Single-port combined subsegment resection (RS3b + S1bi) with a rare branching segment pattern of the bronchi and vessels: case report and literature review

Zhengxin Yin, Lianggang Zhu, Xianfei Zhang, Hecheng Li

Department of Thoracic Surgery, Ruijin Hospital North Campus, Shanghai Jiaotong University School of Medicine, Shanghai, China

Correspondence to: Hecheng Li, MD. Department of Thoracic Surgery, Ruijin Hospital North Campus, Shanghai Jiaotong University School of Medicine, 999 Xiwang Road, Jiading District, Shanghai 201801, China. Email: lihecheng2000@hotmail.com.

Background: Video-assisted thoracoscopic surgery segmentectomy is increasingly being used to resect peripheral small lung cancer. However, to manage some lesions which locate between segment deep inside the parenchyma is still challenging. Generally, wedge resection and segmentectomy are optional for peripheral small lung cancer. However, it is hard to achieve safe surgical margins if the lesion is located in the segment plane deep inside the parenchyma, especially close to the segment hilum. In that situation, lobectomy and bi-segmentectomy are usually performed for the sake of safe margins with the price of excessive normal lung tissue lost. To ensure safe surgical margins and preserve normal lung tissue as far as possible, combined subsegmentectomy is feasible and it is required precise preoperative plan including surgical margin delineation, bronchi and vessels variation and surgical procedure. The variation of bronchi and segment vein in our current case are rare and the branching pattern of pulmonary artery-inferior trunk (Tr.inf) is firstly reported in our case.

Case Description: In 2019, a 41-year-old female presented to the Thoracic Clinic with a history of a 7-mm sized, mixed-density ground-glass opacity (GGO) in the right upper lobe. The lesion located in the segmental plane between S3b and S1b deep inside the parenchyma. We performed precise preoperative planning with 3-dimension pulmonary bronchi and vessels reconstruction and resected RS3b + S1bi via single-port approach. The patient was discharged from hospital on the 5th postoperative day without any complications. Chest computed tomography (CT) scans in the 12th and 24th months after surgery showed good lung recovery, and no atelectasis or pulmonary congestion was observed. Notably, we observed a new branching pattern of A1b, which came from the inferior trunk, combined with A3a. Additionally, we performed a literature review to analyze the variation patterns of segmental structures in the right upper lobe, and the indications, effects, and safety of combined subsegmentectomy.

Conclusions: Our case and review of literature showed that combined subsegmentectomy was feasible for lesion deep inside parenchyma if a detailed preoperative plan and delicate procedures during surgery were implemented.

Keywords: Ground-glass opacity (GGO); video-assisted thoracoscopic surgery; subsegmentectomy; case report

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Introduction

Video-assisted thoracoscopic surgery segmentectomy is increasingly being used as a minimally invasive treatment of small malignant pulmonary lesions. The resection of simple segments, such as S6 or S4+5, is no longer challenging for experienced surgeons, and even the resection of more complex lung segments, such as S3 or S9+10, has been mastered by many surgeons. The main goals of segmentectomy are to ensure safe tumor margins and preserve the maximum amount of pulmonary function. Due to the special location of some lesions, combined subsegmentectomy should be performed to achieve safe surgical margin and it is necessary to confirm the variation of target bronchi and vessels. In this article, we describe our surgical treatment strategy for a small lesion with rare bronchial and vascular variants located in a unique position which is deep inside the parenchyma between subsegments close to segment hilum in the right upper lobe. The bronchial branching pattern of right upper lobe can be divided into 3 types and that in our case is defective B2 subtype" (B1 + B2a, B3 + B2b) which accounts for 2.3% across all subtypes in Nagashima *et al.*'s case series (1) and the pulmonary artery branching pattern is superior trunk, inferior trunk, and an ascending artery described by Nagashima *et al.* (1,2). The inferior trunk in our case comprised of A3b, A1bi and this unique branching pattern of inferior trunk is firstly reported by us. Branching pattern of segment vein in right upper lobe included 14 subtypes and our case is classified to "subtype D3" of the "anterior vein type" (3,4). We also review variation patterns of right upper-lobe segments and segmental/subsegmental resections from literatures in English on PubMed database including 2,393 cases from 23 articles. We present the following case in accordance with the CARE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1603/rc).

