Case Report: iMDT Corner

Rare complex anatomical variation of right pulmonary vessels and bronchi: a case report

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Background: The patterns of bronchopulmonary vascular bifurcation within the lung exhibit considerable diversity. To perform safe and accurate anatomical pulmonary resections, an understanding of the anatomy of the pulmonary vessels and bronchi, including variations, is of utmost importance to general thoracic surgeons.

Case Description: We performed a 3-dimensional (3D) computed tomography (CT) reconstruction of the pulmonary vessels and bronchi for a 66-year-old female patient. From the 3D reconstruction, we were able to observe clearly that this patient had complex variations in the right pulmonary artery, vein, and bronchus. Not only the bronchi and vessels of the right upper lobe, but also the vessels and bronchi of the middle and lower lobes are also variable. Due to this, we performed video-assisted right upper lobectomy and mediastinal lymph node dissection for her without misjudgment of the pulmonary vessels and bronchi. The patient recovered well and was discharged after 3 days.

Conclusions: We first report a very rare case involving complex variations in the right pulmonary artery, vein, and bronchus in a single patient using 3D reconstruction technology. We hope this article can remind all thoracic surgeons to evaluate the variations of pulmonary blood vessels and bronchi thoroughly and comprehensively before surgery and formulate appropriate surgical plans to ensure the successful implementation of the surgery.

Keywords: Anatomical variation; right pulmonary; pulmonary vessels; pulmonary bronchi; case report

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Introduction

The patterns of bronchopulmonary vascular bifurcation within the lung exhibit considerable diversity. For general thoracic surgeons, it is extremely important to have a complete understanding of the anatomy of the pulmonary vessels and bronchi, including anatomical variations, to perform safe and accurate anatomical pulmonary resections (1). In the past, preoperative computed tomography (CT) imaging was the sole method available for assessing patients' pulmonary anatomy, which often lacked intuitive clarity. However, the advent of 3-dimensional (3D) reconstruction technology has significantly enhanced preoperative planning. Numerous studies have demonstrated that 3D reconstruction technology provides a more precise representation of the anatomical structures and variations of pulmonary blood vessels and bronchi (2-6). In this article, we report on a rare case involving complex variations of the right pulmonary bronchi, arteries, and veins. The nomenclature used in this paper are based on the "Illustrated Anatomical Segmentectomy for Lung Cancer" atlas by Nomori and Okada (7). We

present this article in accordance with the CARE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1073/rc).

Case presentation

A 66-year-old female patient was admitted to our department with a peripheral solid nodule approximately 1.5 cm in diameter in the right upper lobe (*Figure 1A*), which was detected by a chest CT scan. It was highly suspected to be early-stage lung cancer, and video-assisted right upper lobectomy was planned. During the preoperative CT imaging examination, we identified anatomical variations of the patient's right pulmonary bronchi, arteries, and veins. We further performed a 3D CT reconstruction of the pulmonary vessels and bronchi using Mimics Medica 21.0 software (Materialise, Belgium) for this patient.

From the 3D reconstruction, we were able to observe clearly that the apical and anterior segmental bronchi (B1+3) shared a common trunk, which arose from the lateral wall of the right main bronchus at the level of the carina. The posterior segmental bronchus (B2) was laterally displaced, arose separately from the right main bronchus (under B1+3), and subsequently divided into two branches: the posterior branch (B2a) and the lateral branch (B2b) (*Figure 1B-1D*). The right middle lobe bronchus (RMB) originated normally from the right intermediate pulmonary bronchus, but the inner basal segmental bronchus (B7) of the right lower lobe bronchus (RLB) was absent (*Figure 1D*).

Regarding the arterial abnormalities, in addition to the truncus anterior (TA), which contained the apical segmental artery (A1), the anterior segmental artery (A3), and the recurrent artery (Rec.A2) of the posterior segment (S2), at the intermediate pulmonary artery, there were 2 ascending A2 (Asc.A2), which we called double Asc.A2, that split off and distributed side by side to independently supply the lateral sub-segment of the independent S2 (*Figure 2*). Correspondingly, due to the absence of B7, the artery of the inner basal segment (A7) was also absent.

