Original Article

Uniportal video-assisted thoracic surgery basal segmentectomy: a single-center retrospective cohort study

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Background: Uniportal video-assisted thoracic surgery (VATS) basal segmentectomy is technically challenging and requires a deep understanding of the segmental anatomy of the lung. This report describes the uniportal VATS segmentectomy of basal segments using a single-direction approach.

Methods: A total of 49 patients who underwent uniportal VATS basal segmentectomy between April 2019 and April 2021 were included in this retrospective study. All the surgeries were conducted using a single-direction approach. The resections of segments 7–8 were mainly performed using the interlobar fissure approach, while the resections of segments 9–10 were performed using the inferior pulmonary ligament approach.

Results: A total of 33 patients underwent a single basal segmentectomy and 16 patients underwent combined basal segmentectomy/sub-segmentectomy. The median operative time was 120 min (range, 60–180 min), and the median blood loss was 20 mL (range, 10–100 mL). The median chest tube duration was 2 days (range, 1–5 days), and the median hospital stay after surgery was 4 days (range, 2–15 days). The morbidity rate after surgery was 6.1% (3/49). There were no perioperative deaths. The pathological examinations revealed 3 cases of adenocarcinoma in situ (AIS), 33 cases of minimally invasive adenocarcinoma, and 13 cases of lepidic-predominant invasive adenocarcinoma. No recrudescence or mortality was reported during the median follow-up time of 7 months (range, 2–25 months).

Conclusions: Uniportal VATS basal segmentectomy is a feasible and reliable technique based on our experience. This single-direction method allows the uniportal VATS basal segmentectomy to be performed in an easy manner with the targeted segmental bronchi and vessels exposed from superficial to deep in order of their appearance while avoiding the repeated turnover of the lung.

Keywords: Segmentectomy; lung cancer; uniportal; video-assisted thoracic surgery (VATS); single-direction

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Introduction

Intentional lung sparing resection, such as anatomic segmentectomy, is increasingly indicated for ground-glass opacity (GGO) dominant lung cancer and comparable long-term outcomes can be achieved (1-6). Since the earliest report of uniportal video-assisted thoracic surgery (VATS) segmentectomy published by Gonzalez-Rivas in 2012 (7), the feasibility and the potential advantages of uniportal VATS segmentectomy have been examined by various surgical groups worldwide (8-10). Basal segmentectomies (of segments 7–10) are much more technically challenging than other kinds of segmentectomies because, due to the deeper hilar structures, more frequent variations, and more complex intersegmental planes, the surgeon has to identify dominant pulmonary vein branches located deep in the lung parenchyma and find simpler methods (11). Consequently, reports on VATS anatomical basal segmentectomies are limited by small sample sizes and those performed using the uniportal approach are even more limited (12-17).

During VATS lobectomy, we developed the fissureless technique of single-direction, which exposes the targeted bronchi and vessels from the superficial to deep based on the order of their appearance while avoiding the dissection of a hypoplastic fissure or the inessential splitting of the lung parenchyma (18). VATS segmentectomy can be considered as a micro lobectomy with hypoplastic fissures. Therefore, we transferred this technique into segmentectomy and found that it enabled the anatomic resection of basal segments to be performed in a simple manner. We also improved the stem-branch method, enabling the simple and accurate tracking of the target structures (19,20). We previously reported the most extensive cohort study of VATS basal segmentectomies worldwide (21). With the accumulative experience, we applied this method to the uniportal VATS basal segmentectomy. This study sought to report our experiences of uniportal VATS anatomic basal segmentectomy using the single-direction method and to verify the feasibility of this method based on an initial 49 cases. We present the following article in accordance with the STROBE reporting checklist (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-651/rc).

Methods

Patients

Between April 2019 and April 2021, a total of 49 patients underwent uniportal VATS basal segmentectomy using the single-direction strategy at department of thoracic surgery, West China hospital. The data of the patients were prospectively gathered and retrospectively reviewed. Informed written consent was obtained from each patient for the surgery and the publication of the study data. The protocol of this study was approved by the Institutional Review Board of West China Hospital (No. 2021-871) and conducted according to the Helsinki Declaration (as revised in 2013).