Case presentation

In 2019, a 41-year-old female presented to the Thoracic Clinic with a history of a 7-mm ground-glass opacity (GGO) in the right upper lobe with mixed-density on chest computed tomography (CT) scan, which had initially measured 5.5 mm when first found by chest CT at a health check-up 1 year ago, at which time the patient had no symptoms, and the physical examination revealed no positive findings. The radiation characteristics of the lesion were associated with malignant disease, which showed mixed density and spiculation. However, due to the interference of the pulmonary vessels, it was difficult to accurately measure the density of the lesion. Given the enlargement of the lesion 1 year later and the possibility of an invasive disease, surgery was suggested. The patient denied any family history of lung cancer or any history of smoking, occupational exposure, or tuberculosis/fungal infection.

The lesion was close to the segmental hilum; however, CT and bronchopulmonary vascular 3-dimensional (3D) reconstruction suggested that a planned resection of S3b + S1bi would ensure adequate margins (*Figures 1*,*2*). The selected surgical approach used a 3.5-cm single-port incision between the midaxillary line and the posterior axillary line in the right 4th intercostal space. The surgery lasted approximately 200 min, with an intraoperative blood loss of approximately 40 mL. Frozen sections indicated *in-situ* adenocarcinoma, which was confirmed in the paraffin sections. The thoracic drainage tube was withdrawn 4 days after surgery. The patient was discharged on the 5th postoperative day without complications or adverse events, except slight chest pain that lasted for about 2 weeks postoperatively. Chest CT scans in the 12th and 24th months after surgery showed good lung recovery, and no atelectasis or pulmonary congestion was observed. The treatment timeline of the current case is showed in *Figure 3* and the 3D reconstruction was performed using Vitaworks (www.vitaworks.cn).

All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with the Declaration of Helsinki (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Preoperative planning

According to the CT findings and the results of the preoperative 3D reconstruction (see *Figure 2*), the branching pattern of the bronchi was the "defective B2" type (B1 + B2a, B3 + B2b). The nodule was adjacent to B1bi and close to the *b* subsegment of the anterior segment (S3b). Thus, a resection of S3b + S1bi was planned. CT revealed that the lesion was approximately 2 cm from the beginning of B1bii; thus, the B1bii had to

be exposed intraoperatively to ensure an adequate margin in this direction (see *Figure 2*).

The pulmonary right upper lobe artery branching pattern of our case was superior trunk, inferior trunk, and an ascending artery. The superior trunk comprised A1 and A2a, while the inferior trunk comprised A3 and A1bii. We dissected 2 arteries, including A1bi and A3b. A1bi was located both anterior and posterior to B1bi, and A3b was located at the anterior side of B3b and shared a common trunk with A1bii and A3a (*Figures 4,5*).

The 3D reconstruction indicated the branching pattern of the pulmonary vein as an "anterior type", V2a drained into the anterior V1 and V2t, and V2b, and V2c drained into the central vein. We planned to resect V1a and V1b to achieve sufficient surgical margins (*Figures 4,6*).

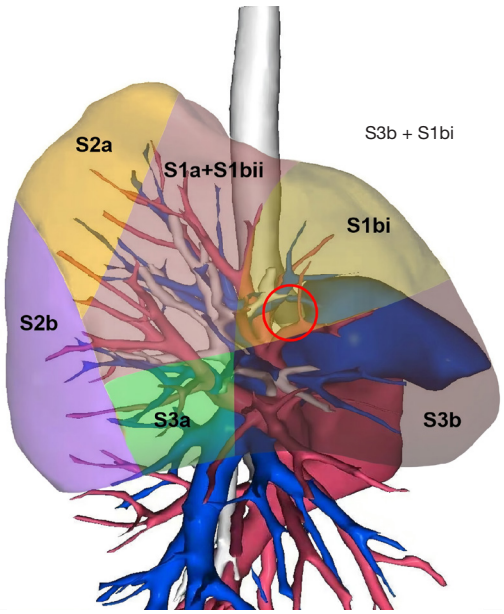


Figure 1 A bronchopulmonary vascular 3D reconstruction showing the location of the lesion. The red circle is the positon of lesion. 3D, 3-dimensional.

