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Intraoperative bronchial blood flow evaluation using indocyanine green fluorescence for bronchoplasty: A case report

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ABSTRACT

INTRODUCTION AND IMPORTANCE: Blood flow evaluation of bronchial arteries using indocyanine green fluorescence (ICG-FL) is rarely reported during pulmonary resection. We present the case of a patient with bronchiectasis and a history of bronchial artery embolization (BAE) for hemoptysis. Bronchial artery blood flow was evaluated using ICG-FL during lobectomy with bronchoplasty.

CASE PRESENTATION: A 63-year-old woman presented with right middle lobe bronchiectasis (due to nontuberculous mycobacteriosis) and repeated hemoptysis, which had previously been corrected each time with hemostasis by BAE. Bronchoscopy revealed a swollen blood vessel proximal to the right middle lobe bronchus that was suspected of being the origin of bleeding. Right middle lobectomy with bronchoplasty was performed to prevent hemoptysis. ICG-FL was used to detect the patency of the right bronchial arteries, and the arteries surrounding the right middle lobe bronchus were ligated. The proximal side of the right middle lobe bronchus was cut in a deep wedge shape, and the bronchus was anastomosed. ICG-FL revealed that the blood supply was maintained at the bronchial anastomosis. No bronchial anastomotic leakage was observed after the surgery.

CLINICAL DISCUSSION: The key to successful bronchoplasty is the maintenance of blood flow. Bronchial artery blood flow theoretically decreases after BAE. In this case, ICG-FL was able to detect bronchial artery patency before cutting the bronchus as well as the maintenance of blood flow at the bronchial anastomosis after bronchoplasty.

CONCLUSION: Intraoperative blood flow evaluation of the bronchus using ICG-FL may reduce the risk of bronchial anastomotic leakage caused by ischemia after bronchoplasty.

1. Introduction

Indocyanine green fluorescence (ICG-FL) has been used for intraoperative evaluation during thoracic surgery, including visualization of adjacent lung segments [1], identification of the location of small pulmonary nodules [2], and blood flow evaluation of muscle flaps [3]. Blood flow evaluation of the bronchial artery using ICG-FL has rarely been reported [4,5]. We report the surgical case of a patient with bronchiectasis and a history of repeated bronchial artery embolization (BAE) for hemoptysis. To our knowledge, this is the first report evaluating bronchial artery blood flow using ICG-FL after BAE.

This case report has been reported in line with the SCARE Criteria [6].

2. Presentation of case

The patient was a 63-year-old woman with right middle lobe bronchiectasis caused by nontuberculous mycobacteriosis who had repeated hemoptysis (Fig. 1a). The patient was taking erythromycin and ambroxol for bronchiectasis. The patient had no history of smoking or family history of lung disease. BAE using metallic coils and a gelatin sponge was performed for hemoptysis, and hemostasis was achieved each time. In the last 5 months, hemoptysis requiring mechanical ventilation occurred three times. The most recent BAE was performed 2 months before surgery. Since recanalization of the embolized right bronchial arteries was observed (Fig. 1b), these arteries were repeatedly embolized (Fig. 1c). Bronchoscopy revealed a swollen blood vessel running from the distal

Abbreviations: ICG-FL, indocyanine green fluorescence; BAE, bronchial artery embolization; POD, postoperative day.

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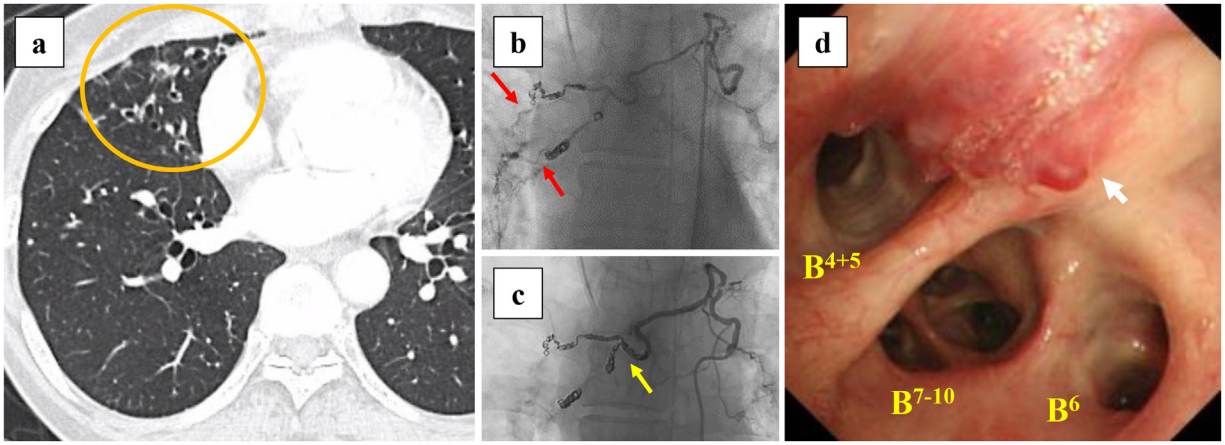