The variations in the veins of the right pulmonary were even more complex. The right superior vein (SPV) contained only the central vein (CV), which drained from all the apical and anterior segments (S1+3) as well as part of the independent S2. In addition, a variant vein originated from the uppermost of the right inferior pulmonary vein (IPV) and drained from the independent S2 through the posterior mediastinum (*Figure 3*). Furthermore, the right middle lobe vein drained into the IPV, rather than the SPV (*Figure 3B-3D*).

The intraoperative pathology of the patient indicated invasive adenocarcinoma. We performed video-assisted right upper lobectomy and mediastinal lymph node dissection. Postoperative pathology suggested stage IA, and the surgical procedure was successful without misjudgment of the blood vessels. The patient recovered well and was discharged after 3 days.

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.

Highlight box

Key findings

- We report a very rare case involving complex variations in the right pulmonary artery, vein, and bronchus.

What is known and what is new?

- Previous articles have described various bronchial and vascular variations.
- This is the first report of a rare complex anatomical variation of right pulmonary vessels and bronchi.

What is the implication, and what should change now?

- All thoracic surgeons need to evaluate the variations of pulmonary vessels and bronchi thoroughly and comprehensively to ensure the successful implementation of the surgery.

International Multidisciplinary Team (iMDT) discussion

Discussion among physicians from Lishui Municipal Central Hospital

An understanding of the anatomy of the pulmonary blood vessels and bronchi, including variations, is of utmost importance to general thoracic surgeons. Misjudging the anatomy may lead serious complications (8). Previously, we could only rely on preoperative CT images to understand the patients' pulmonary anatomy, which was not always intuitive. However, currently, 3D reconstruction technology is widely used. Many studies have shown that 3D reconstruction technology can more accurately demonstrate the anatomical