Surgical procedure

Based on the branching pattern of the pulmonary vein, an anterior approach was adopted, which involved the dissection from the anterior structures (veins) to the posterior structures (arteries and bronchi. Thus, any sectioned and preserved structures were exposed and compared to the 3D reconstruction to avoid misidentification. Additionally, the structures that needed to be preserved were dissected to a certain length to ensure an adequate margin. Finally, the inflation-deflation method was used to expose the intersegmental plane, and the target segment was resected by stapling to avoid air leakage (*Video 1*).

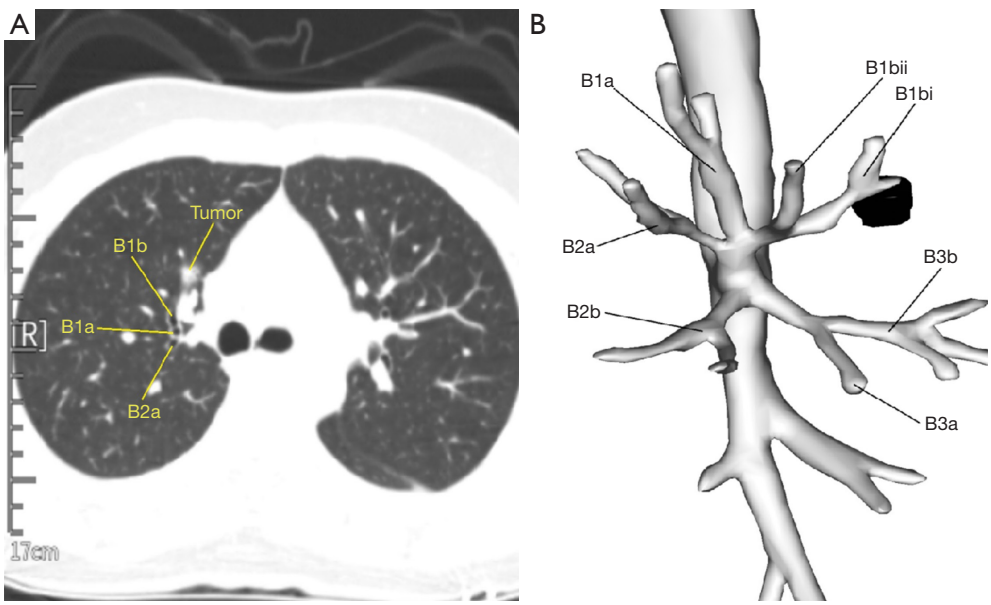


Figure 2 Tumor location and branching pattern of right upper lobe bronchi. (A) Tumor and relative bronchi on CT scan; (B) branching pattern of the bronchi in the current case (defective B2 subtype). CT, computed tomography.

