


ORIGINAL ARTICLE

Uniportal video-assisted thoracoscopic left pneumonectomy: Retrospective analysis of eighteen consecutive patients from a single center

Jiagen Li , Qi Xue, Yushun Gao, Yousheng Mao, Jun Zhao & Shugeng Gao

Department of Thoracic Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China

Keywords

Lung cancer; pneumonectomy; safety; uniportal; video-assisted thoracoscopic surgery.

Correspondence

Shugeng Gao, Department of Thoracic Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Panjiayuananli No. 17, Chaoyang District, 10021 Beijing, China. Tel: +86 10 8778 7150 Fax: +86 10 6771 3359. Email: saintfisk@163.com

Received: 3 September 2020;

Accepted: 16 October 2020.

doi: 10.1111/1759-7714.13728

Thoracic Cancer **12** (2021) 324–328

Abstract

Background: Uniportal video-assisted thoracoscopic surgery (VATS) is being more widely used in lung cancer, yet reports on its application in pneumonectomies are limited. This study aimed to evaluate the safety and feasibility of uniportal video-assisted thoracoscopic left pneumonectomy for lung cancer.

Methods: A series of 18 lung cancer patients who had received uniportal video-assisted thoracoscopic left pneumonectomies were included in the study. Their clinical, pathological, and surgical features, as well as postoperative recovery, were analyzed.

Results: The majority of the patients were male and smokers and their average age was 62.0 ± 8.9 years. All had primary lung cancer, while three (16.7%) had received neoadjuvant therapy. A total of 16 (88.9%) patients had stage II–III disease, with an average tumor size of 3.6 ± 1.5 cm. The average surgery time was 137.4 ± 47.0 minutes, with a 16.7% (3/18) conversion rate. The mean blood loss was 37.5 ± 59.4 mL and no patients needed blood transfusion during, or after, surgery. There was no perioperative death and the overall complication rate was 22.2% (4/18). Two (11.1%) patients needed to stay in the intensive care unit after surgery, and the average length of hospital stay after surgery was 6.3 ± 1.1 days (range 4–7 days).

Conclusions: Uniportal video-assisted thoracoscopic left pneumonectomy is a safe and feasible procedure for selected lung cancer patients. The use of uniportal VATS in right pneumonectomies and the effect of uniportal video-assisted thoracoscopic pneumonectomy on the survival of patients merits further study.

Patients receiving uniportal VATS pneumonectomies had standard surgical results and recovery. Uniportal VATS pneumonectomy is safe for properly selected lung cancer patients.

Key points

Significant findings of the study

- Patients receiving uniportal VATS left pneumonectomies had standard surgical results and recovery.

What this study adds:

- Uniportal VATS left pneumonectomy is safe for properly selected lung cancer patients.

Introduction

Lung cancer ranks as the world's most prevalent and deadly malignancy.¹ Surgical resection is the primary treatment strategy for resectable non-small cell lung cancer (NSCLC).² With the development of bronchus and vessel plasticity techniques and the growing trends of early stage diseases, the use of pneumonectomy is becoming increasingly limited for the surgical treatment of lung cancer.^{3,4} However, for patients with centrally located tumors infiltrating the main trunk of vessels or airways, tumors that invade multiple lobes, or multiple tumors in different lobes, pneumonectomy has to be performed when none of the parenchyma-sparing procedures offer radical resection.^{4,5}

Since its initiation over 20 years ago, video-assisted thoracoscopic surgery (VATS) has been accepted as the standard treatment for early stage lung cancer and is being used more and more in advanced diseases.^{2,6,7} With advances and refinements in surgical equipment and techniques, uniportal VATS, in which all the instruments and camera use a single incision, has developed significantly during the past decade.^{8,9} Uniportal VATS has been found by published studies to have advantages over open and multiportal VATS procedures in various aspects.¹⁰⁻¹²

Pneumonectomy is a major surgical procedure associated with high mortality and morbidity.¹³ It is also challenging for surgeons due to centrally located, large tumors invading hilar vessels, obstructive inflammation, and with a higher risk of bleeding. There have been some previously reported studies on series of multiportal VATS pneumonectomies.¹⁴⁻¹⁶ However, according to our knowledge, the reports on uniportal VATS pneumonectomies have not gone beyond case reports or video presentations.^{4,5,17} In the current study, we present a series of pneumonectomies done by uniportal VATS in our center and investigate the safety and feasibility of uniportal VATS in this complex and challenging procedure.

