

Technical Aspects And Early Results of Uniportal Video-Assisted Thoracoscopic Complex Segmentectomy: A 30 Case-Series Study

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Technical aspects and early results of uniportal video-assisted thoracoscopic complex segmentectomy: a 30 case-series study

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Abstract

Background. With the advantages of better cosmetic incision and faster recovery, uniportal video-assisted thoracoscopic surgery (UP-VATS) has developed rapidly worldwide in recent decades and indications for UP-VATS were further expanded as those for conventional VATS. Complex segmentectomy that makes several, or intricate intersegmental planes, with more a complex procedure, continues to be a difficulty in minimally invasive techniques. However, there are few reports as yet on UP-VATS complex segmentectomy. In this report, we describe the perioperative clinical data and operative techniques and present our early results of UP-VATS complex segmentectomy in our hospital.

Methods. The records of a total of 30 patients who underwent UP-VATS complex segmentectomy by a single surgeon between January 2021 and June 2021 were retrospectively reviewed. We defined cases as complex segmentectomy if they required resection of segment 9, 10, combined segmentectomy, segmentectomy+subsegmentectomy, subsegmentectomy, or combined subsegmentectomy.

Results. The mean age was 52.8 ± 9.9 years old; mean nodule size was 0.84 ± 0.36 cm; the mean margin width was 2.307 ± 0.309 cm; median operative time was 229.0 ± 58.06 minutes; mean operative hemorrhage was 56.60 ± 17.95 mL; 5.58 ± 1.74 lymph nodes dissected had not metastasized; mean duration of postoperative chest tube drainage was 4.7 ± 1.4 days; and mean postoperative hospital stay was 6.5 ± 3.0 days. Although 1 patient experienced a prolonged air leak, the other 29 recovered uneventfully. Another patient failed to reach the 2cm safe margins who received completion lobectomy later.

Conclusions. UP-VATS complex segmentectomy is a safe and effective procedure in the treatment of lung cancers, sparing more pulmonary parenchyma and ensuring safe margins, the disadvantage being lengthy operative times during early acquisition of skills.

Keywords: Uniportal video-assisted thoracic surgery; complex segmentectomy; subsegmentectomy; three dimensional computed tomography.

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Introduction

For benign lesion and ground glass opacity (GGO) –dominant early stage lung cancer, the current trend is precise resection with sufficient surgical margin and more preservation of pulmonary function[1][2][3][4]. Anatomic segmentectomy in treating early stage non–small cell lung cancer (NSCLC) is chosen more frequently because of the same oncological outcomes as lobectomy and a sufficient surgical margin[5][6].

A study based on high–resolution computed tomography reported that more than 33% of c–T1aN0M0 pulmonary nodules involved multiple segments[7]. To ensure an adequate surgical margin, complex segmentectomy has been applied in certain clinical circumstances. Complex segmentectomy creates several, or intricate intersegmental planes, with more a complex procedure[7][8][4][9]. Currently, few articles have addressed complex segmentectomy, a procedure that may be particularly challenged in the setting of UP–VATS, as the dexterity and fineness of instrument operation under UP–VATS are limited[10][11][12].

Our main goal is to evaluate the technical feasibility of UP–VATS complex segmentectomy and to analyze the early clinical results of using this procedure.

Materials and methods

Patient Population

The Ethics Committee of Harbin Medical University Cancer Hospital approved this study because of the retrospective design. From January 2021 and June 2021, 30 UP–VATS complex segmentectomies were performed for benign lesion and ground glass opacity (GGO) –dominant early stage lung cancer by a team at the Thoracic Surgery Department of Harbin Medical University Cancer Hospital.

Complex segmentectomy was defined as segmental resection of the segment 9, 10, combined segmentectomy, segmentectomy+subsegmentectomy, subsegmentectomy, or combined subsegmentectomy.