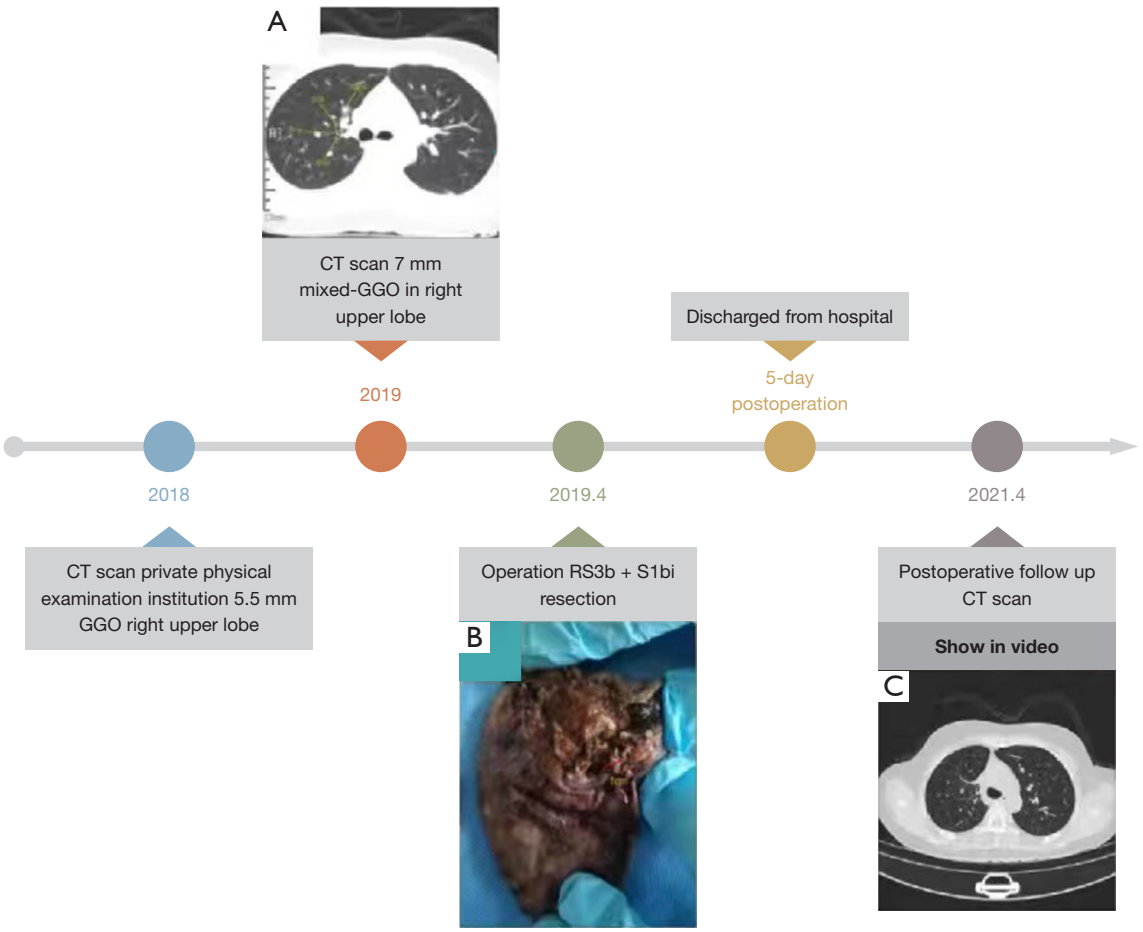


Figure 3 The treatment timeline of the case. (A) Tumor on CT scan in 2019; (B) the specimen of removed segments (RS3b + S1bi) and the nearest surgical margin (1 cm); (C) chest CT scan 2-year after surgery. CT, computed tomography; GGO, ground-glass opacity.

Discussion

Under the United States National Comprehensive Cancer Network guidelines for non-small cell lung cancer, sublobar surgery is recommended for peripheral lung nodules (5), as it is easy to achieve a sufficient surgical margin when the lesion is located in the outer 1/3 of the lung fields. In the present case, the lesion was located in the inner 1/3 of the lung parenchyma, near the plane of the anterior and apical segments. To ensure a sufficient surgical margin (as illustrated in JCOG0804) (6), we performed a combined resection of the subsegments.

A combined subsegmentectomy has some advantages over a uni-segmentectomy or wedge resection. Horinouchi *et al.* (7) reported that 30% of nodules in the right lower lobe and 40% in the right upper lobe were located beyond 1 segment. In such cases, it is difficult to achieve a safe margin using uni-segmentectomy, especially when the nodules are located near the intersegmental plane close to the segmental hilum, as was the case in the current patient. In such cases, a segmentectomy combined with adjacent subsegmentectomy or a combined subsegmentectomy should be performed to ensure safe surgical margins and our suggestion should be certified in further studies. For tumors with a consolidation to tumor ratio >0.5 in JCOG0802 (8), a strict surgical margin and No. 12 and No. 13 lymph nodes status evaluations were required; in such cases, anatomical segmentectomy or subsegmentectomy should be performed.

