATS lobectomy has been reported in several studies [8, 11–13], comparative studies of uniportal VATS versus conventional VATS have been reported only for cases with minor pulmonary resections [7]; no prior study directly compared the results of uniportal VATS and conventional VATS for major pulmonary surgeries such as lobectomies.

We compared the clinical outcomes of uniportal VATS lobectomy and conventional VATS lobectomy in lung cancer patients. Although the two groups did not undergo surgery in exactly the same time period, because uniportal VATS lobectomies were performed after April 2013 and the majority of conventional VATS lobectomies were performed between January and April 2013, this time difference is unlikely to have resulted in a significant difference in VATS skills. In addition, all operations were performed by a single surgeon who was fully experienced with VATS.

Since April 2013, our VATS lobectomy strategy has changed. We initially attempted the majority of our pulmonary resection surgeries via a uniportal VATS approach. Conventional VATS approach or thoracotomy were initially attempted in only certain cases of advanced lung cancer with N2-positive lymph nodes or when sleeve resection were needed according to the preoperative findings of computed tomography (CT) scan and bronchoscopy, or when the tumour was >7 cm. Therefore in the beginning of the procedure, we always explored the pleural cavity through a small incision in the fifth intercostal space of the mid-axillary line using a 5-mm thoracoscope. Next, based on the intraoperative findings, such as incomplete fissure, periarterial anthracotic lymph nodes, as well as the patient's ability to tolerate one-lung ventilation, which was evaluated by intraoperative arterial blood gas analysis, we decided whether to continue with uniportal VATS or convert to conventional VATS or open thoracotomy. There are some successful case reports of uniportal VATS lobectomies in complex cases of pulmonary resection [9, 10, 20], and we have had success with a uniportal VATS lobectomy approach in complex cases such as N2 lung cancer patients after neoadjuvant chemoradiation. We consider the uniportal VATS approach to be a good alternative to the conventional VATS approach due to the minimally invasiveness of the former, which may benefit the patient, but we do not consider it a priority or an obligation to perform uniportal VATS. Therefore, if the same results can be obtained, uniportal VATS may

Table 4: Postoperative complications

	Uniportal VATS lobectomy *n* (%)	Conventional VATS lobectomy *n* (%)	*P*-values
Patients, *n*	90 (60)	60 (40)	
Total, *N*	18 (20)	17 (28.3)	0.237
Persistent air leakage	8 (8.9)	4 (6.7)	
Arrhythmia	3 (3.3)	4 (6.7)	
Acute lung injury	0	2 (3.3)	
Pneumonia	0	3 (5)	
Bronchial stenosis	1 (1.1)	1 (1.7)	
Intraoperative pulmonary artery bleeding	1 (1.1)	0	
Hydropneumothorax	0	1 (1.7)	
Right middle lobe atelectasis	1 (1.1)	0	
Persistent drainage	4 (4.4)	0	
Pneumothorax after chest tube removal	0	1 (1.7)	
Oesophagitis	0	1 (1.7)	

Table 5: Univariate analysis of clinical outcomes of patients with clinical stage I lung cancer in the uniportal VATS group versus the conventional VATS group

Variables	Uniportal VATS lobectomy *n* (%)	Conventional VATS lobectomy *n* (%)	*P*-values
Patients, *n*	60 (60.6)	39 (39.4)	
Operative time (min)	154.58 ± 48.38	156.36 ± 39.80	0.683
Chest tube duration (days)	5.07 ± 2.63	4.92 ± 2.75	0.698
Postoperative hospital stay (days)	6.57 ± 3.33	6.54 ± 3.08	0.876
Incomplete resection	0	0	–
Total number of removed lymph nodes	13.43 ± 6.41	15.82 ± 7.72	0.202
Total number of positive lymph nodes	0.87 ± 3.47	0.38 ± 1.23	0.797
Complications	10 (16.7)	7 (17.9)	0.869
Reoperation	1 (1.7)	1 (2.6)	1.000
Mortality	0	0	–

be preferable to the conventional VATS approach, but if not, conversion is always acceptable. Thus, during the operation, considering that we may shorten the operative time by performing the conventional VATS lobectomy in complex cases, we had no hesitation in converting to two- or three-port VATS as needed, which was easily achieved with the simple addition of one or two small incisions in the seventh intercostal space of the mid-axillary line and the fourth intercostal space of the mid-axillary line. As a result, we had a higher global conversion rate of 35.5% than the rates of 4.5–16% reported in previous studies [8, 11]. However, considering the distinct characteristics of Korea, such as the high incidence of inflammatory diseases such as tuberculosis, the higher conversion rate is not unacceptable. Most conversions were to two-port VATS (18 out of 32) mainly due to diffuse, tight pleural adhesions and anthracotic hilar lymph nodes. Reasons for conversion to three-port VATS and open lobectomies were sleeve resections due to tumour location and bronchial injury after a stapling error that occurred in the initial period of uniportal VATS lobectomy. Such operations are generally completed by open thoracotomy in most other centres. The inclusion of these highly complex cases in our uniportal VATS lobectomy inclusion criteria may explain our higher conversion rate than those reported in previous studies.