Methods

All patients who had received a uniportal VATS pneumonectomy in the National Cancer Center, Cancer Hospital, Chinese Academy of Medical Sciences (CHCAMS) from June 2015 to October 2019 were included in the study. An intent-to-treat analysis was done so that patients who underwent conversions to multiportal VATS of open surgeries were also included. The demographic, clinical, pathological, surgical, and recovery data were obtained electronically from medical records, pathological examinations, and surgical records. This study was approved by the Medical Ethics Committee of CHCAMS. Written informed consent was obtained from each patient before surgery.

Preoperative evaluation

Preoperative assessments of the patients included in the study were similar to those for lobectomy, including complete blood count, biochemical profiles, enhanced chest computed tomography (CT) scan, positron emission tomography CT (PET-CT) scan, pulmonary functional test, electrocardiogram, and bronchoscopy. Exercise electrocardiogram, coronary angiography, and 24 hour dynamic electrocardiogram were performed in selected patients. All patients had been diagnosed with malignancy before surgery.

Surgical techniques

All patients underwent a left pneumonectomy. The surgeries were performed with the patients placed in the right lateral decubitus position under double lumen general anesthesia. A 3–5 cm incision was made between the posterior and middle axillary line in the fourth or fifth intercostal space according to the preference of the surgeon. A wound protector was used without rib-spreading. A high definition, 10 mm, 30-degree thoracoscope was placed through the posterior part of the incision, and all the instruments, including the stapler, were used through the anterior part of the incision. Long, biarticulated VATS instruments were routinely used. An electrocoagulation hook or ultrasonic scalpel and a long curved suction device were also applied for vessel and bronchus division and lymph node dissection.

After exploring the pleural cavity to rule out possible metastasis, the lung was retracted posteriorly and inferiorly to expose and dissect the anterior mediastinal pleura. The superior pulmonary vein and main pulmonary artery were divided and the hilum and upper mediastinal lymph nodes were removed. The inferior pulmonary vein was then divided after dissecting the pulmonary ligament. The vessels were cut by vascular endostaplers. The main bronchus was mostly divided after transection of all the vessels and removal of mediastinal lymph nodes for better exposure. The bronchus was transected as proximal as possible with an endostapler or liner stapler. The resected left lung was then put into a tissue retrieval bag and taken out through the incision. A chest tube was placed through a muscle tunnel at the posterior part of the incision.

Statistical analysis

Quantitative variables are presented as mean with standard deviation (SD) and categorical variables by number with percentage.

Results

Between June 2015 and October 2019, 18 patients received uniportal VATS left pneumonectomy in our center. The detailed data for all the patients is listed in Appendix S1.

Demographic and clinical features

The demographic and clinical characteristics of the patients are shown in Table 1. In summary, the majority of the patients were male, smokers, with a mean age of 62.0 ± 8.9 years (range 36–73 years). All of the patients were found to have malignant tumors before surgery either by bronchoscopy or by core needle biopsy. Among the three patients who had undergone neoadjuvant therapy, two received chemotherapy and one received chemotherapy + immunotherapy. Surgeries were performed 4–6 weeks afterwards. The indication for pneumonectomy in all patients, except one, was a centrally localized tumor invading the main vessels or bronchus. Preoperative comorbidities were found in half (9/18) of the patients. Among these patients, hypertension was observed in seven, diabetes mellitus in three, hepatitis B in two, coronary artery disease in one arrhythmia in one, and ischemic stroke in one (Table 2).

Pathological characteristics

We next evaluated the postoperative pathological findings of the patients. Almost 90% of patients had centrally localized squamous cell carcinoma. The average tumor size was 3.6 ± 1.5 cm (range: 1.5–6.5 cm). The majority of the patients had locally advanced carcinoma (TNM stage II and III: 16 [88.9%] patients) with lymph node metastasis (14 [77.8%] patients) (Table 3).