Selection criteria

To be eligible for inclusion in this study, the patients had to be candidates for basal segmentectomy with a ≤2 cm pure or part-solid GGO that was suspected to be malignant. At our center, patients with lesions ≤2 cm and a GGO ≥75% are sometimes chosen for intentional wedge resection. A safe surgical margin is considered >2 cm or at least more extensive than the maximum diameter of the tumor. In cases in which the tumor is located close to the intersegmental border, a combined segmentectomy and/or sub-segmentectomy was designed and performed. The 8th edition of the tumor, node, metastasis (TNM) staging system (22) and the newly proposed histologic classification system (23) were adopted for the surgical-pathologic staging and the histologic typing, respectively.

Operative procedure

Preoperative planning

The regular evaluations before surgery included a physical examination, cardiopulmonary function tests, blood tests, and imaging studies of the brain, upper abdomen, and the bone. Positron emission tomography/computed tomography (CT) was not suggested for patients with GGO lesions. Contrast-enhanced high-resolution computed tomography (HRCT) scans were performed for each

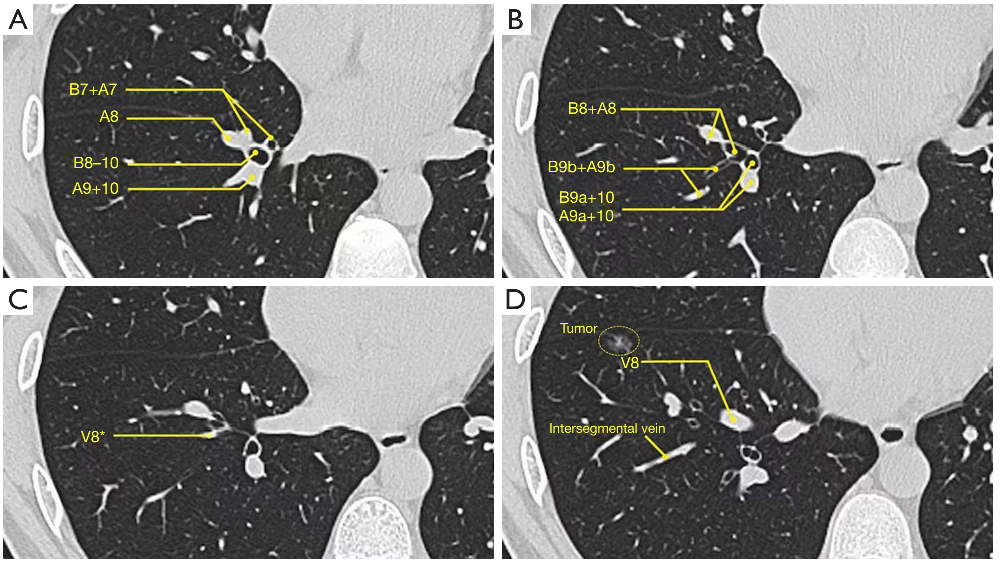
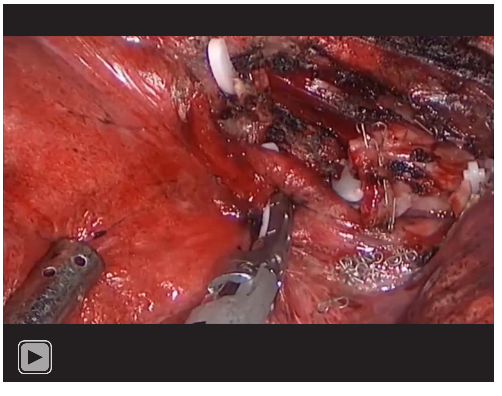


Figure 1 Identification of the target segmental bronchi and vessels and their positional characteristics (a right S8 segmentectomy as an example). (A) A8 runs just posterior to A7, while A9 and A10 have a common stem; (B) B8 and B9b have a common stem and B8 runs anterior to B9b; (C) identifying a small intrasegmental vein of V8*, V8 was the major drainage vein while V8* was a small branch; (D) identifying the main intrasegmental drainage vein of S8 (V8) and the intersegmental vein between S8 and S9.



