General Thoracic and Cardiovascular Surgery (2019) 67:344–347
https://doi.org/10.1007/s11748-018-0964-4

HOW TO DO IT

Thoracoscopic right middle lobe segmentectomy

Toshiki Yajima[1] · Kimihiro Shimizu[1] · Akira Mogi[1] · Takayuki Kosaka[1] · Seshiru Nakazawa[1] · Ken Shirabe[1]

Received: 17 April 2018 / Accepted: 22 June 2018 / Published online: 25 June 2018

Abstract
Reports of right middle lobe segmentectomy are rare. We report here that anatomical right middle lobe segmentectomy is a relatively simple surgical procedure and can achieve good expansion of the remnant lung for patients with a relatively large right middle lobe.

Keywords Right middle lobe · Segmentectomy · Complete video-assisted thoracic surgery

Introduction

Lobectomy is routinely performed to treat lung diseases of the right middle lobe (RML), especially if nodules are unresectable by wedge resection [1]. However, reports of RML segmentectomy are rare, probably because anatomical information is limited and because the RML is the smallest lobe. Therefore, the benefits of limited lung resection are considered marginal [1–3]. Although the RML usually accounts for only 10% of total lung volume [4], we occasionally encounter patients with large RMLs. In this report, we discuss the surgical technique for RML segmentectomy, which may be beneficial for patients with a relatively large RML.

Technique

We performed one S^4 and one S^5 segmentectomy in 2017. Patient 1 (a 39-year-old woman) had subcentimeter metastatic colon cancer in the lateral segment (S^4) (Fig. 1a). She also had metastatic nodules in the right posterior and superior segments (S^2 and S^6) and left anterior basal segment (S^8). Patient 2 (a 38-year-old man) had a 0.5-cm metastatic renal cancer mass in the right medial segment (S^5) (Fig. 1c), and had undergone prior segmentectomy of the left anterior segment (S^3). In patient 1, wedge resection for the nodules in S^2 and S^4 was difficult because of the nodules' location within the inner two-thirds of the lobe. Wedge resection was also difficult in patient 2 because the nodule was presumed to be nonpalpable (Fig. 1c). Preoperative simulation confirmed that segmentectomy would secure a surgical margin larger than 1 cm in both patients. Analysis of three-dimensional computed tomographic images also showed that RML volume in these patients was relatively large: 498 ml in patient 1 and 510 ml in patient 2 (16 and 11% of total lung volume, respectively). Therefore, we decided to perform segmentectomy to preserve lung volume.

Each patient was placed in a left lateral decubitus position with the main surgeon at the ventral side, the assistant operating the thoracoscope at the caudal side, and the main assistant at the dorsal side. Two 20-mm and two 10-mm ports were used [5].

Patient 1

The interlobar fissure between the RML and the right lower lobe (RLL) was divided. We identified two RML arteries (A): A^4a and $A^4b + A^5$ (Figs. 1b, 2a), and we dissected A^4a. After dividing the incomplete fissure between the right upper lobe (RUL) and S^4 preserving the fusion of S^5, two branches of A^4b arising from $A^4b + A^5$ were identified and dissected. Vein 4 (V^4) was identified, and the peripheral side of the intersegmental vein between S^4 and S^5 was exposed (Figs. 1b, 2b). Bronchus 4 (B^4) was identified and dissected using a surgical stapler. Because the tumor was located along the intersegmental vein (Fig. 1b),

✉ Kimihiro Shimizu
kmshimizu@gmail.com

[1] Division of General Thoracic Surgery, Integrative Center of General Surgery, Gunma University Hospital, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan

