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Case Report

Venous Branching Pattern in a Patient with Hemorrhagic Infarction in the Lingula after the Upper Division Resection of the Left Lung

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Background: Because left upper division resection is similar to right upper lobectomy, this procedure is frequently employed. Few studies have used the anatomic courses of veins evaluated on preoperative computed tomography (CT) imaging to determine what types of patients are at the highest risk for hemorrhagic pulmonary infarction.
Case: We describe our experience with a patient in whom hemorrhagic pulmonary infarction occurred at 6 days after transecting two superior branches (V^1 and V^3) of the three branches of the left superior pulmonary vein. We preoperatively confirmed that small-caliber lingular veins were perfused by V^3. However, the patient had a poor pulmonary function, and the tumor was located distal to V^3. Left upper division resection was therefore performed.
Conclusion: The division of V^3 could be the cause of hemorrhagic infarction in the lingular segment after upper division segmentectomy.

Keywords: venous branching pattern, left upper division resection, lingular hemorrhagic infarction, lung cancer, thoracoscopic surgery

Introduction

Two surgical textbooks recommend that the superior branches of the left superior pulmonary vein should be transected, and the middle branch of the left superior pulmonary vein (V^3) should be preserved during left upper division resection.[1,2] However, another textbook recommends that V^1 and V^3 should be transected at their origins, and only the lingular vein preserved.[3] Another textbook vaguely recommends that V^3 should be preserved if it is of large caliber.[4] To our knowledge, very few studies have used the anatomic courses of veins evaluated on preoperative computed tomography (CT) imaging to determine what types of patients are at the highest risk for hemorrhagic pulmonary infarction caused by few remaining veins after transection of the V^3 in left upper division resection. We described our experience with a patient with lung cancer who underwent left upper division resection. Pulmonary infarction developed after the transections of V^1 and V^3 at their origin, preserving only the lingular vein. We reported the clinical course of this patient, including the anatomical characteristics of the pulmonary veins.

Because there are no internationally accepted symbols for describing subsegments, Yamashita's abbreviations for the subsegments[5] are used in the figures and text of this report (**Table 1**). Although V^3a and V^3b indicate veins that run between the upper division and lingular segment in textbook, there are many variations of the venous branching pattern especially in the left upper lobe.

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Table 1 Anatomical abbreviations of lung segments and segmental pulmonary veins and other abbreviations

$S^{1+2}b$: subapical posterior subsegment of apicoposterior segment
^{S1+2}c: horizontal subsegment of apicoposterior segment
S^3a: lateral subsegment of anterior segment
S^3b: medial subsegment of anterior segment
S^3c: superior subsegment of anterior segment
V^1: superior branch of left superior pulmonary vein draining mainly the apicoposterior segment
V^3: middle branch of left superior pulmonary vein draining mainly the anterior segment
Lingular veins: lowermost branch of left superior pulmonary vein draining mainly the lingular division
V^2b: postlateral vein between S1+2b and S1+2c
V^3a: lateral vein between S3a and S3b
V^3b: anterior vein between S3b and S4
V^3c: superior vein between S3b and S3c
CT: computed tomography
HRCT: high-resolution computed tomography
COPD: chronic obstructive pulmonary disease
$FEV_{1.0}$: forced expiratory volume in one second
Metasequoia: a three-dimensional modeling software
CTTRY: our homemade software

Case Report

The patient was a 70-year-old man who presented with dyspnea on effort. CT of the chest revealed a mass measuring 16 × 20 mm in the upper lobe of the left lung. Positron emission tomography showed the increased uptake of fluorodeoxyglucose with a maximum standardized uptake value of 13.4 at the mass. On pulmonary function testing, the forced vital capacity was 3.35 L, and the forced expiratory volume in one second ($FEV_{1.0}$) was 1.10 L. However, treatment with a bronchodilator allowed his $FEV_{1.0}$ to increase to 1.49 L. No diagnosis was reached on bronchoscopic examination. Therefore, three-dimensional image models of the bronchi and pulmonary vessels at the hilum (**Fig. 1**) were constructed from the CT data, and upper division segmentectomy was thoracoscopically performed.[6] The superior and middle branches of the left pulmonary vein (V^1 and V^3) were transected at their origins in accordance with the preoperative plan, and upper division resection was performed. Veins coursing between the superior segment and the lingular region were included in the resection (**Fig. 1**). Frozen-section examination revealed that the resected mass was squamous cell carcinoma. Lymph nodes at the hilum were also sampled and submitted for frozen-section examination, and no metastasis was found. The patient recovered uneventfully after surgery. However, the patient began to complain about bloody sputum on the morning of postoperative day 6. The body temperature was 37.6°C, with a white-cell count of 10.14 × $10^3/\mu L$. Bronchoscopy showed the edema-like stenosis