Video 1 In this video, we used a right S8 segmentectomy as an example to depict the techniques of a uniportal video-assisted thoracic surgery (VATS) basal segmentectomy in detail.

patient. The location of the lesion was identified and the anatomic variations of the basal segmental bronchi and vessels and positional relationships among them were analyzed by carefully reviewing the HRCT (see *Figure 1A-1D*, *Video 1*). The data on the anatomic relationships between the lesion and the neighboring structures (e.g., segmental bronchus, intersegmental and intrasegmental veins, and arteries) were collected to design an appropriate surgical resection. Previously, we did not routinely perform the preoperative localization of the lesion when the team converged on a solid convincement that it was located in the target segment as planned.

Surgical techniques

General anesthesia was administered to each patient and differential ventilation was obtained via double-lumen intubation. The position and port strategy are shown in *Figure 2*. Depending on the surgeon's preference, the uniportal incision was placed in the fourth or fifth intercostal space. All the procedures followed the single-direction strategy; the interlobar fissure approach was primarily used for S7–8 segmentectomies (*Figure 3A*), while the inferior pulmonary ligament approach was preferred for S9–10 segmentectomies (*Figure 3B*).

In this article, we used a right S8 segmentectomy as an example to depict the uniportal VATS basal segmentectomy techniques in detail (see *Figure 4*, *Video 1*). The surgery was initiated by incising the oblique fissures to dissect the pulmonary artery. First, the artery of S7 and the feeding artery of S8 (A8) were identified by studying the imaging results before the operation (see *Figure 4A*). The A8 was divided using a stapler. Next, the bronchus of S8 (B8) was dissected, and was identified by referring to the preoperative HRCT (see *Figure 4B*) and divided using

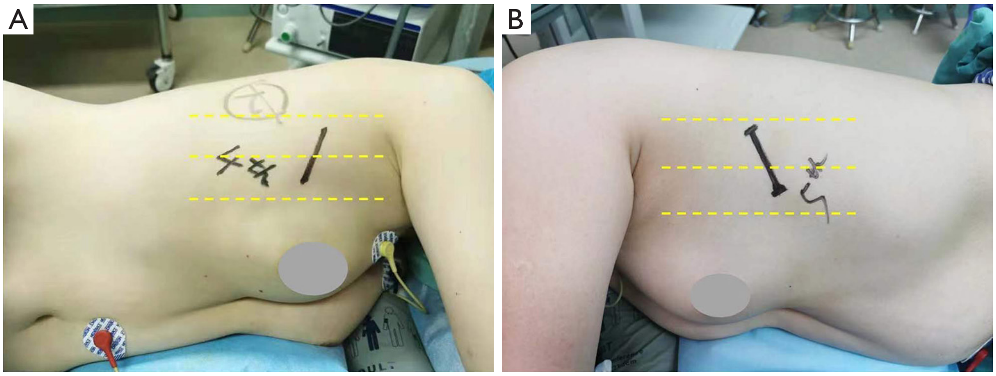


Figure 2 Patient positioning and port strategy used for uniportal thoracoscopic basal segmentectomy. The patient was placed in the lateral decubitus position. The incision is placed in the 4th (A) or 5th (B) intercostal space across the midaxillary line.

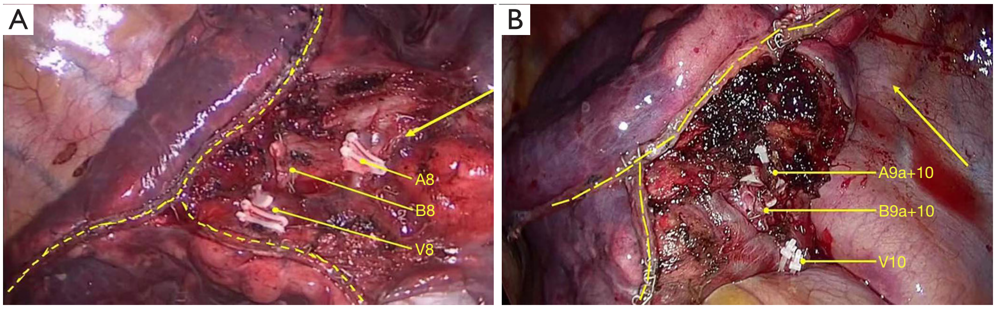


Figure 3 Demonstration of the single-direction method. (A) The procedure was initiated via the dissection of the interlobar fissure and then proceeded via the dissection of the segmental structures, which were managed from superficial to deep in order of their appearance (i.e., artery, bronchus, vein, and finally, the intersegmental planes) (a right S8 segmentectomy). (B) The procedure was initiated via the dissection of the inferior pulmonary ligament and then proceeded with the dissection of the segmental structures, which were managed from superficial to deep in order of their appearance (i.e., vein, bronchus, artery, and finally, the intersegmental planes) (a left S9a+10 segmentectomy).