Fig. 1. Preoperative imaging findings.
(a) Computed tomography scan showing bronchiectasis of the right middle lobe (orange circle). Bronchial artery embolization findings at the time of hemoptysis (2 months before the surgery) showing (b) recanalization of the embolized right bronchial arteries (red arrows), and (c) repeated embolization using metallic coils (yellow arrow) and a gelatin sponge. (d) A bronchoscopic image showing a swollen blood vessel running from the distal side of the truncus intermedius to the proximal side of the right middle lobe bronchus (white arrow).

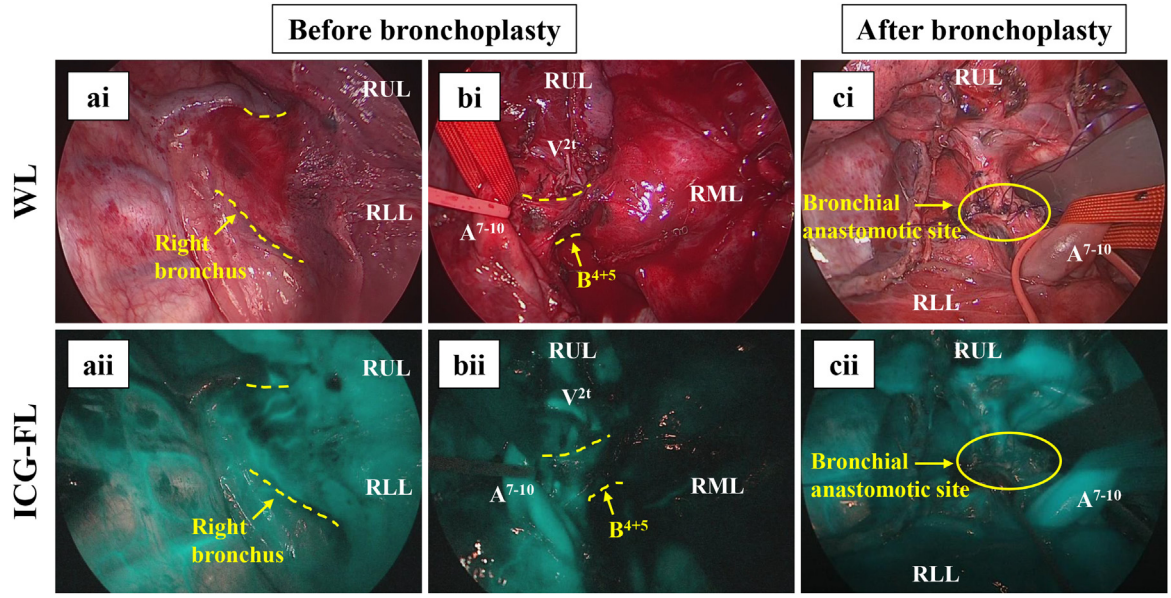

Fig. 2. Intraoperative blood flow evaluation of bronchus using indocyanine green fluorescence (ICG-FL).
(ai, aii, bi, bii) Patency of right bronchial arteries revealed prior to bronchoplasty. (ci, cii) Maintenance of blood flow at the bronchial anastomosis revealed after bronchoplasty. WL, white light mode; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe.

side of the truncus intermedius to the proximal side of the right middle lobe bronchus (Fig. 1d), and this vessel was suspected of being the bleeding point. Surgical resection was required to prevent repeated hemoptysis, and informed consent was obtained from the patient.

Right middle lobectomy with bronchoplasty was performed via thoracotomy. The pulmonary arteries (A^4, A^5) and veins (V^4 and V^5) were cut. A^6 was injured during lobulation between the upper and lower lobes and was sacrificed to achieve hemostasis. ICG (5 mg/body) was intravenously injected, and the patency of the right bronchial arteries was detected using infrared thoracoscopy (IMAGE1 S^{TM} system, SPECTRA A mode; KARL STORZ Endoskope, Japan K.K., Tokyo, Japan) (Fig. 2ai, aii, bi, bii). The bronchial arteries surrounding the right middle lobe bronchus were ligated. The proximal side of the right middle lobe bronchus was cut in a deep wedge shape, and the bronchus was anastomosed using interrupted suturing. ICG (5 mg/body) was intravenously injected again, and maintenance of blood supply at the bronchial anastomosis was observed (Fig. 2ci, cii). The bronchial anastomosis was wrapped with a pedicled intercostal muscle flap. The operation time was 250 min, and the volume of blood loss was 300 mL.