All 30 patients fulfilled the followed criteria: (1) The maximum diameter of the pulmonary nodule detected on CT reconstruction lung window imaging was required to meet ≤ 2 cm with a $\geq 50\%$ ground glass opacity appearance on CT. (2) The lesion is far away from the visceral pleura, so wedge resection is difficult to ensure the safe margin. (3) Intraoperative frozen negative lymph nodes were found in 10, 11, 12 and 13, and the estimated margin width was ≥ 2 cm. (4) Compromise surgery or benign tumors may be involved.

Clinical data of patients undergoing UP–VATS complex segmentectomy were retrospectively reviewed on age, sex, resected region, operative time, operative blood loss, final pathologic diagnosis, duration of chest tube placement, hospitalization, intraoperative and postoperative complications. Each patient had undergone enhanced thin–section (1–mm) thoracic CT. The reconstruction software “Mimics” was used to reconstruct images of the pulmonary bronchi and blood vessels.

Operative Techniques

Complex segmentectomies were planned and performed under the guidance of 3D navigation. Tumor locations, segmental structures and all bronchi, arteries, and veins involved were confirmed. To achieve an adequate surgical margin, we designed the complex segmentectomy based on a nodule centered surgical planning with parenchymal resection margins ≥ 2 cm and subsegment as a surgical unit (Fig 1). An incision

about 3.0 cm in length was made at the 5th intercostal space between the anterior–axillary line and posterior–axillary line and protected with a wound retractor (Fig 2a,b). The specific location of the incision depends on the anatomic location of the hilar of the target segment. It is best to strive for a 45 degree angle between the operation angle of the surgical instrument and the hilar of the segment.

A electric hook with two curvature and ultrasonic scalpel were used for bronchovascular dissection and No. 10, 11, 12 and 13 lymph nodes sampling (Fig 3a,b). The target bronchus was transected using a stapler or Hem–o–lok (Fig 4). The target vessels can be stapled, ligated, or clipped according to the specific conditions. A modified “inflation–deflation” technique was used to identify the intersegmental border thereafter (Fig 5), enabling dissection of intersegmental planes using electrocautery, ultrasonic scalpel, or staple along the intersegmental veins (Fig 6). Air leak test was done, and fibrin glue was applied to reduce postoperative air leak. The margin width (from the resection margin to the nodule detected in the removed specimen) was measured by the surgeon intraoperatively (Fig 7).

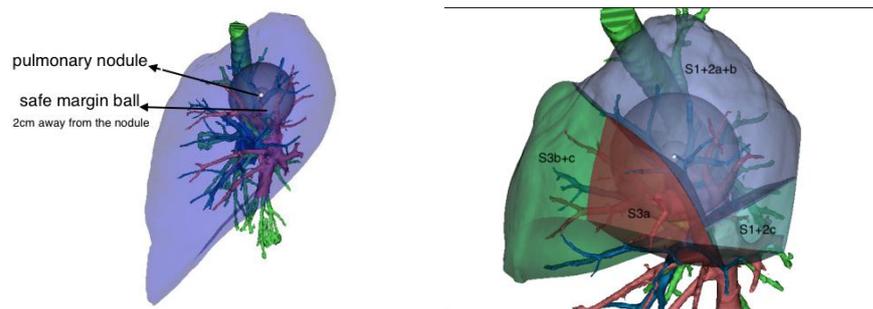


Figure 1 Complex segmentectomy based on a nodule centered surgical planning with parenchymal resection margins ≥ 2 cm and subsegment as a surgical unit with the guidance of three dimensional (3D) navigation.

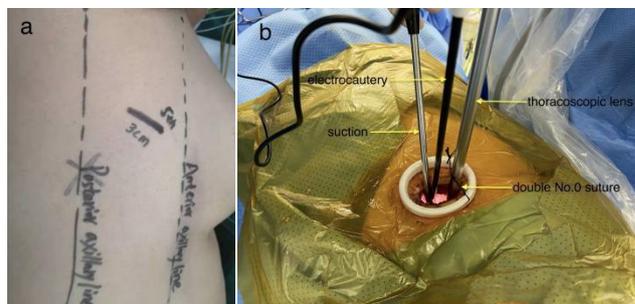


Figure (a) Body surface location of surgical incision. (b) Assistant stands on the opposite side of the operator and holds the thoracoscopic lens, which is limited by the double No.0 suture.