a stapler. At the same time, the peri-bronchial lymph nodes were retrieved. The drainage vein of S8 was then dissected and divided while preserving the intersegmental vein (see *Figure 4C,4D*). The segmental hilum was further dissected along the intersegmental veins using energy devices. The intersegmental demarcation line was revealed using the modified method of inflation-deflation. Next, a stapler divided the intersegmental planes in a step-by-step fashion. Finally, a uniportal single-direction VATS S8 segmentectomy was completed.

The surgical margin was examined immediately after resection. Intraoperative frozen section pathological examinations were applied to both the tumor and N1 station lymph nodes. Hilar and lobe-specific mediastinal lymph node sampling (stations 7, 8, and 9) was performed for cases with primary pulmonary malignancy. Systemic lymph node sampling was performed if multiple synchronous malignancies were confirmed in different lobes. Air leakage was checked via the inflation of the residual lung under a water seal. A chest tube was placed along with the posterior mediastinum to the apex of the cavity.

Regular blood tests and chest X-rays were administered to each patient on postoperative day 1. The chest tube was removed when there was no air leakage, the drainage was <300 mL during the last 24 hours, and the lung was fully inflated on the chest X-ray. Patients were discharged if there were no major complications. The last follow-up was in May 2021.

Statistical analysis

The data were analyzed using SPSS, version 22.0 (SPSS

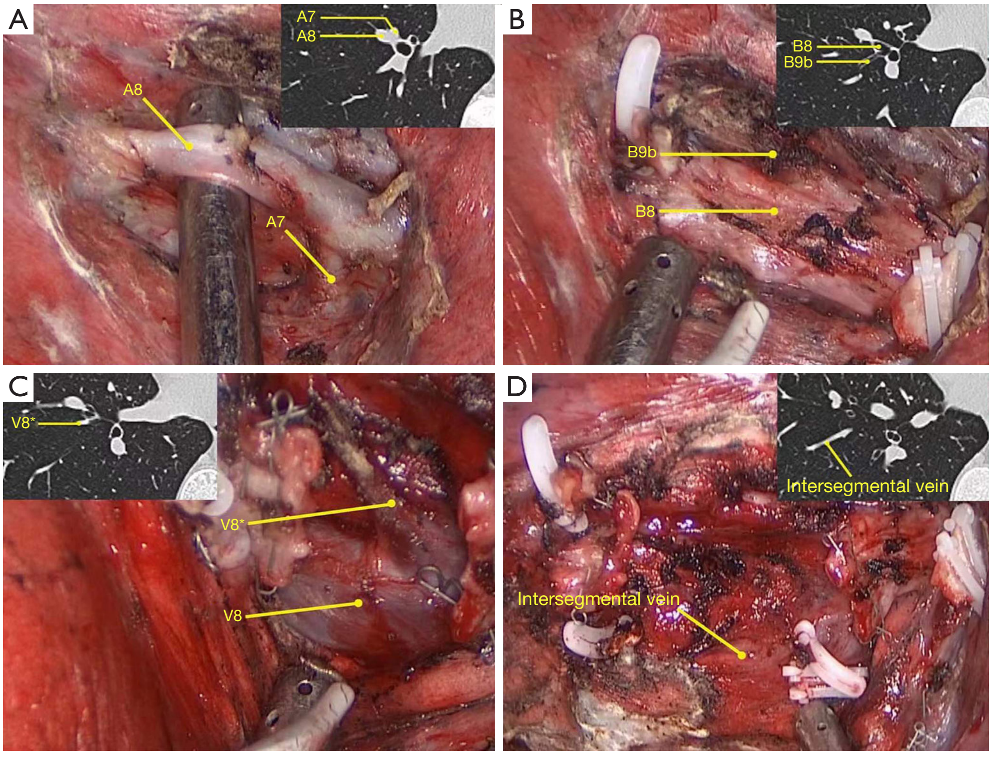


Figure 4 Identifying the target segmental structures during the operation (a right S8 segmentectomy). (A) Identifying A8 with reference to A7 according to their running directions and the positional relationships between them as demonstrated on the preoperative CT scans. (B) Identifying B8 with reference to B9b according to their positional relationships as demonstrated on the preoperative CT scan. B9b was a small branch, which shared a common stem with B8 and ran just posterior to B8. (C) Identifying the intrasegmental vein of V8 and V8*. V8 was the major drainage vein while V8* was a small branch. Both of them ran directly into the parenchyma of S8. (D) Identifying the intersegmental vein, which was running between S8 and S9. It was the mark of intersegmental border between S8 and S9.

