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Original Article

Lateral Dorsal Basal Lung Resection Based on Functional Preserving Sublobectomy Method: Single-Center Experience

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Purpose: Functional preserving sublobectomy (FPSL), a novel balancing strategy for segmentectomy and wedge resection, allows rapid and accurate removal of invisible nodules without the use of any preoperative localization markers. This study aimed to share single-center experience of lateral dorsal basal lung resection based on FPSL, so as to provide new surgical options for thoracic surgeons.
Methods: A retrospective analysis was performed on 13 patients who underwent thoracoscopic basal lung resection after FPSL at XX hospital from January 2021 to August 2022.
Results: The operation was successfully performed in 13 patients by using FPSL, including 12 patients with malignant tumors. The mean operating time was 107.5 ± 25.6 min. The mean postoperative hospital stay was 3.7 ± 2.4 days. None of the patients needed extended excision, such as an entire basal or inferior lobectomy.
Conclusion: Our single-center experience showed that the FPSL method only dealt with the target vessels, which greatly reduced the technical difficulty of surgery. In addition, both arteries and veins could be used as target vessels, and in particular cases such as undeveloped interlobar fissure, the operation could still be completed successfully. Lateral dorsal basal lung resection based on FPSL may be a new surgical option for surgeons.

Keywords: functional preserving sublobectomy, thoracoscopic, segmentectomy, lung cancer

Introduction

Lung cancer is one of the most common malignant tumors, with the highest mortality rate of all malignancies.[1)] With the widespread application of low-dose computed tomography in lung cancer screening, lung cancer can be detected and treated at an early stage, thus reducing mortality.[2,3)] Lobectomy is often the standard treatment for patients with early stage lung cancer.[4)] However, studies in recent years have also shown that patients who undergo segmentectomy can achieve the same prognosis.[4–6)]

Sublobar resection includes segmentectomy and wedge resection.[7)] For peripheral lung tumors, such as ground-glass opacities (GGOs), wedge resection is limited by its difficulty in obtaining adequate surgical margins, especially when the tumor is located deep in the tissue.[8)] Segmentectomy requires dissection of target vessels and bronchus, which is relatively complicated, especially when the nodules are located at the junction of the two segments. Basal segmentectomy, especially lateral dorsal basal segmentectomy ($S^{9,10}$), is considered one of the most complex operations in thoracic surgery.[9–13)] In 2021, Professor Ge Mingjian proposed the concept of

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functional preserving sublobectomy (FPSL), which mainly adopts the principle of simple occlusion of blood vessels, without treatment of segmental bronchus, to display the intersegmental plane after expansion and collapse, and ultimately uses cutting closure device to mechanically divide the intersegmental plane to complete the operation.[14] The results showed that patients who underwent FPSL had shorter surgery times, less blood loss, and fewer complications than those who underwent traditional segmentectomy.

Based on the above, the purpose of this study was to share the single-center experience of lateral dorsal basal lung resection following the application of the FPSL strategy, with a view to providing surgeons with new surgical options.

Materials and Methods

Patients

From January 2021 to August 2022, a total of 13 patients had undergone surgery using FPSL at our hospital. The surgery was performed with a conventional three-port approach by the same surgeon to ensure quality. Each patient was informed of the procedure and signed a consent prior to surgery. Data were retrospectively collected for analysis.

Selection criteria

Inclusion criteria included pure GGOs less than 2 cm in diameter or mixed GGOs with less than 25% solid component, or solid nodules less than 2 cm or mixed GGOs with more than 25% solid component (in case a patient with poor lung function would be unfit for lobectomy, lung function tests, boarding tests, arterial blood gas analysis, and other assessment were used for evaluation); preoperative three-dimensional computed tomography bronchography and angiography (3D-CTBA) suggested that the nodule was located in the peripheral 1/3 of the lung; patients agreed with this surgical approach (i.e. FPSL) preoperatively and had signed a consent form.

Operative procedure

Prior to surgery, all patients were required to complete a 3D-CTBA, the results of which illuminated the location of the nodule, the target vessel to be blocked, and the extent of lung tissue to be resected. To reduce the rate of local recurrence, the distance between the incision margin and the tumor was required to exceed 2 cm or the diameter of the tumor. Patients underwent general anesthesia. Then, the anesthetist inserted a double-lumen tracheal tube to perform one-lung ventilation. After anesthesia, the patient was placed in the lateral position. We chose a three-port approach, with the primary operating port located in the anterior axillary line between the 3rd or 4th ribs, approximately 3 cm in length; the secondary operating port located in the posterior axillary line between the 8th or 9th ribs, approximately 1.5 cm in length; and the observation port located in the mid-axillary line between the 7th ribs, approximately 1 cm in length. We choose a patient as an example to explain our surgical procedure in detail (**Video 1**; The videos are available online.). Still, if the intraoperative cryopathological findings suggest positive margins (i.e. metastases) or positive lymph nodes, lobectomy (i.e. an extended resection) was adapted.