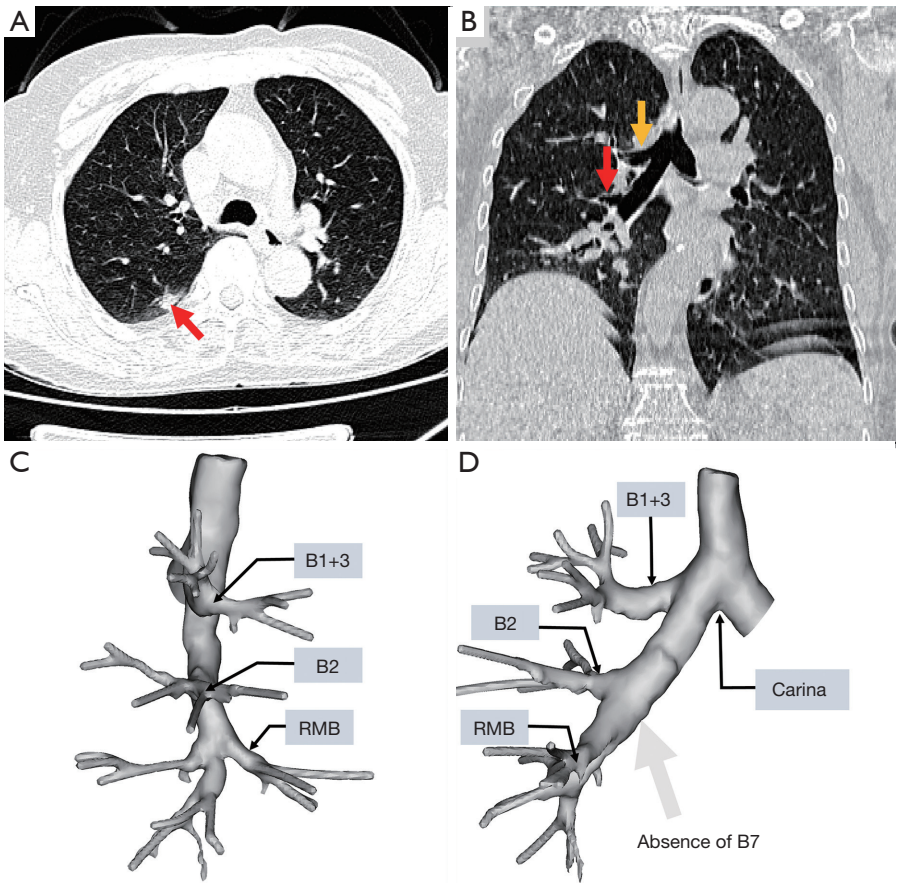

Figure 1 CT images of pulmonary nodule and bronchi variation. (A) (CT axial image) A nodule in the right upper lobe (red arrow). (B) (CT coronal image) B1+3 (yellow arrow) arose from the right main bronchus at the level of the carina. The displaced B2 (red arrow) arose separately from the right main bronchus (under B1+3). (C) (3D right lateral view) Separated B1+3 and B2. (D) (3D anterior view) Separated B1+3 and B2, absent B7. B1+3, apical and anterior segmental bronchi; B2, posterior segmental bronchus; RMB, right middle lobe bronchus; B7, inner basal segmental bronchus; CT, computed tomography; 3D, 3-dimensional.

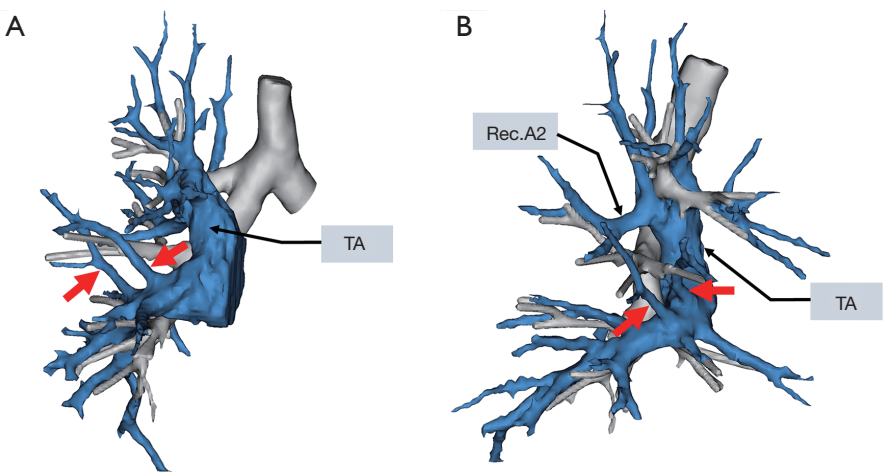

Figure 2 TA and double Asc.A2 (red arrows). (A) 3D anterior view. (B) 3D right lateral view. TA, truncus anterior; Rec.A2, recurrent artery; Asc.A2, ascending A2; 3D, 3-dimensional.