Inc., Chicago, IL, USA). Descriptive statistics were used to report the medians for the continuous study variables and the number for categoric variables.

Results

The characteristics of the patients are presented in *Table 1*. The details of the surgical procedures, including the types of basal segmentectomies and synchronous procedures, are listed in *Table 2*. A total of 33 patients underwent single basal segmentectomy, 12 patients underwent combined basal segmentectomy, 2 patients underwent combined basal sub-segmentectomy, 1 patient underwent combined basal segmentectomy and sub-segmentectomy, and 1 patient underwent basal sub-segmentectomy. The interlobar fissure approach was adopted in 27 cases and the inferior ligament approach was adopted in the other 22 cases. A total of 19 patients underwent synchronous combined surgeries for multiple lesions in other lobes, of whom 12 underwent wedge resection, 6 underwent segmentectomy, and 1 underwent combined segmentectomy and sub-segmentectomy.

All the procedures were successfully performed with no conversion to lobectomy and no conversion to a multi-portal procedure or thoracotomy. The perioperative outcomes are summarized in *Table 3*. The median operative time was 120 min (range, 60–180 min), and the median blood loss was 20 mL (range, 10–100 mL). The median chest tube duration was 2 days (range, 1–5 days), and the median postoperative hospital stay was 4 days (range, 2–15 days). The postoperative morbidity rate was 6.1% (3/49, 3 cases of postoperative pneumonia). All the patients were discharged with no significant complaints. There were no perioperative deaths.

A final pathologic examination confirmed the radical resections with free surgical margins in all the patients.

Table 1 Patients' characteristics

Characteristics	Total number (N=49)
Age (years)	
Range	26–70
Median	49
Male/female	9/40
Chief complaint	
No symptom	38
Dry cough	6
Cough with sputum	1
Chest pain	2
Chest distress	2
Comorbidity	
Hypertension	3
Diabetes	1
Arrhythmia	1
Coronary heart disease	2
Hyperthyroidism	1
History of malignancy	
Lung cancer	2
Melanoma	1
Cervical cancer	1
Smoking history	
Yes	2
No	47
Synchronous multiple lesions	
Yes	19
No	30

Table 2 Surgical procedures

Types of basal segmentectomy	Synchronous procedures	Number of cases
RS7p	–	1
RS7	–	1
RS8	–	6
RS8	RS2	1
RS8	RS3	1
RS8	RULW	1
RS8	RULW + RLLW	1
RS8+9	RULW + RMLW	2
RS8+9	–	1
RS9	–	1
RS9+10	–	1
RS9+10	RULW	2
RS10	–	1
RS10	RULW	1
RS10	RS1a+2	1
LS8	–	8
LS8	LS3	2
LS8	LULW	2
LS8	RULW	1
LS8+9	–	1
LS9+10	–	2
LS9+10+6	–	1
LS9+10	LULW	1
LS9a+10	–	1
LS10	–	3
LS10	LULW + LS6W	1
LS10	LS3	1
LS10+6	–	1
LS10a+ci	–	1
LS10b+c	LS1+2	1

RULW, right upper lobe wedge resection; RMLW, right middle lobe wedge resection; RLLW, right lower lobe wedge resection; LULW, left upper lobe wedge resection; LS6W, left superior segment wedge resection.