Overall, the clinical outcomes of uniportal VATS lobectomy in our study, such as operative time, chest tube duration, length of postoperative hospital stay, complications, reoperation rate and mortality rate were similar to those of conventional VATS lobectomy and we therefore consider them acceptable. Similar results were obtained in subgroup analysis of clinical stage I cases from the two groups and also in additional comparative analysis of initial conventional VATS and converted conventional VATS. Based on these results, uniportal VATS lobectomy to treat lung cancer does not appear to be inferior to conventional VATS lobectomy from a technical perspective.

Furthermore, to assess the adequacy of mediastinal lymphadenectomy in uniportal VATS lobectomy, oncological factors such as completeness of resection and the total number of removed lymph nodes were reviewed by pathological analysis. Effective mediastinal lymph node staging and diagnosis through uniportal VATS has already been attempted by some surgeons [15] and therefore, all our lobectomies in this lung cancer series were performed with complete mediastinal lymphadenectomy. As given in Table 3, the results did not differ between the two groups, and our uniportal VATS lobectomy results were not inferior to those reported in previous studies [13].

Most of the uniportal VATS operations we performed were uneventful. However, in our fifth case of uniportal VATS that involved simultaneous right upper lobectomy and right lower lobe superior segmentectomy, the right lower lobar bronchus was partially injured by stapling while dividing the right lower lobe superior segment due to lack of careful visual confirmation of the stapler tip's location. The large volume of emphysematous lung and interfissural pleural adhesions, together with our then limited experience in managing the thoracoscopic view through a uniportal VATS approach, resulted in the stapling error. After conversion to three-port VATS, the partially stapled bronchus was opened and was corrected using the wedge bronchoplasty method. The patient was finally discharged without any remnant complications, but this case emphasized to us the importance of the basic principle of the VATS procedure, namely always rechecking the placement of the stapler before firing, regardless of the operative technique. As mentioned in a previous study, the uniportal VATS technique for major lung resection should be learned and performed carefully, especially during the initial period of the learning curve [12].

The safety and feasibility of uniportal VATS lobectomy have been reported in previous studies. Some authors have reported using a uniportal VATS approach in most of their pulmonary resection cases [9, 10, 20]. Also, it is reported that the advantages of uniportal approach are not confined only for the patients, but also for the surgeons. Unlike in conventional VATS approach, which creates the torsional angle, it is reported to allow the surgeons to see the operative field in a more anatomical and direct view which allows a better instrumentation by bimanual instrumentation just like in the open approach [21]. We agree that it is technically possible for a surgeon experienced in VATS to perform most pulmonary resections with a uniportal VATS approach. However, despite the worldwide trend towards minimally invasive approaches, uniportal VATS approach should not be considered as a necessary requisite, but should rather be viewed as an alternative, less-invasive procedure that can be performed safely and effectively when the patient is carefully selected and preparation is adequate.

The retrospective nature of the study, the absence of evaluation of postoperative pain, paraesthesia, or perioperative pulmonary function, short postoperative follow-up period, and the lack of data regarding survival and recurrence are limitations of this study. Our results should therefore be interpreted with caution. However, uniportal VATS lobectomy does appear to be comparable to with conventional VATS lobectomy from a technical perspective, especially in patients with early peripheral lung cancers with good anatomy and without tight pleural adhesions. And also, this is the first report to directly compare the perioperative clinical outcomes of the uniportal and conventional VATS approaches. We also provided information regarding the indications and complications that surgeons may experience during the initial period of implementing a uniportal VATS approach.

In conclusion, we found that perioperative outcomes of uniportal VATS lobectomies were favourable. Given that most cases were clinical and pathological stage I, a uniportal VATS approach should be carefully considered as an alternative to the conventional VATS approach especially in simple lobectomy patients with early peripheral lung cancers who have a good anatomy and are in good general condition.

Conflict of interest: none declared.