Table 1 Demographic and clinical features of the patients ($n = 18$)

Feature	Number
Age (year), average (SD)	62.0 (8.9)
Gender (male)	17 (94.4%)
Tobacco use (yes)	15 (83.3%)
Family history [†] (yes)	6 (33.3%)
Neoadjuvant therapy (yes)	3 (16.7%)
Tumor location	
LUL	8 (44.4%)
LLL	6 (33.3%)
LUL + LLL	1 (5.6%)
Left main bronchus	3 (16.7%)
Indication for pneumonectomy	
Tumor invading hilum	17 (94.4%)
Multiple tumors in both LUL & LLL	1 (5.6%)
Comorbidities (yes)	9 (50.0%)

[†]Family history of cancer. LLL, left lower lobe; LUL, left upper lobe.

Table 2 Preoperative comorbidities ($n = 9$)

Patient ID	Comorbidities
UVP3	DM, hepatitis B
UVP5	HTN
UVP6	HTN, hepatitis B
UVP7	HTN
UVP12	HTN
UVP13	HTN, DM
UVP14	HTN, DM, CHD, arrhythmia
UVP16	HTN, DM
UVP13	Ischemic stroke

CHD, coronary heart disease; DM, diabetes mellitus; HTN, hypertension.

Surgery and surgical related features

We then assessed the safety and feasibility of the procedure by analyzing the surgical features of the cases. Among the 18 patients, one was converted to three-port VATS, while two were converted to thoracotomy, resulting in a conversion rate of 16.7% (Table 4). The reason for conversions of the case converted to three-port VATS and the case converted to thoracotomy was difficulty in the division of the left main artery due to infiltration of tumor. The other conversion to open surgery was for intensive adhesions. The average duration of surgery was less than two and a half hours. The mean volume of blood loss was less than 37.5 ± 59.4 mL (range: 10–200 mL) and none of the cases needed in or postoperative blood transfusion, indicating safety of the procedure. On average, 8.9 ± 1.3 (range: 6–11) stations of hilum and mediastinum lymph nodes were dissected with the number of resected lymph nodes

Table 3 Pathological characteristics of the patients ($n = 18$)

Features	Number
Subtype	
SCC	16 (88.9%)
ADC	2 (11.1%)
Tumor size (cm), average (SD)	3.6 (1.5)
T stage	
1	4 (22.2%)
2	7 (38.9%)
3	5 (27.8%)
4	2 (11.1%)
N stage	
0	4 (22.2%)
1	8 (44.4%)
2	6 (33.3%)
TNM stage	
I	2 (11.1%)
II	5 (27.8%)
III	11 (61.1%)

ADC, adenocarcinoma; SCC, squamous cell carcinoma.

Table 4 Surgery related features of the cases ($n = 18$)

Feature	Number
Place of incision	
Fourth intercostal	6 (33.3%)
Fifth intercostal	12 (66.7%)
Conversion (yes)	3 (16.7%)
Surgical duration (minutes), average (SD)	137.4 (47.0)
Blood loss (mL), average (SD)	37.5 (59.4)
Station of LND, average (SD)	8.9 (6–11)
Number of LND, average (SD)	24.9 (7.6)

LND, lymph node dissection.

being 24.9 ± 7.6 (range: 17–41) (Table 4), which shows the efficacy of lymph node clearance of uniportal VATS.

Postoperative recovery of patients

The safety of uniportal VATS pneumonectomy was further evaluated by analyzing the patients' postoperative recovery. There was no unplanned return to the operating room or death within three months among the 18 patients in the study. Two patients needed to stay in the intensive care unit after surgery and the overall complication rate was 22.2% (Table 5). Of the four patients who had complications, three had cardiac arrhythmia while the other patient had an infection of the incision. The average thorax drainage volume after surgery was 490.0 ± 421.9 mL (range 110–1650 mL) and the mean time of chest tube removal was 5.6 ± 1.3 days (range 4–7 days) after surgery (Table 5). All patients were discharged within one week after surgery with the average postoperative length of stay being 6.3 ± 1.1 days (range 4–7 days) (Table 5). These results confirm the standard recovery of patients after surgery and indicate the safety of the procedure.