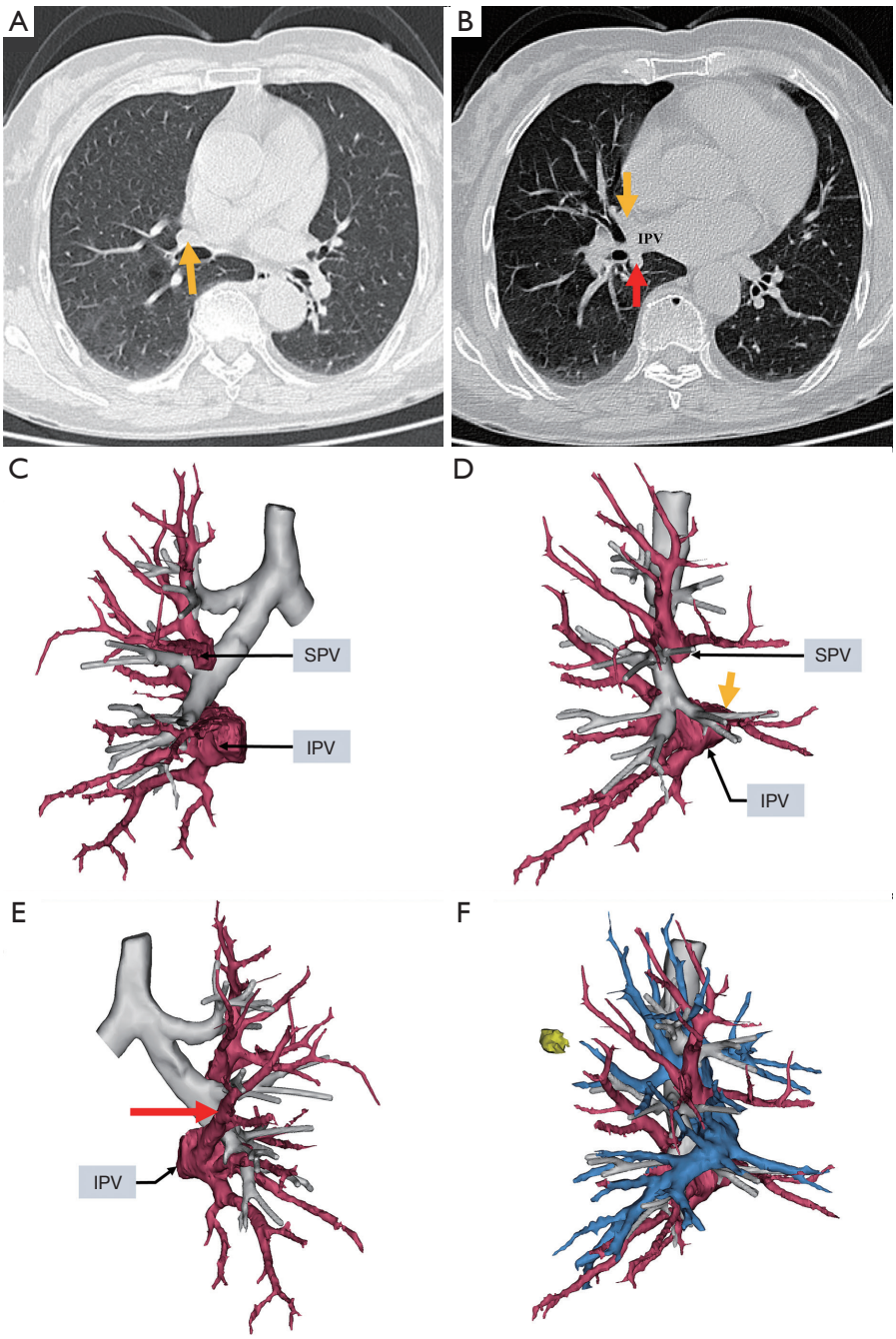

Figure 3 Veins variation and the 3D anatomical structure of the nodule and right lung vessels and bronchi. (A) (CT axial image) SPV (yellow arrow) contained only CV. (B) (CT axial image) Right middle lobe vein (yellow arrow) drained into the IPV, a variant vein (red arrow) originated from the uppermost of IPV drained from the independent S2 through the posterior mediastinum. (C) (3D anterior view) Branching patterns of the right pulmonary veins. (D) (3D right lateral view) Right middle lobe vein (yellow arrow) drained into the IPV. (E) (3D posterior view) The variant vein (red arrow) originated from the IPV drained from the independent S2. (F) (3D right lateral view) The 3D anatomical structure of the nodule and right lung vessels and bronchi. IPV, inferior pulmonary vein; SPV, superior vein; 3D, 3-dimensional; CT, computed tomography; CV, central vein.

structure and variations of the pulmonary blood vessels and bronchi before surgery, guide surgeons to perform surgeries more safely, reduce intraoperative bleeding, save surgery time, and facilitate improved patient recovery (2-6). The study by Seguin-Givelet *et al.* showed that preoperative 3D modeling and tracking simplified the steps of thoracoscopic segmentectomy and should be considered as part of the surgery (9). Xie *et al.* used 3D technology to evaluate the practical classification patterns of the pulmonary arteries and bronchi in 358 patients. These data can be used by clinicians for teaching pulmonary artery anatomy and preoperative preparation for anatomical lobectomy (10).