3D-CTBA results suggested that the nodule was located at S^{9+10} in the 1/3 of the peripheral lung, with the target vessel being A^{9+10} (**Fig. 1A**). The right lower pulmonary artery was identified by dissecting the interlobar fissure (i.e. oblique fissure). After A^{6} was easily identified, the basal segmental artery was continued to be dissected to expose A^{7+8}. A^{6} and A^{7+8} could be used as markers, and the target vessel (i.e. A^{9+10}) was located midway between these two vessels. Further dissection revealed A^{9+10} (**Figs. 1B** and **1C**). Rather than dissecting (or cutting off) A^{9+10}, we chose to use a blocking forcep to temporarily block the blood flow (**Fig. 1D**). Subsequently, the anesthetist was informed to use pure oxygen (i.e. 100% oxygen) to ventilate the lung. One-lung ventilation was continued until the entire right lower lung was fully inflated, and then we waited for approximately 10–15 min. During this period, we could selectively clear the peripheral lymph nodes. Eventually, the intersegmental plane was revealed (**Figs. 2A** and **2B**). We first marked the intersegmental plane with an electric hook and then used an electrically powered stapler-based technique to cut the lung tissue along the marked line, resulting in a Mercedes logo-like plane (**Figs. 2C** and **2D**) (**Video 2**).

If the interlobar fissure was difficult to manage (or poorly developed), blocking the vein of the target segment ($V^{9–10}$) was an alternative, which, in our experience, still led to a well-revealed intersegmental plane.

Statistical analysis

The data were analyzed using SPSS, version 22.0 (SPSS Inc., Chicago, IL, USA). Measurement data were expressed as mean ± standard deviation.

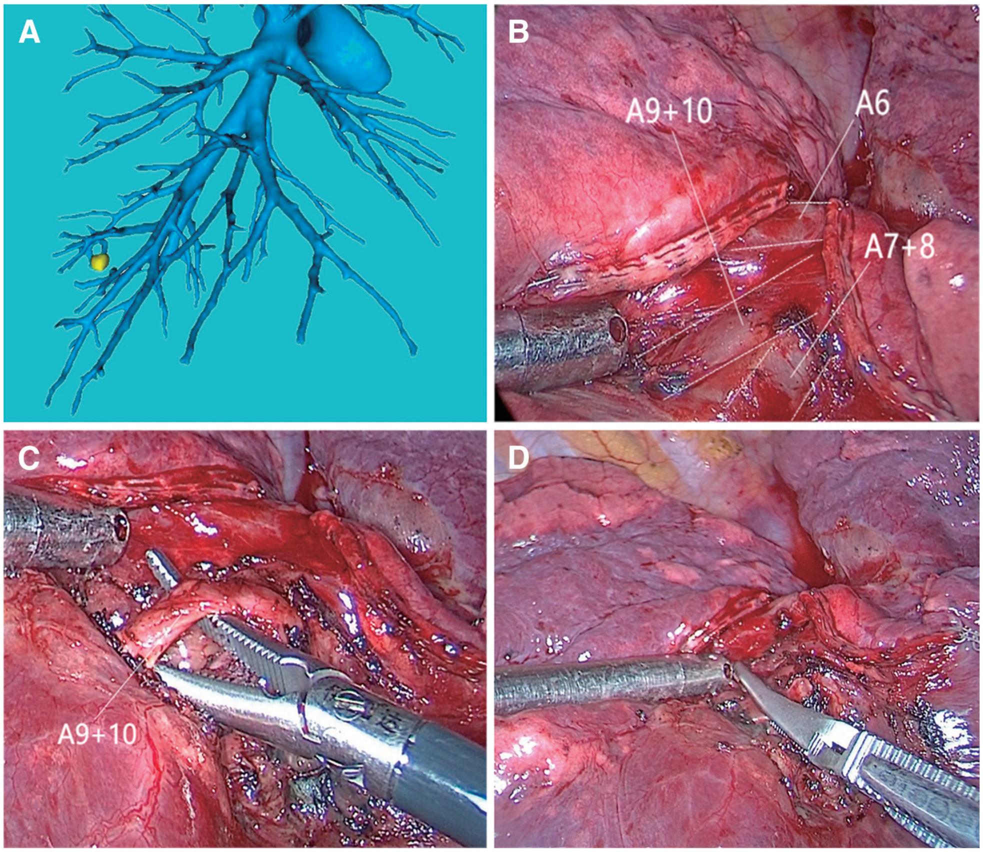

Fig. 1 (**A**) A preoperative 3D-CTBA of the segmental arteries (reconstruction with Mimics; Materialise Medical, Leuven, Belgium). (**B**) The FPSL strategy of right S^{9+10} lung resection through an interlobar fissure approach. The basilar arterial trunk branches in 2 arteries: A^{7+8} and A^{9+10}. (**C**) A^{9+10} was dissected and identified just between A6 and A^{7+8}. (**D**) We use a vascular clamp for temporary blockage of A^{9+10}. 3D-CTBA: three-dimensional computed tomography bronchography and angiography; FPSL: functional preserving sublobectomy