Histopathological findings revealed an abnormally thick artery (100 μm diameter) in the lamina propria of the bronchus; this artery was suspected of being the bleeding point (Fig. 3a–c). Chest radiography on postoperative day (POD) 3 revealed atelectasis of the right lower lobe, which improved following physical therapy (Fig. 4a, b). Postoperative air leakage had resolved by POD 7, and the chest drain tube was removed on POD 9. Bronchoscopy on POD 13 revealed stenosis of the right lower lobe bronchus due to postoperative edema at the bronchial anastomosis (Fig. 4c). The patient was discharged on POD 16. No hemoptysis was observed at the 5-month follow-up visit. Bronchoscopy did not reveal vascular lesions inside the bronchus, and improvement of the edema at the bronchial anastomosis was observed (Fig. 4d).

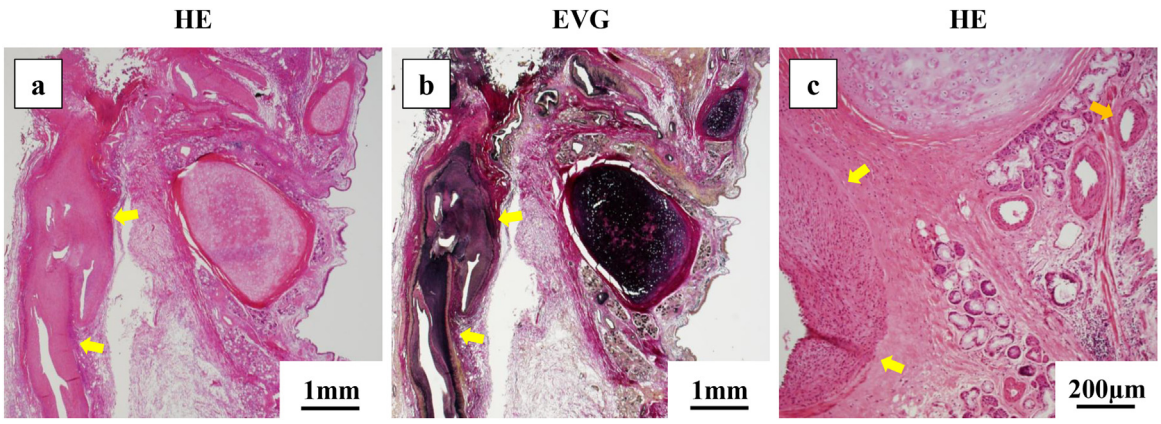

Fig. 3. Histopathological findings.
(a, b, c) A 1.5 mm diameter bronchial artery with a thick wall caused by proliferation of elastic fibers and collagen fibers runs meander in the bronchial adventitia (yellow arrows). An abnormally thick artery (100 μm diameter) is observed in the lamina propria (orange arrow), suggesting the bleeding point. HE, hematoxylin and eosin staining; EVG, Elastica Van Gieson staining.