However, 3D technology had some limitations, including the duration necessary for preoperative reconstruction and, in certain instances, the associated costs. Therefore, our center only performed 3D reconstruction in patients with abnormalities found in CT images or in patients who need complex lung segmentectomy.

We also utilized preoperative chest CT images to roughly understand the patient's anatomical variations, and consequently applied 3D reconstruction to further visualize the intricate anatomical variations of the right pulmonary vessels and bronchi, ultimately accomplishing the surgery successfully.

We conducted a comprehensive review of prior studies that investigated bronchial and vascular variations in the right lung utilizing 3D reconstruction, bronchoscopy, or autopsy specimens (1,11-14). These articles described various bronchial and vascular variations. However, complex bronchial and vascular variations in a single patient like those described in this article have not been reported. Anatomical abnormalities of the S2 have been documented in several case reports (15-17). However, other complex variants similar to those found in the present case have not been reported in these cases. Nagashima *et al.* (1) conducted an analysis of variations in the right upper pulmonary bronchovascular structures in a cohort of 263 patients using three-dimensional reconstruction techniques. Their findings indicated that the incidence of the CV type (where V1–3 drain into the CV) was 7%, and the incidence of V2 associating with the lower pulmonary vein was 1.9%. However, the study did not describe the specific subtype of the CV+ variation in V2, nor did it report any bronchial or arterial variations similar to those observed in the present case. Nagashima *et al.* conducted another study involving 3D reconstructions derived from a cohort of 270 patients, through which they identified variations in the bronchovascular structures of the right middle and lower lobes (18). Their findings indicated that the incidence of complete merging of the middle lobar vein into the lower lobar vein was 4.1%, while the incidence of partial merging was 3%. Notably, the study did not report any instances of a missing B7 or A7.

Several issues on the diagnosis and treatment of this patient were further discussed as follows

Question 1: What should we do if we find a variant pulmonary vessel which is unclear before surgery?

Expert opinion: Dr. René H. Petersen

When the anatomy is unclear on CT, a 3D reconstruction should be performed. If a segmentectomy is planned a 3D reconstruction is recommended according to the European Society of Thoracic Surgeons (ESTS) Consensus document, published recently (19). During surgery it is recommended to do careful dissection of hilar structures before division.

Question 2: Misjudgment of the blood vessel and ligation, how should we remedy it?

Expert opinion: Dr. René H. Petersen

If a vein accidently is ligated, necrosis most likely will occur and the corresponding segment/lobe should be removed. If an artery is accidently ligated, the area will not be perfused, however no necrosis will usually occcur. If it is a small vessels, no further action is needed, however if a major vessel is transected, an anastomosis should be performed.

Question 3: In addition to 3D reconstruction, what other techniques do we have to help us better understand the anatomy of pulmonary bronchovascular anatomy?

Expert opinion: Dr. René H. Petersen

Intraoperative careful dissection before dividing any hilar structures may promote accidental transection. This was recommended in an analysis of major intraoperative complications during video-assisted thoracoscopic anatomical lung resections from the ESTS MITIG group (Minimally Invasive Thoracic Surgery Interest Group) (8).

Conclusions

To our knowledge, complex variations involving the right pulmonary bronchi, arteries, and veins such as this case have not been reported in previous literature. We hope this article can remind all thoracic surgeons to evaluate the variations of pulmonary blood vessels and bronchi

thoroughly and comprehensively before surgery and formulate appropriate surgical plans to ensure the successful implementation of the surgery.

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Footnote

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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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