Results

The patient characteristics and operative results are shown in **Table 1**. In total, there were 3 male and 10 female patients, with the median age of 54.8 years (range of 38–69 years). The mean operative time was 107.5 ± 25.6 min (range of 75–165 min). The mean postoperative hospital stay was 3.7 ± 2.4 days (range of 2–10 days).

A total of 12 cases were performed via an interlobar fissure approach, and only one patient was performed via an inferior ligament approach. In all, 9 patients underwent combined basal lung resection (S^{9+10}), 3 patients underwent S^{10} lung resection, and one patient underwent S^9 lung resection. Adenocarcinoma in situ was pathologically confirmed in 2 patients, minimally invasive adenocarcinoma in 6, and invasive adenocarcinoma in 4. Histologically, the majority of patients had a diagnosis of malignancy (12/13). No patient required conversion to extended resection such as the entire basal or lower lobar resection.

Discussion

With the publication of the JCOG0802/WJOG4607L results, segmentectomy shows an increasingly wide application.[15] Basal segmentectomy, especially lateral dorsal basal segmentectomy, is one of the most difficult surgical techniques.[16] The FPSL method used in this study only needs to deal with the target vessels, which greatly reduces the technical difficulty of the operation. In 2021, professors Chu XP and Zhong WZ mentioned a similar approach, which involves temporarily blocking the target pulmonary artery and using indocyanine green fluorescence during surgery.[17] We believe that there are two differences. First, in addition to blocking the pulmonary arteries, we can also choose to block target veins in

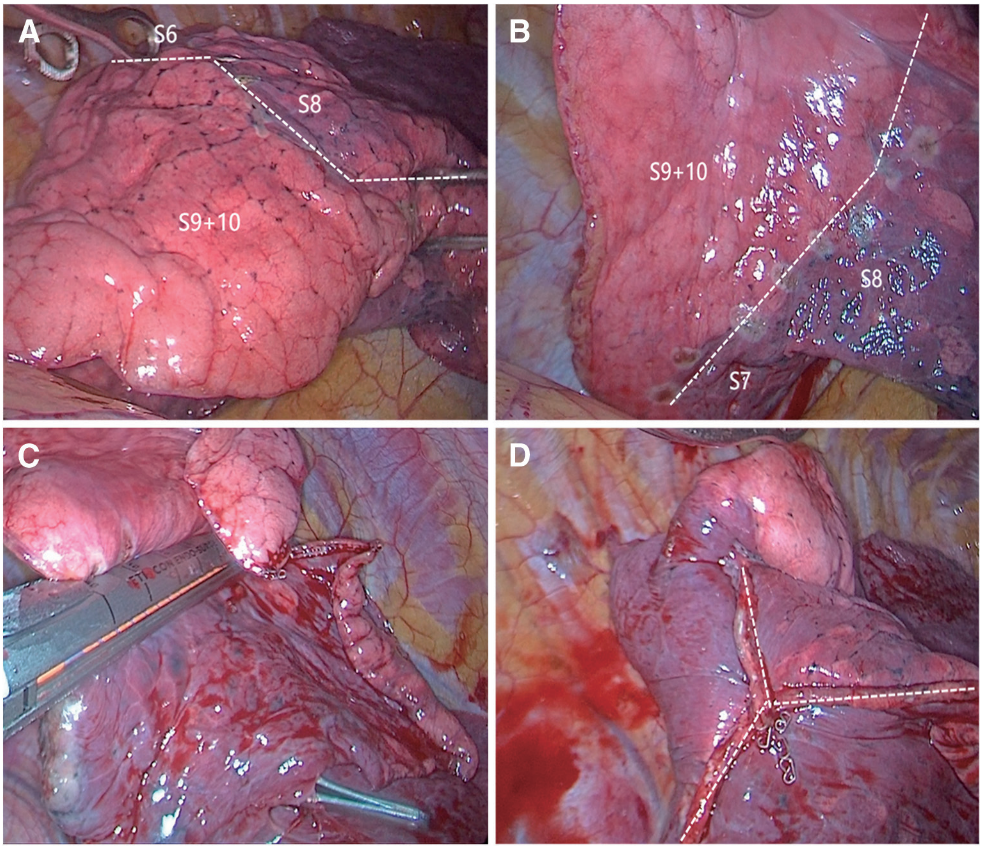

Fig. 2 (**A** and **B**) The intersegmental planes were identified using the method of inflation/deflation. (**C** and **D**) The intersegmental planes were tailored using a stapler-based technique.

individual cases. Second, after blocking the vessels, we only need to use the inflation–deflation method to expose the intersegmental plane, which is easier to operate.