In total, 19 patients were confirmed to have synchronous multiple primary lung cancers. The median size of the tumor in the resected basal segment was 1.0 cm (range, 0.7–1.9 cm). The histologic subtypes of the basal segmental lesions were as follows: 3 cases of adenocarcinoma in situ (AIS), 33 cases of minimally invasive adenocarcinoma, and 13 cases of lepidic-predominant invasive adenocarcinoma. In total, 30 patients underwent lobe-specific lymph node sampling while 19 patients underwent systemic lymph node sampling due to multiple primary malignancies in different lobes. No lymph node involvement was documented in this series. No recurrence or death was observed during the

Table 3 Perioperative outcomes

Variables	Total number (N=49)
Operative time (min)	
Range	60–180
Median	120
Blood loss (mL)	
Range	10–100
Median	20
Chest tube duration (days)	
Range	1–5
Median	2
Postoperative hospital stay (days)	
Range	2–15
Median	4
Postoperative complications	
Pneumonia	3
Tumor size (cm)	
Range	0.7–1.9
Median	1.0
Types of LN dissection	
Lobe-specific LN dissection	30
Systemic LN sampling	19
Number of LNs dissected	
Range	2–12
Median	6
Histologic subtypes of the basal segmental lesions	
AIS	3
MIA	31
Invasive AC (LPA)	15
Synchronous multiple primary lung cancer	
Yes	19
No	30
Pathological TNM stages for the basal segmental lesions	
0	3
IA1	33
IA2	13

LN, lymph node; AIS, adenocarcinoma in situ; MIA, minimally invasive adenocarcinoma; AC, adenocarcinoma; LPA, lepidic-predominant adenocarcinoma; TNM, tumor, node, metastasis.

median follow-up period of 7 months (range, 2–25 months).

Discussion

Among VATS segmentectomies, single or combined basal segmentectomies are the most challenging (24). Only a few studies have reported and evaluated the feasibility and safety of VATS basal segmentectomies (14-17,21,25). Notably, performing a basal segmentectomy using a uniportal approach is much more technically challenging than that using a multiportal approach. Thus, very few uniportal VATS basal segmentectomies have been conducted and the methods employed have varied (26-32).

The placement of the incision during the uniportal VATS basal segmentectomy is crucial. We selected the 4th or 5th intercostal space crossing the midaxillary line, which provides good exposure and an adequate dissection angle, using either an interlobar fissure approach or an inferior pulmonary ligament approach. For a segmentectomy of S7–8, the anterior border of the incision reaches the anterior axillary line. For a segmentectomy of S9–10, the incision is moved slightly backwards to reach the posterior axillary line.

As has been commonly found, segmentectomies of S7–8 of both sides can be easily approached through the interlobar fissures. During our practice of uniportal thoracoscopic S7–8 segmentectomy and combined S8+9 segmentectomy, we approached the segmental hilum from the fissures and proceeded using a single-direction approach. Conversely, it is much more challenging to approach the segmental hilum of S9–10. Several methods have been reported for approaching S9–10 during multi-portal procedures. One method creates a tunnel between S6 and the basal segments to expose the hilum of the basal segments (15). Ojanguren *et al.* reported 1 case of uniportal S9+10 segmentectomy using this method (30). However, splitting the lung parenchyma and creating the tunnel between S6 and the basal segments are technically demanding procedures through the uniportal approach. The 2nd type of method employs a posterior approach or a nearly identical method called the "bidirectional" approach (13,15). This method allows a segmentectomy of S10 or S9+10 to be performed. However, these 2 methods do not apply to a segmentectomy with the resection of a part or the whole of S9. Another method is to approach the segmental hilum using an inferior pulmonary ligament approach (16,20). This method enables all types of basal segmentectomies to be completed without reference to the condition of the interlobar fissures. Ojanguren *et al.* provided 1 video of uniportal VATS S9+10 segmentectomy using the inferior ligament approach (32). We also prefer the inferior ligament approach for the resection of S9–10 when performing the uniportal procedure. However, many consider this approach suboptimal for interlobar lymph node dissection. We limited the indication for this procedure to GGO dominant lesions. In this cohort, all the segmentectomies that involved S9–10 and the 1 case that involved RS8 with totally incomplete fissures were performed using the inferior pulmonary ligament approach.