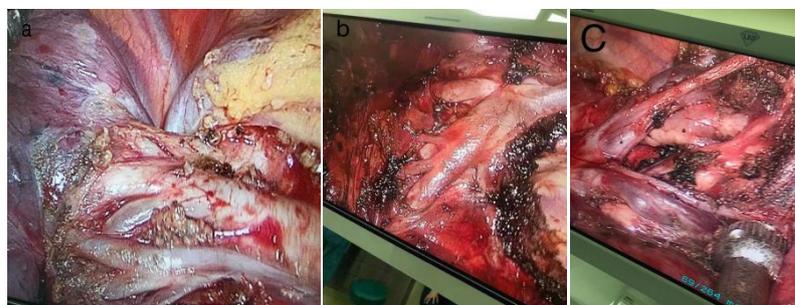


Figure 3 (a) Arteriovenous dissection and lymph nodes sampling of right upper lobe. (b) Arterial dissection and lymph nodes sampling of right lower lobe. (c) Bronchovascular dissection and lymph nodes sampling of left upper lobe.



Figure 4 The target bronchus was transected using a stapler or Hem-o-lok.

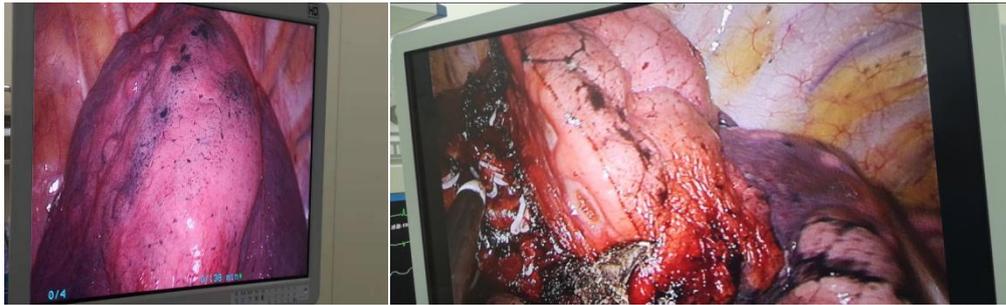


Figure 5 A modified "inflation-deflation" technique was used to identify the intersegmental border.

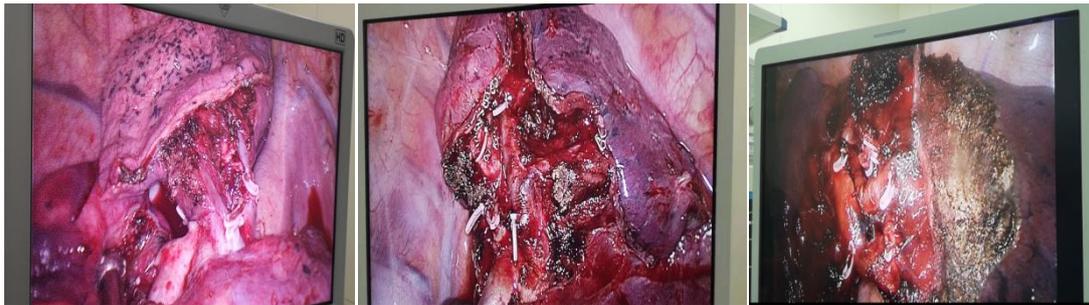


Figure 6 Combine application of energy devices and staplers to the management of intersegmental plane.



Figure 7 The safe margin width ≥ 2 cm.

Results

The clinical characteristics of the 30 patients (9 men and 21 women, mean age 52.8 ± 9.9 , range: 32–71 years), the details of the nodule locations and surgical procedures in this study are presented in Table 1. The mean nodule size was 0.84 ± 0.36 cm. The lesions were located in the right upper lobe (13, 43.3%), the left upper lobe (11, 36.6%), and the lower lobe (6, 20.0%).