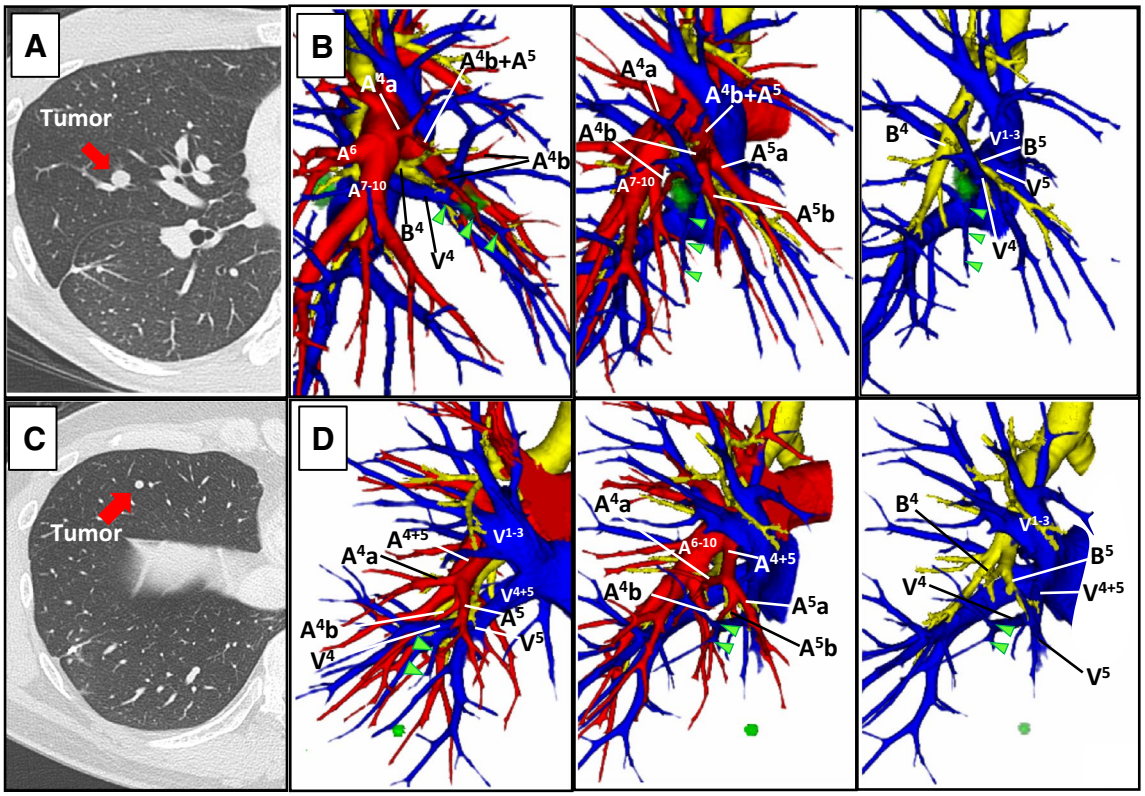

Fig. 1 Multidetector-row computed tomography and three-dimensional computed tomographic angiography and bronchography (3D-CTAB) images of patient 1 (**a, b**) and patient 2 (**c, d**). Three-dimensional computed tomography images analyzed with Ziostation (version 2.1.5; Ziosoft, Redwood city, CA). Reconstructed images of the arteries (red), veins (blue), bronchi (yellow), and tumor (green) are merged into a single 3D-CTAB image. (*A* artery, *B* bronchus, *V* vein). Green arrows indicate the intersegmental vein between S^4 and S^5 (**b, d**)

V^4 was dissected at the root. Finally, we detected a nodule by finger palpation to secure a surgical margin larger than 1 cm and then residual lung parenchyma between S^4 and S^5 was dissected with surgical staplers including the intersegmental vein, (Fig. 2c). We selected surgical staplers for dividing intersegmental plane in this case to secure an adequate surgical margin from nodule. S^2 segmentectomy and wedge RLL resection were performed for the other nodules. Operation time was 310 min and blood loss was 110 g. The patient experienced delayed-onset pulmonary fistula, which resolved with drainage alone. S^8b subsegmentectomy was performed for a contralateral lung nodule 3 months later.

Patient 2

V^{4+5} was identified by dissecting the mediastinal pleura, (Figs. 1d, 2e). A^{4+5} was then identified from the ventral side after dividing the incomplete fissure between the RUL and S^5 preserving the fusion of S^4 (Fig. 2e). A^5a and A^5b arising from A^{4+5} were then identified and dissected (Fig. 1d). V^4 was identified, and the peripheral side of the intersegmental vein between S^4 and S^5 was exposed (Fig. 2f) followed by dissection of V^5. After isolating B^5, selective jet ventilation of S^5 was performed followed by resection with a surgical stapler. Finally, we dissected the peripheral part of the intersegmental plane between S^4 and S^5 using electrocautery along the inflation-deflation line (Fig. 2g). Operation time was 220 min, and blood loss was 10 g. There were no postoperative complications.