Discussion

In the current study, we detail the clinicopathological and surgical related characteristics of 18 patients with primary lung cancer who received uniportal VATS left pneumonectomies. The reasonable surgical features and standard

Table 5 Postoperative recovery of the patients ($n = 18$)

Feature	Number
Stay in ICU (yes)	2 (11.1%)
Complication (yes)	4 (22.2%)
Drainage volume (mL), average (SD)	490.0 (421.9)
Time of chest tube removal (day) [†] , average (SD)	5.6 (1.3)
Postoperative LOS (day), average (SD)	6.3 (1.1)

[†]Including the day of surgery. ICU, intensive care unit; LOS, length of stay.

postoperative recovery of the patients have shown the safety and feasibility of uniportal VATS pneumonectomy for the treatment of lung cancer in selected patients.

Pneumonectomy can be quite a challenging procedure in many cases, even by thoracotomy. To date, the publications on uniportal VATS pneumonectomy are limited.^{4,5,17} Based on our understanding, this study is the summary of the largest case series of uniportal VATS pneumonectomy thus far.

Uniportal VATS for the treatment of lung cancer is now being used more and more widely and has developed at a fast rate. A growing number of experienced thoracic surgeons are using it in advanced, complicated diseases.^{9,18,19} Uniportal VATS has been found to be superior to open surgery and multiportal VATS, especially with regard to the postoperative recovery of patients.^{10–12} Thus, the results of our study are important, as they show the safety of using uniportal VATS in left pneumonectomy and may provide benefits to this specific group of patients should it become more accepted in the field.

It is critical to note that pneumonectomy is a high risk procedure associated with higher rates of morbidity and mortality compared to other lung resections.^{5,13} Thus, risk assessment before surgery and risk control during surgery are fundamental for the safety of patients. Uniportal VATS pneumonectomies are performed only in selected patients under careful evaluation and consideration of factors including patient status, tumor size, position, lymph nodes, hilum structures, etc. To perform uniportal VATS pneumonectomies, a surgeon must be experienced in both uniportal VATS lobectomies and thoracotomy pneumonectomies. The 18 surgical procedures in this study were accomplished by five of the senior surgeons with the largest volume of surgeries in our center. In case of unexpected situations, such as intensive adhesions, difficulties in division of the vessels or bronchus, or bleeding, conversion without hesitation is critical for the safety of patients.

Although neoadjuvant therapy may bring extra difficulties and risk, surgeries after induction therapy have been proven to be safe and effective in several previously published studies.^{20–22} Our study has provided similar results. The three patients who underwent neoadjuvant therapy had equally standard surgical and recovery results as the other patients, indicating that uniportal VATS pneumonectomy is a reasonable option for patients after induction therapy.

All the cases in the study were left pneumonectomies, as right pneumonectomies are used very sparingly in our center and only for very extraordinary cases. Thus, our study has an important limitation in that it only covers patients who underwent left pneumonectomy. Additionally, the survival of the patients has not been reported in the study because many of the cases were performed within one year. Thus, long-term survival results are currently unavailable. Therefore, the use of uniportal VATS for

right pneumonectomies and the effect on the survival of patients still requires further assessment.

In conclusion, the clinicopathological and surgical related features for 18 cases of uniportal VATS pneumonectomies are summarized here and a reasonable surgery time, conversion rate, blood loss, and lymph node dissection were observed in our study. All patients had standard recovery with acceptable complications. Our results showed that uniportal VATS pneumonectomy is safe and feasible for the surgical treatment of selected lung cancer patients.

Acknowledgments

This work was supported by the Beijing Hope Run Foundation (LC2017B24), Fundamental Research Funds for the Central Universities (2017PT32001), and the CAMS Innovation Fund for Medical Sciences (2017-I2M-1-005).

Disclosure

The authors report no conflict of interest to disclose.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1. Clinical and Surgical Data for the Eighteen Patients that have Received Pneumonectomy.