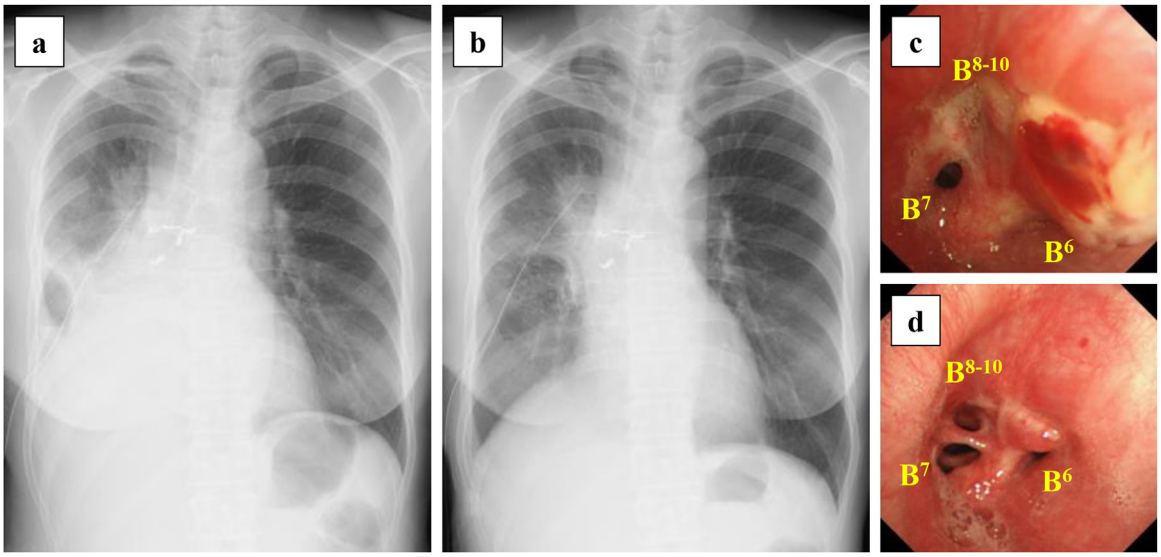

Fig. 4. Postoperative imaging findings.
(a) Chest radiography on postoperative day (POD) 3 showing atelectasis of the right lower lobe. (b) Chest radiography on POD 7 showing that atelectasis had improved following physical therapy. (c) A bronchoscopic image on POD 13 showing stenosis of the right lower lobe bronchus due to postoperative edema at the bronchial anastomosis. (d) A bronchoscopic image 3 months after the surgery showing no vascular lesions inside the bronchus, and improvement of the edema in the right lower lobe bronchus.

3. Discussion

BAE is generally performed to treat hemoptysis, with a reported procedural success rate of 93.4% [7]. In Japan, metallic coils and gelatin sponges are commonly used for BAE [7,8]. The recurrence-free hemoptysis rate was reported to be 89.0% and 75.9% at 1 and 2 years, respectively, for nontuberculous mycobacteriosis, and 87.6% and 85.1% at 1 and 2 years, respectively, for bronchiectasis [7]. The most common mechanism causing repeated hemoptysis after BAE is recanalization of embolized blood vessels [9], in which is consistent with this case. Based on the above, patients with bronchiectasis often develop recurrent hemoptysis, and surgical treatment is recommended if the lesion is localized [10]. In patients with bronchiectasis, the reported postoperative symptom improvement rate is 71–75% [11,12]. Notably, the symptom improvement rate is higher when the lesions are completely resected [11]. Blood vessel swelling inside the bronchus, which was the bleeding point in this case, can result from hypervascularity or dilation of the bronchial arteries [13]. In this case, since bronchial ectasia and the swollen bronchial blood vessel were completely resected, rebleeding was not observed after the surgery.

Because of the localization and bleeding pattern in this case, right middle lobectomy with bronchoplasty was required for complete removal of the target lesions. Right middle lobectomy with bronchoplasty is reported to account for 1.3–2.0% of pulmonary resections requiring bronchoplasty [14,15]. The key to successful bronchial anastomosis includes relieving tension and maintaining blood flow [5]. It is necessary to release the surrounding tissue to reduce the tension between the anastomotic sites of the bronchus, although this maneuver carries the risk of reducing bronchial blood flow [4]. In this case, although the blood flow of the bronchial arteries was expected to be decreased by BAE, ICG-FL was able to detect the patency of these vessels before cutting the bronchus as well as the maintenance of blood flow at the bronchial anastomosis after bronchoplasty. One limitation of this report is that blood flow evaluation cannot be shown as objective data. In the future, it will be beneficial to develop a procedure to quantify blood flow.

4. Conclusion

ICG-FL can easily detect bronchial blood flow during surgery. Intraoperative blood flow evaluation of the bronchus using ICG-FL may reduce the risk of bronchial anastomotic leakage caused by ischemia after bronchoplasty.

Declaration of Competing Interest

The authors report no declarations of interest.

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Ethical approval

Ethical approval was not required for our paper because case reports are exempt from ethical approval at our institute.

Consent

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 Editor-in-Chief of this journal on request.

Author contribution

Nobutaka Kawamoto performed the operation, acquired the data, and drafted the manuscript.

Riki Okita assisted in the operation and conducted the entire study.

Masataro Hayashi assisted in the operation.

Ryo Suetake performed medical treatment and bronchoscopy.

Tomoyuki Murakami diagnosed the patient based on the pathological findings.

Hidetoshi Inokawa supervised the writing of the manuscript.

All authors have read and approved the final manuscript.

Registration of research studies

Not Applicable.

Guarantor

Nobutaka Kawamoto.

Provenance and peer review

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