The remnant RML showed sufficient volume after inflation in both patients (Fig. 2d, h). To avoid postoperative air leakage, the intersegmental plane was covered with a polyglycolic acid sheet (Neoveil®; Gunze, Kyoto, Japan) and fibrin sealant (Beriplast® P; King of Prussia, PA, USA). Six months postoperatively, we confirmed that lung volume in the remnant RML was preserved in both patients (Fig. 3a). There was no recurrence.

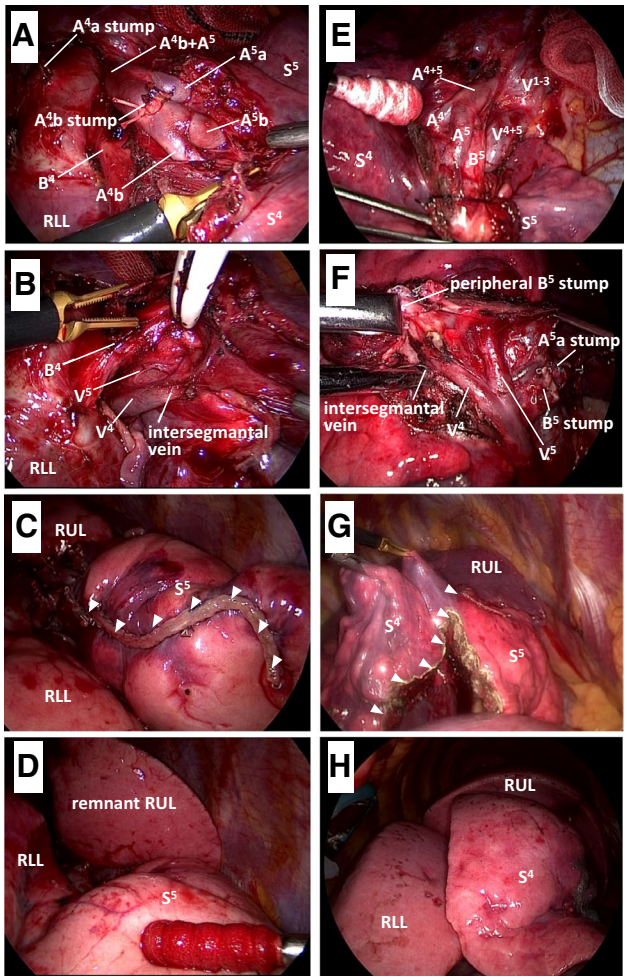

Fig. 2 Intraoperative photographs of patient 1 (**a**–**d**) and patient 2 (**e**–**h**) showing: **a, e** exposure of the arteries and veins; **b, f** exposure of the intersegmental vein from the central part of the lobe; **c, g** dissection of the intersegmental plane, with the white arrows indicating the intersegmental plane between S^4 and S^5; and **d, h** the good expansion of the remnant RML after segmentectomy

Comment

We previously analyzed pulmonary bronchovascular patterns of the RML using three-dimensional computed tomographic angiography and bronchoscopy [3]. The RML bronchus was single-stemmed with no variation. Arteries and veins were mostly classified as either two-stemmed (approximately 70%) or single-stemmed (approximately 30%). Overall, the bronchovascular anatomy of the RML was relatively simple compared with other lobes. The intersegmental plane between S^4 and S^5 is considered flat because S^4 and S^5 are located lateral and medial to the RML, respectively (Fig. 3b), which we confirmed intraoperatively (Fig. 2c, g). Dissection of the intersegmental plane by either surgical staplers or electrocautery was thus, relatively simple especially by thoracoscopic approach. Therefore, we found that RML segmentectomy was a relatively simple surgical procedure compared with other atypical segmentectomies.