To successfully perform subsegmentectomy surgery, careful preoperative planning is required to identify the accurate locations of lesions and branching patterns of the segmental bronchi and vessels. Locating the nodules preoperatively is necessary for surgical margin planning. Due to anatomical variations of the segmental bronchi, a dominant segment often appears, and varies among patients.

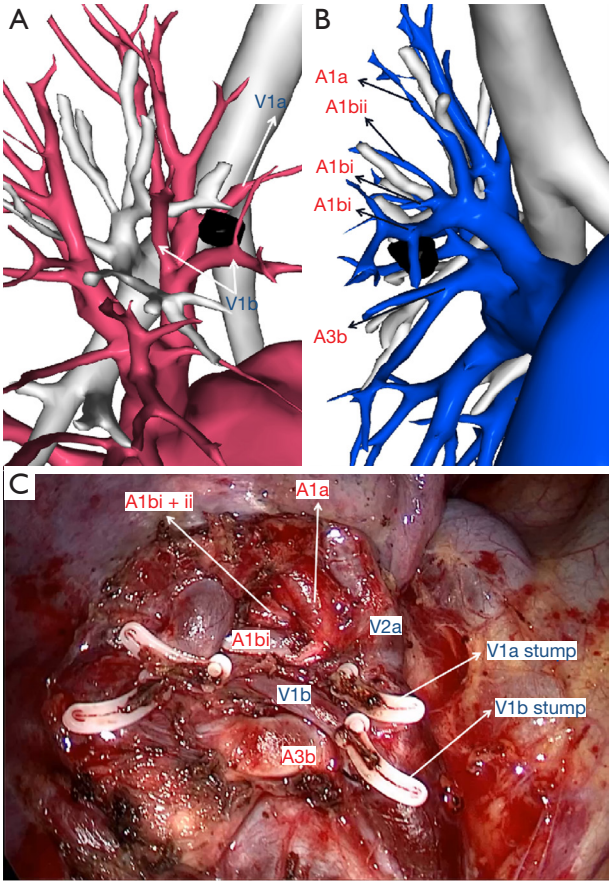


Figure 4 Branching patterns of V1 and A1. (A) Branching patterns of the anterior V1; (B) superior trunk (tr. Sup) artery; (C) branching patterns of segmental veins and arteries in surgery.

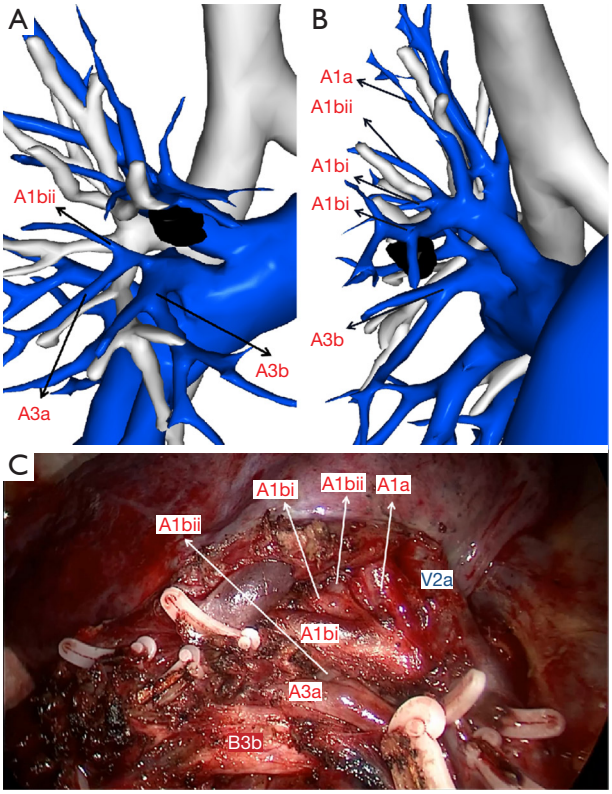


Figure 5 Branching patterns of A1 and A3. (A,B) Branching patterns of inferior trunk (tr. Inf): A3a + A1bii; (C) branching patterns of inferior trunk (tr.Inf) in surgery.