REFERENCES

[1] Naidoo R, Windsor MN, Goldstraw P. Surgery in 2013 and beyond. J Thorac Dis 2013;5:S593–606.
[2] Ugo C, Matilde De S, Alessandro B. Is video-assisted thoracic lobectomy safe and successful for locally advanced non-small cell lung cancer? J Thorac Cardiovasc Surg 2013;146:1302–03.
[3] Villamizar NR, Darrabie M, Hanna J, Onaitis MW, Tong BC, D'Amico TA *et al*. Impact of t status and n status on perioperative outcomes after thoracoscopic lobectomy for lung cancer. J Thorac Cardiovasc Surg 2013;145: 514–20; discussion 20–1.
[4] Iwata H. Minimally invasive pulmonary surgery for lung cancer, up to date. Gen Thorac Cardiovasc Surg 2013;61:449–54.
[5] Swanson SJ, Herndon JE II, D'Amico TA, Demmy TL, McKenna RJ Jr, Green MR *et al*. Video-assisted thoracic surgery lobectomy: report of calgb 39802—a prospective, multi-institution feasibility study. J Clin Oncol 2007; 25:4993–7.
[6] Rocco G. One-port (uniportal) video-assisted thoracic surgical resections—a clear advance. J Thorac Cardiovasc Surg 2012;144:S27–31.

[7] Jutley RS, Khalil MW, Rocco G. Uniportal vs standard three-port vats technique for spontaneous pneumothorax: comparison of post-operative pain and residual paraesthesia. Eur J Cardiothorac Surg 2005; 28:43–6.
[8] Tam JK, Lim KS. Total muscle-sparing uniportal video-assisted thoracoscopic surgery lobectomy. Ann Thorac Surg 2013; doi:10.1016/j.athoracsur.2013.07.002.
[9] Gonzalez-Rivas D, Delgado M, Fieira E, Mendez L, Fernandez R, de la Torre M. Uniportal video-assisted thoracoscopic pneumonectomy. J Thorac Dis 2013;5:S246–52.
[10] Gonzalez-Rivas D, Delgado M, Fieira E, Pato O. Left lower sleeve lobectomy by uniportal video-assisted thoracoscopic approach. Interact CardioVasc Thorac Surg 2014;18:237–9.
[11] Gonzalez-Rivas D. Vats lobectomy: surgical evolution from conventional vats to uniportal approach. Sci World J 2012;2012:780842.
[12] Gonzalez-Rivas D, Fieira E, Delgado M, Mendez L, Fernandez R, de la Torre M. Uniportal video-assisted thoracoscopic lobectomy. J Thorac Dis 2013;5:S234–45.
[13] Gonzalez-Rivas D, Paradela M, Fernandez R, Delgado M, Fieira E, Mendez L *et al*. Uniportal video-assisted thoracoscopic lobectomy: two years of experience. Ann Thorac Surg 2013;95:426–32.
[14] Kamiyoshihara M, Nagashima T, Igai H. The indications for uniportal video-assisted thoracic surgery. Ann Thorac Surg 2012;93:1398. author reply 98–9.
[15] Rocco G, Brunelli A, Jutley R, Salati M, Scognamiglio F, La Manna C *et al*. Uniportal vats for mediastinal nodal diagnosis and staging. Interact CardioVasc Thorac Surg 2006;5:430–2.
[16] Rocco G, Khalil M, Jutley R. Uniportal video-assisted thoracoscopic surgery wedge lung biopsy in the diagnosis of interstitial lung diseases. J Thorac Cardiovasc Surg 2005;129:947–8.
[17] Rocco G, Martin-Ucar A, Passera E. Uniportal vats wedge pulmonary resections. Ann Thorac Surg 2004;77:726–8.
[18] Rocco G, Martucci N, La Manna C, Jones DR, De Luca G, La Rocca A *et al*. Ten-year experience on 644 patients undergoing single-port (uniportal) video-assisted thoracoscopic surgery. Ann Thorac Surg 2013;96:434–8.
[19] Salati M, Brunelli A, Rocco G. Uniportal video-assisted thoracic surgery for diagnosis and treatment of intrathoracic conditions. Thorac Surg Clin 2008;18:305–10, vii.
[20] Gonzalez-Rivas D, Delgado M, Fieira E, Mendez L. Single-port video-assisted thoracoscopic lobectomy with pulmonary artery reconstruction. Interact CardioVasc Thorac Surg 2013;17:889–91.
[21] Bertolaccini L, Rocco G, Viti A, Terzi A. Geometrical characteristics of uniportal VATS. J Thorac Dis 2013;5:S214–6.