Although the RML relative lung volume is generally considered to be approximately 10% of total lung volume [4], volumes were 16 and 11% in our patient 1 and patient 2, respectively. Because patients with multiple metastatic carcinoma may need several operations to achieve complete resections, it is important to preserve lung volume in each resection; therefore, for patients with a large RML, segmentectomy is a valuable lung-sparing procedure. We confirmed that the residual RML expanded well after segmentectomy (Fig. 3a). We consider that the indication of RML segmentectomy includes lung metastasis, non-invasive lung cancer, or nonmalignant diseases located in areas unresectable by wedge resection, in addition, the RML relative lung volume should be more than 10% of total lung volume.

RML torsion occasionally occurs after RUL resection in patients with well-lobulated RMLs. Therefore, to prevent similar torsion in the remnant RML after segmentectomy, we avoided excessive dissection of the interlobar fissure between the remnant RML and the RUL or RLL. This may be an important technical point in RML segmentectomy.

In conclusion, we showed that thoracoscopic RML segmentectomy is technically feasible. Although candidates are limited, RML segmentectomy may be valuable to preserve lung volume in patients with lung metastasis, non-invasive lung cancer, or nonmalignant diseases.

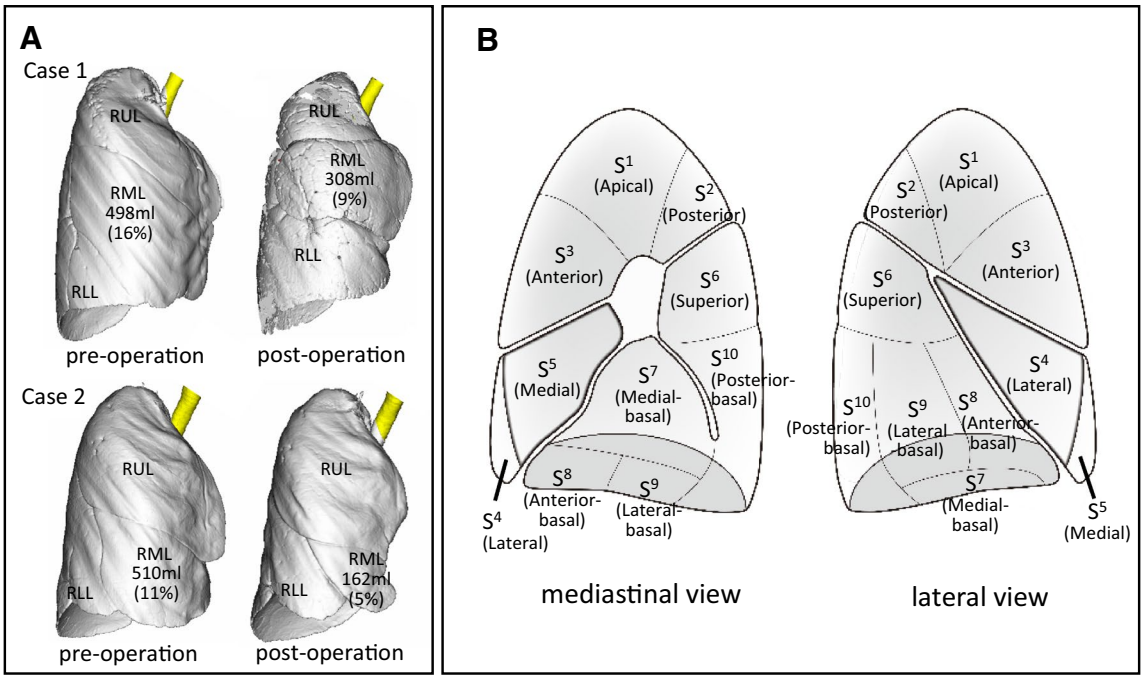

Fig. 3 **a** Three-dimensional computed tomography images from lateral views before and after operation in patients 1 and 2. Computed tomographic images were transferred and analyzed on a three-dimensional workstation using Ziostation (*RUL* right upper lobe, *RML* right middle lobe, *RLL* right lower lobe). The volume of each lobe was calculated using Synapse Vincent (Fuji Film Co., Ltd., Tokyo, Japan). **b** Schema of the segmental anatomy of the right lung. The lateral and medial segments occupy the lateral and mediastinal part of the right middle lobe, respectively

Funding There was no funding for this study.

Compliance with ethical standards

Conflict of interest All authors participated in this study and agree on the content of this manuscript. No author has any financial or other relationships that could lead to a conflict of interest.

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