The nodule position cannot be accurately determined using 2-dimensional CT scans. Several studies (9-11) have evaluated the power of nodule location and surgical margin planning with 3D-CT or 3D reconstructions with excellent results. The accuracy of nodule localization was 100% in a study performed by Chan *et al.* (12). In our case, the lesion was located in S1bi and adjacent to S3b (V1b); thus, we planned to resect S3b + S1bi.

The branching patterns of the bronchi and vessels in our patient were relatively rare. Nagashima *et al.* reported 3 branching types of the segmental bronchi in the right upper lobe, and the bifurcated type was further divided into 3 subtypes (1). The branching pattern of the bronchi in our patient met the criteria for "defective B2 subtype" (B1 + B2a, B3 + B2b), which was relatively rare in Nagashima *et al.*'s case series (6/260, 2.3%). The right upper lobe pulmonary artery branching pattern in our patient was superior trunk, inferior trunk, and an ascending artery. This branching pattern, among which the inferior trunk (Tr.inf) consisted of A2b, A3a and A3b with different combination, accounted for 13.7% of the 4 branching patterns of the right upper lobe in Nagashima *et al.*'s study (1,2). However, in the present case, inferior trunk (Tr.inf) comprised A3a and A1bii, which, to the best of our knowledge, represents a new branching pattern.

In our patient, V1 + V2a drained into the anterior vein, and V2b + V2c + V2t drained into the central vein, which was classified as the "subtype D3" of the "anterior vein type" as described in previous studies (3,4), in which V2a runs through the posterior side of B1. The vein branches relevant to our surgical procedure were V3c, V3b, V1b, V1a, and V2al; thus, our surgical approach involved an anterior approach to identify B1bi, B1bii, artery, and vein branches combined with an interlobe approach to identify B3a and B3b. To achieve a sufficient surgical margin, V1a was sectioned, and the drainage of S1a went to V2a.

Due to the complex branching and rare variant patterns of the segmental or subsegmental structures, preoperative

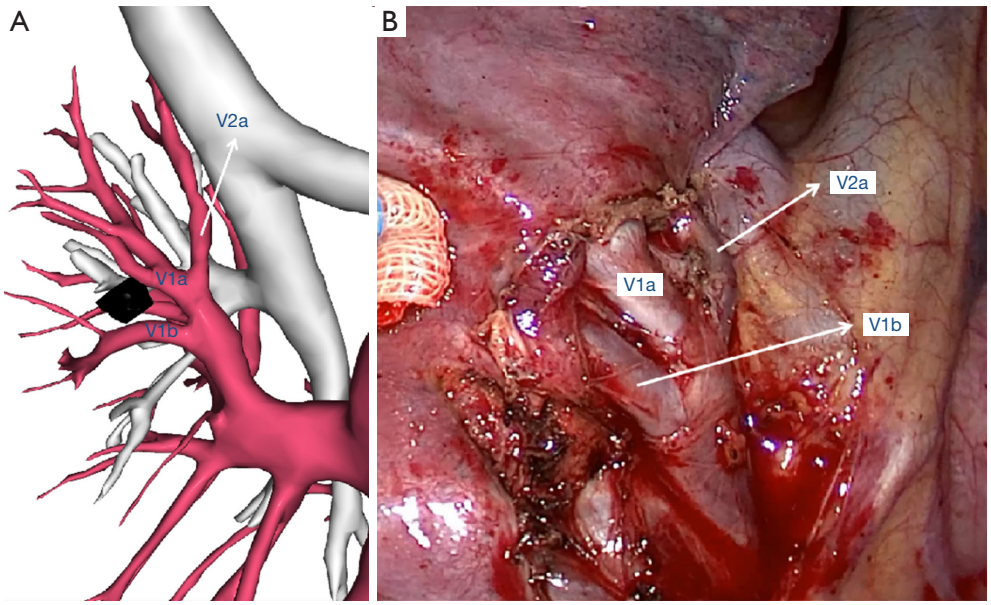
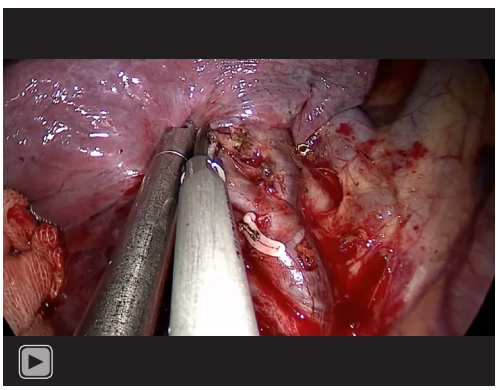


Figure 6 The special relationship between tumor and V1. (A) V1a & V1b are adjacent to the tumor; (B) sectioning of V1a and V1b to achieve sufficient surgical margins.