Artery or vein

We suggested the approach through interlobar fissure that gave priority to blocking the target artery. First of all, the identification of arteries is relatively simple. A^6 and A^8 can be chosen as marker arteries, so the A^{9+10} between them is easily revealed (**Fig. 1B**). Second, the author believes that arteries, compared with veins, are more suitable for dissociation and other surgical operations, and less prone to bleeding. More importantly, in many patients, the intersegmental plane shows that S^{10} is not directly adjacent to the inferior pulmonary ligament, separated by S^7. In addition, treatment of the target vein via the inferior pulmonary ligament approach may result in loss of lung function in part of the inner basal segment (**Fig. 2B**). Therefore, the preferred target vessel for our operation was the artery. If there are no special circumstances such as undeveloped interlobar fissure, veins can also be selected as target vessels. From our experience, the venous plane is still clearly visible.

Vascular dissection or temporarily blocking

In the early phase, the target vessel was disconnected after silk ligature. During the intersegment plane cutting, it was necessary to cross the distal end of the disconnected vessel. In this way, part of the lung tissues of S^6b and S^8a would be lost in the cutting plane. Removing more lung tissue means more loss in lung function. Afterward, we improved the surgical technique. We chose to temporarily blocking the blood vessel without disconnecting the blood vessel, and then cut the intersegment plane between S^{9+10} and S^6 and S^8 based on the experience of the surgeon. Theoretically, more lung tissue could be preserved in this way. After releasing the blocking forceps, it was also suggested that the preserved lung tissue had pulmonary function (hypoxia area).

Classic three-port or uniportal VATS

For young thoracic surgeons, it is quite difficult to complete the lateral dorsal basal lung resection using a single-port endoscope, and this operation was performed using a three-port endoscope. The plane cutting between S^7 and S^{10} was completed through the secondary

Table 1 The patients' characteristics and perioperative outcomes

Variables (n = 13)	Results
Age (years)	
Range	38–69
Mean ± SD	54.8 ± 10.5
Gender (n)	
Male	3
Female	10
Length diameter of nodule (mm)	
Range	6–13
Mean ± SD	9.5 ± 2.7
Short diameter of the nodule (mm)	
Range	4–11
Mean ± SD	8.0 ± 2.3
Distance from nodule to pleura (mm)	
Range	11.3–38.6
Mean ± SD	19.7 ± 7.3
Basal lung resection (n)	
S^{9+10}	9
S^{9}	1
S^{10}	3
Surgical approach (n)	
Interlobar fissure approach (artery blocked)	12
Inferior pulmonary ligament approach (vein blocked)	1
Operation time (min)	
Range	75–165
Mean ± SD	107.5 ± 25.6
Length of postoperative stay (days)	
Range	2–10
Mean ± SD	3.7 ± 2.4
Histologic subtypes (n)	
AIS	2
MIA	6
IAC	4
Benign	1

SD: standard deviation; AIS: adenocarcinoma in situ; MIA: minimally invasive adenocarcinoma; IAC: invasive adenocarcinoma

operating hole into the cavity with a smoother angle and easier operation (**Fig. 2C**). As for the experienced surgeon, the plane cutting can be skillfully completed using a single-port endoscope.[18] We hold the opinion that excessive pursuit of small incisions should be avoided, which instead leads to the removal of many unnecessary lung tissues and loss of lung function.

Conclusion

Unfortunately, not all patients are suitable for FPSL. For instance, when the nodule is close to the center, it is necessary to disconnect the bronchus to ensure adequate incisional margin, or in patients with poor lung quality, combined with chronic obstructive pulmonary disease, poor exposure of the intersegmental plane, it is difficult to identify the intersegmental plane by the inflation–deflation method. In conclusion, we believe that FPSL reduces the difficulty of surgery and can be used as a new surgical option for surgeons.

Author Contribution

Bing Han contributed to the study design and wrote the article. Peirui Chen conducted the literature search and acquired the data. Zheng Qin performed data analysis. Mingqiang Diao and Liqiang Yuan revised the article. All authors gave the final approval of the version to be submitted.

Informed Consent

The methods were carried out in accordance with the approved guidelines. Written informed consent was obtained prior to the study.

Disclosure Statement

The authors report no conflict of interest.

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