We previously described the technical details of the tri-portal VATS basal segmentectomy adopting the single-direction approach and using the stem-branch method (18). These techniques enable complex VATS basal segmentectomies to be performed in a simple manner. However, dissecting and getting a panorama of all the basal segmental structures is difficult using the uniportal approach. Thus, when applying these techniques to uniportal procedures, the different technical details should be noted. First, the characteristics of the venous, arterial, and branchial branches should be precisely identified in the preoperative planning. Second, when approaching via the interlobar fissure, the artery is the first structure to be managed. On the left side, A8 is the first and the innermost branch. On the right side, the feeding artery of S7, the innermost branch, is a good reference point for identifying A8 and/or A9. Next, the accompanied target bronchus can be identified. When approaching through the inferior pulmonary ligament, the drainage veins of S6, which are normally isolated and located at the most posterior and superior of the inferior pulmonary vein, are a good reference point for the identification of the basal segmental veins. Next, the target intrasegmental veins can generally be identified based on the characteristics of the venous branches identified in the preoperative planning. The target segmental bronchus can primarily be identified based on the positional relationships between it and the intersegmental vein rather than the adjacent bronchi. Third, owing to the limited operation angle, the technique of intracavitary overhanging approach is helpful for the placement of the stapler when dealing with the bronchus (33). Fourth, for the division of the intersegmental plane, we prefer to begin stapling from the diaphragmatic side and continue in a cephalad direction. A short stapler (e.g., of 45 mm) is recommended.

The localization of the small nodule is a critical issue. In practice, we do not routinely employ any assistant techniques for lesion localization when we plan to perform a segmentectomy; instead, we review the targeted segment by carefully reviewing the HRCT during the preoperative planning. Then, if we resect the planned segment, the nodule will be resected successfully. However, if the surgeon is not sure that he/she can localize the nodule, additional intraoperative localization techniques are encouraged.

In addition, it is quite important to check the surgical margin immediately after the resection. A safe margin is defined as the distance between the tumor border, and the surgical margin should be no less than the maximum diameter of the nodule or ≥2 cm. In relation to the identification of the intersegmental plane, there are also different kinds of methods [e.g., differential ventilation (inflation/deflation) after the identification of the target bronchus, intravenous indocyanine green injection with the feeding artery divided or temporarily clamped, and the identification of the intersegmental pulmonary vein]. It should be noted that the method of inflation/deflation is not sufficiently accurate for patients with severe emphysema. Each surgeon should select an appropriate method according to each patient's condition and use the one with which he/she is most familiar.

In this study, all the basal segmentectomies were successfully performed using the single-direction method employing a uniportal approach without conversion to a multi-portal procedure or open thoracotomy. There was also no conversion to a lobectomy. In total, 17 cases of S9-10 segmentectomies or combined segmentectomies, which are considered the most challenging, 2 cases of combined sub-segmentectomy (LS10a+ci and LS10b+c), and 1 combined segmentectomy and sub-segmentectomy (LS9a+10) were successfully completed. We have published featured videos of uniportal RS9 (34) and LS10a+ci (35) in other publications. Thus, we only chose a relatively simple procedure of a RS8 for our demonstration. The uniportal procedures are much more technically demanding; however, the overall perioperative outcomes are similar to those of the multi-portal procedures we reported previously (20). As we largely limited the indication of segmentectomy to GGO dominant lung cancers, we only performed lobe-specific lymph node sampling for 1 lesion or systemic sampling for multiple lesions.

Limitations

This study is a retrospective study with small sample size, and it did not make any comparisons of the techniques. However, as the experience with uniportal VATS basal segmentectomy is very limited worldwide, we believe that it is still of great importance. We intend to begin a comparative study in the near future to compare the uniportal and multi-portal procedures in basal segmentectomy. In addition, considering that the case volume is still small and there are varied complexities of different basal segmentectomies, it was difficult for us to depict a definite learning curve. Basal segmentectomy is actually much more difficult than other types of segmentectomy. Only those experienced with other common thoracoscopic segmentectomies can start to perform basal segmentectomies. Finally, the follow-up period was short, and the long-term outcomes were not examined. We intend to observe and share the long-term outcomes in the future to verify the oncological efficacy of this procedure.

Conclusions

Uniportal VATS basal segmentectomy is a feasible and safe technique in our experience. This single-direction method allows the uniportal VATS anatomic basal segmentectomy to be performed in a simple manner with the targeted segmental bronchi and vessels exposed from superficial to deep in order of their appearance while avoiding the repeated turnover of the lung.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-651/rc

Data Sharing Statement: Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-651/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-651/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Informed written consent was obtained from each patient for the surgery and the publication of the study data. The protocol of this study was approved by the Institutional Review Board of West China Hospital (No. 2021-871) and conducted according to the Helsinki Declaration (as revised in 2013).

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