Evaluation of intraoperative and postoperative factors were shown in Table 2. No patients required conversion to thoracotomy. Median operative time was 175 minutes (range, 75 to 294 minutes); mean operative hemorrhage was 56.60 ± 17.95 mL; 5.58 ± 1.74 lymph nodes dissected had not metastasized; mean duration of postoperative chest tube drainage was 4.7 ± 1.4 days; and mean postoperative hospital stay was 6.5 ± 3.0 days. Aside from one instance of prolonged air leak (>7 days), all patients recovered uneventfully. Another patient failed to reach the 2cm safe margins who received completion lobectomy later. No deaths occurred. The tumor pathological diagnoses included: invasive adenocarcinoma (10 cases), minimally invasive adenocarcinoma (9 cases), adenocarcinoma in situ (6 cases), atypical adenomatous hyperplasia (3 cases), and benign (2 cases).

Table 1 Clinical characteristics of the patients, nodule locations and surgical procedures

Factor	Complex Segmentectomy
Age	
Mean (range)	52.8±9.9 (32–71 years)
Gender	
Male	9
Female	21
Mean nodule size (cm)	0.84±0.36
Nodule location	
RUL	13
S ¹ +S ² a	3
S ² +S ³ a	1
S ³ +S ¹ b	3
S ¹ +S ² +S ³ a	1
S ¹ b	1
S ³ b	1
S ² b+S ³ a	2
S ¹ +S ² +S ³ ai+bi	1
LUL	11
S ¹⁺²	1
S ¹⁺² a+b	2
S ¹⁺² a+b+S ³ c	2
S ¹⁺² b	1
S ¹⁺² c+S ³ a+b	1
S ¹⁺² c+S ² a	1
S ³ +S ¹⁺² a	2
S ² a+S ⁴ a	1
RLL	2
S ⁶ b+S ⁸ a+S ⁹ a	1
S ¹⁰	1
LLL	4
S ⁶ +S ⁹ a	1
S ⁸ a+S ⁹ a	1
S ⁷ +S ⁸	1
S ⁹ +S ¹⁰	1

RUL, right upper lobe; LUL, left upper lobe; RLL, right lower lobe; LLL, left lower lobe.

Table 2 Evaluation of intraoperative and postoperative factors

Factor	Complex Segmentectomy
Mean margin width (cm)	2.307±0.309
Average operative duration (minutes)	229.0±58.06
Operative hemorrhage (mL)	56.60±17.95
Number of lymph nodes dissected	5.58±1.74
Duration of postoperative chest tub drainage (days)	4.7±1.4
Postoperative hospital stay (days)	6.5±3.0
Pathological diagnoses	
Benign	2
AAH	3
AIS	6
MIA	9
IAC	10

AAH, atypical adenomatous hyperplasia; AIS, adenocarcinoma in situ; IAC, invasive adenocarcinoma; MIA, minimally invasive adenocarcinoma.

Discussion

Segmentectomy could be subdivided into simple and complex segmentectomy according to condition of the intersegmental boundaries[8]. The ability to obtain a ≥ 2 cm safe surgical margin is the key factor that makes complex segmentectomy superior to simple segmentectomy[7][13][11]. With the use of reconstruction software “Mimics”, we designed the complex segmentectomy based on a nodule centered surgical planning with parenchymal resection margins ≥ 2 cm and subsegment as a surgical unit.

In our study, the margin width (2.307 ± 0.309 cm) met the surgical requirement, except one patient who received completion lobectomy later. The advantage of complex segmentectomy is achieving a sufficient margin for the great majority of nodules.

It is generally considered that it can be more difficult to divide complex segments when instruments are operated in a single direction or are limited by angle changes in UP-VATS[14][15][11]. However, with accumulated experience and familiarity with anatomy and operation techniques, the UP-VATS complex segmentectomy could be performed safely[15][16][17]. The following tips of technical aspects can help if we have some difficulties during the UP-VATS complex segmentectomy.