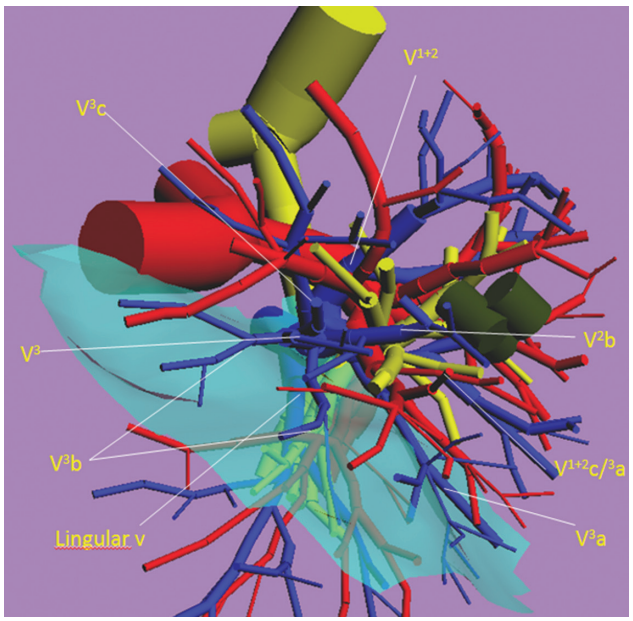

Fig. 1 A three-dimensional model of the bronchi (yellow), pulmonary arteries (red), pulmonary veins (orange), and mass (black) of the patient, created from preoperative HRCT images with Metasequoia shareware using CTTRY (2), and the cut surface at initial surgery (light blue-green). The mass was located between $S^{1+2}b$ and $S^{1+2}c$. As for the branching pattern, V^2b coursed through the mass, merged with a vein arising between $S^{1+2}c$ and S^3a, and then merged with V^3a, V^3b, and V^3c to become V^3. On contrast-enhanced HRCT, the caliber of V^3a was 2.5 mm. The root diameters of the other branches measured on contrast-enhanced HRCT were as follows: V^1, 5.8 mm; V^3, 8.8 mm; V^3c, 7.1 mm; the vein formed by the confluence of V^2b, V^3a, V^3b, and other branches, 4.8 mm; and lingular vein, 4.8 mm. All abbreviations are given in **Table 1**. HRCT: high-resolution computed tomography

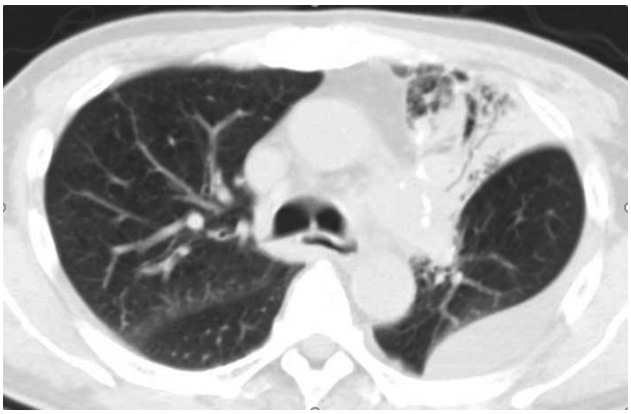

Fig. 2 A CT scan of the patient's chest obtained on postoperative day 6, showing consolidation associated with air bronchograms in the lingular segment of the left lung and plural effusion in the left side of the thoracic cavity. CT: computed tomography

of the lingular bronchi with blood inside the lumina. There were no abnormalities at the stump of the superior segmental bronchi. CT of the chest demonstrated consolidation with air bronchograms with loss of more than half of the air volume in the lingular region (**Fig. 2**). Pulmonary infarction caused by torsion and excessive venous resection was suspected, and reoperation was performed thoracoscopically again. The lingula had become dark purple and was friable, with no adhesion to the thoracic cavity. However, there was no evidence of torsion. Left lingulectomy was thus performed. Histopathological examination showed bleeding and tissue necrosis, indicating hemorrhagic infarction. The infarction was found to be stronger in S^4 and spread in S^5. No thrombi were found in both the arteries and veins of the resected lung. The patient was discharged from the hospital on day 9 after the second operation. At 10 years after surgery, there has been no recurrence.

Discussion and Conclusion

In our patient, we preoperatively confirmed that some of the veins in S^4 drained into V^3. Three veins that drained from S4 toV3 were found, and the calibers of those veins were approximately 1 mm for two and less than 1 mm for one. However, lymph-node dissection was facilitated by the following conditions: 1) the branches from S^4 were of small caliber and 2) the mass was located distal part to V^3 (**Fig. 1**). We therefore divided V^1 and V^3. We decided to perform upper division resection rather than left upper lobectomy because the patient had decreased pulmonary function, and we considered it important to preserve the lung tissue as much as possible. Consequently, some of the veins for draining in the lingular region were transected, resulting in decrease in the drainage capacity. Subclinical or latent congestion could exist in the site just after surgery, gradually progressed with time, and eventually clinically appeared on postoperative day 6. In these patients, we believed that V^3 should be preserved or the left upper lobectomy should be initially performed. In the authors' institution, the upper division resections of the left lung were performed in 54 cases with lung cancer, metastatic lung tumor, and infection from January to December 2016. In 45 of total 54 cases, three-dimensional image models, where the bronchi and pulmonary vessels at the hilum were constructed from the CT data, were prepared before surgeries, and in those cases, V^{1+2} type in five cases were performed by V^1 and V^3 cutting technique, and for other type cases, non-V^3-cutting technique was used. No cases showing symptoms similar to those observed in the patients of this report were found. However, one case without making three-dimensional image model was treated by V^1 and V^3 cutting technique and showed symptoms similar to those observed in the patients of this report.

Compared with reports on infarction in the middle lobe after the transection of the right upper-lobe, there have been a few reports about infarction in the lingular segment after the resection of the upper division.[7] To our knowledge, hemorrhagic infarction in the absence of torsion after left upper division segmentectomy has not been reported previously. Surgically, division of the two superior branches of the left superior pulmonary vein with preservation of the lowermost lingular vein is technically easy to be accomplished.[8] One textbook 4) recommends that whether V^3 is preserved or not should be empirically decided intraoperatively on the basis of the caliber of V^3. Venous branching patterns are diverse, and V^3 drains only S^3 in some patients. In other patients, V^3 drains S^{1+2}b and S^{1+2}c as well as S^3, similar to the patient in this report. Because of these complex venous branching patterns, the implications of different root-diameter ratios remain unclear. Our patient had a history of heavy smoking and chronic obstructive pulmonary disease (COPD), which could contribute to the development of pulmonary hemorrhagic infarction.

Disclosure Statement

The authors report no conflicts of interest.

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