Video 1 Comprised of patient history, tumor location, preoperative pulmonary bronchi and vessels' reconstruction, detailed surgical procedure, the specimen with nearest margin and postoperative chest CT scan 2-year after surgery. Detailed surgical procedure includes the dissection of segmental vessels and bronchi compared with 3D-reconstruction, exposure of segmental plane and the management of segmental plane. CT, computed tomography.

3D-CT bronchography and angiography (3D-CTPA) are important to ensure the efficacy and safety of subsegmental resections. In 2010, Nakashima *et al.* reported a segment with 6 resections with A6c from the left basal pulmonary artery (13). The surgery was performed with the navigation by 3D reconstruction to avoid injuring A6c. Other studies demonstrated the navigational role of 3D reconstruction in segmental and subsegmental resection surgery (7,12,14-20).

Previous studies have sought to evaluate the safety and efficacy of subsegmentectomy compared to segmentectomy (21-23) and found that the surgical time, blood loss, duration of drainage, hospitalization, and complications of the subsegmentectomy were not superior to those of the segmentectomy (see *Table 1*). Further, the blood loss and postoperative air leakage were less in the subsegmentectomy group than the segmentectomy group, which was mainly due to the use of a stapler in the subsegmentectomy group; postoperative air leakage was more likely to occur in the segmentectomy group if the intersegmental plane was dissected with energy instruments (24).

Another purpose of anatomical sublobe surgery is to preserve lung tissue and function. Harada *et al.* described the advantages of lung function preservation after segmentectomy compared to lobectomy (25). Another study showed that combined subsegmentectomy had a better postoperative forced expiratory volume in the first second (FEV1) value than combined segmentectomy, but statistically, the result was not significant (26). This was likely due to the use of different surgery methods in different lobes. Combined subsegmentectomy was more frequently performed in the right upper lobe, while multiple segmentectomy was more frequently performed in the lower lobe, and the compensatory ability of the lower

Table 1 Surgical outcomes of subsegmentectomy and segmentectomy

Studies	Surgical time (min), mean/median			Blood loss (mL), mean/median			Duration of drainage (days), mean/median			Hospitalization (days), mean/median			Complications (%)		
	Sub[a]	Seg[b]	P value	Sub	Seg	P value	Sub	Seg	P value	Sub	Seg	P value	Sub	Seg	P value
Kato *et al.* (22), 2021	167	178	0.005	13	53	0.006	1	1	0.063	5	6	0.090	8.8	16.3	0.12
Chang *et al.* (21), 2019	157	171	0.029	25.3	81.4	<0.001	2.4	2.6	0.408	3.6	4.3	0.095	5.5	8.5	0.460
Matsui *et al.* (23), 2020	182	181	0.88	5	5	0.14	0[c]	0[c]	0.44	3	3	0.91	5	8	0.58

[a], subsegment resection; [b], segmentectomy; [c], chest tubes are removed within 24 hours after surgery in this study.

lobe was better than that of the right upper lobe (26).

We presented a feasible surgical strategy (RS3b + S1bi resection) for the lesion deep inside the lung parenchyma close to the segmental hilum which is usually referred to lobectomy to achieve safe surgical margin. We firstly described a variant pattern of segmental pulmonary artery. The limitation of our report is the applicability of our surgical strategy for the lesions with special position. And further clinical trials are necessary to confirm the effect of subsegmentectomy for lesions deep inside the lung parachyma close to the segmental hilum. Detailed preoperative planning with 3D-CTPA and the implementation of delicate surgical methods are the basis for this successful surgery.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-1603/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1603/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. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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