1. Further dissect the segmental hilar structures

It is important to dissect the surrounding lung parenchyma and lymph nodes away from the root of target segmental bronchus and vessels as completely as possible so that the bronchovascular bundle can be further identified in targeted segments.

2. Apply rotatable stapler and adjust the angle by pulling the lung

It is better to staple target segmental blood vessels and bronchi with rotatable stapler and adjust the angle by pulling the lung to compensate the limitation in access angle for stapler. However, when segmental hilar structures are right below the field of vision, stapler is difficult to be applied. In this case, the better choice is ligation and clipping directly.

3. Combine application of energy devices and staplers to the management of intersegmental plane

It is better to directly use electrocautery or ultrasonic scalpel to separate the inflation–deflation interface along the intersegmental veins up to the outer one third of the pulmonary parenchyma. Once the distal stumps of transected bronchus and vessels are dragged distantly from the hilum, the residual intersubsegmental parenchyma is tailored by staplers easily. This method can keep the residual lung extending and reduce air leakage.

In our study, 1 patient experienced a prolonged air leak and stayed in hospital for 20 days after operation. Air leakage was one of the major complications after segmentectomy[18]. The main causes of air leakage are: ① injury of visceral pleura when dissecting segmental vessels, bronchus and lymph nodes; ② injury of pulmonary parenchyma when energy devices are used to the management of intersegmental plane; ③ air leakage at nail holes of stapler in patients with emphysema; ④ Injury of bronchus. In order to reduce the occurrence of postoperative air leakage, it is necessary to separate the inflation–deflation interface along the intersegmental veins when separating the intersegmental plane. If bronchial injury is found, it must be sutured and repaired.

Preoperative 3D lung reconstruction can clarify the anatomical structures, pre-judge the variations and plan the surgical approach. Realtime 3D navigation can clearly identify the targeted bronchi and vessels and localize the nodules, which improves the accuracy of the surgical technique[19][20].

The study has several limitations. First, this was a single institute, retrospective review. Second, the sample size was small, so statistical analysis was not robust. Finally, definition of complex segmentectomy continues to be controversial. With the improvement of surgical experience and techniques, it is easy to

resect the lung segments with their own anatomical structure except the segment 9, 10. So we propose our own definition of complex segmentectomy, which makes several intersegmental planes or involves multiple target bronchi, arteries and veins. Our sample was limited and did not fully reflect the complexity of complex segmentectomy. More various resection methods for complex segmentectomy should be assessed further in future studies.

Conclusion

In conclusion, our limited experience indicates that UP–VATS complex segmentectomy is a safe and effective procedure in experts' hands, sparing more pulmonary parenchyma, ensuring safe margins and providing the benefit of minimal invasiveness.

Abbreviations

VATS: Video–Assisted Thoracoscopic Surgery; UP–VATS: uniportal video–assisted thoracoscopic surgery; GGO: ground glass opacity; CT: Computer Tomography; 3D: three dimensional; RUL: right upper lobe; LUL: left upper lobe; RLL: right lower lobe; LLL: left lower lobe; AAH: atypical adenomatous hyperplasia; AIS: adenocarcinoma in situ; MIA: Minimal Invasive Adenocarcinoma; IAC: Invasive Adenocarcinoma.

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None.

Authors' contributions

Hai Xu contributions to the conception and design of the work. Xianglong Kong contributions to the acquisition, analysis, interpretation of data and the drafting and revision of the work. Jun Lu contributions to the interpretation of data. The other authors read and approved the final manuscript.

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Availability of data and materials

The data and materials during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The Ethics Committee of Harbin Medical University Cancer Hospital approved this study because of the retrospective design. All patients obtained written consent on surgical technology and data use agreement before surgery.

Consent for publication

Consent form from Harbin Medical University Cancer Hospital was obtained from patients included in the research.

Competing interests

No authors report any conflict of interest.

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