

Intraoperative Inhalation of Indocyanine Green for Near-Infrared Visualization of Adult Intralobar Pulmonary Sequestration

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Case Report

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Additional Declarations: No competing interests reported.

Abstract

Background

The border between sequestered and normal lung in intralobar pulmonary sequestration (ILS) is often indistinct, complicating precise resection. Intravenous indocyanine green (ICG) can outline a perfusion-based boundary but requires prior control of the aberrant systemic artery and does not directly reflect the airway isolation that defines ILS.

Case Presentation

: Four adults with contrast-enhanced CT-confirmed ILS underwent video-assisted thoracoscopic surgery with intraoperative unilateral ICG inhalation. After single-lung ventilation, aerosolized ICG (2.5 mg/mL) was delivered via a nebulizer connected to the double-lumen tube for 10 to 15 minutes. Near-infrared thoracoscopy showed homogeneous fluorescence in ventilated normal lung and no fluorescence in sequestered tissue, producing a clear demarcation. Three patients underwent wedge resection; one with extensive basal segment involvement underwent lobectomy. No ICG-related adverse events occurred, and all patients recovered uneventfully.

Conclusions

Intraoperative aerosolized ICG inhalation safely and directly visualizes the ventilation-based boundary characteristic of adult ILS, enabling early lesion mapping and selection of the least extensive complete resection.

Background

Pulmonary sequestration is nonfunctional lung parenchyma supplied by aberrant systemic arteries. In intralobar pulmonary sequestration (ILS), the border between diseased and normal lung is frequently obscure, and lobectomy is often selected to avoid residual sequestered tissue.^{1,2} Intravenous indocyanine green (ICG) can identify a perfusion-based boundary after vascular control,³ whereas aerosolized ICG may exploit the ventilation defect of ILS: ventilated normal lung fluoresces and the sequestered lung remains unstained. We describe 4 adult ILS cases managed with intraoperative unilateral ICG inhalation and near-infrared (NIR) thoracoscopy.

Case presentation

Four adults underwent video-assisted thoracoscopic surgery (VATS) for contrast-enhanced computed tomography (CT)-confirmed ILS. Patient 1 was a 33-year-old woman with cough, sputum production, and hemoptysis for 2 months; CT showed posterior basal right lower lobe consolidation supplied by an artery

from the celiac trunk (Fig. 1). Patient 2 was an asymptomatic 57-year-old man with a small lesion in the medial basal segment of the left lower lobe supplied by the descending aorta (Figure S1). Patient 3 was a 63-year-old woman with occasional cough and sputum production; CT demonstrated an irregular right lower lobe lesion with an aberrant artery from the thoracic aorta (Fig. 2). Patient 4 was a 31-year-old woman with hemoptysis for 5 months; CT revealed an irregular lesion in the left lower lobe supplied by the descending aorta (Figure S2). Written informed consent for publication was obtained from all patients.

After induction of general anesthesia and placement of a double-lumen tube, a mesh nebulizer was connected between the tube and the ventilator heat-moisture filter (Figure S3). Subsequently, aerosolized ICG (2.5 mg/mL) was delivered to the lung for 10 to 15 minutes. Thoracoscopy was then performed with white-light and NIR fluorescence modes. Normal lung showed homogeneous green fluorescence; sequestered lung remained non-fluorescent, creating a clear pleural demarcation. The line was marked with electrocautery before division of the aberrant systemic artery and parenchymal resection.

In patients 1,2 and 4 (Fig. 1, S1-2), the non-fluorescent area was localized, and wedge resection was completed along the marked boundary with an endoscopic stapler. In patient 3 (Fig. 2), the posterior basal, lateral basal, and part of the medial basal segments of the right lower lobe were non-fluorescent, indicating extensive involvement; right lower lobectomy was therefore performed. No intraoperative oxygen desaturation, airway pressure elevation, or ICG-related adverse event occurred. All patients recovered uneventfully, and at the 3-month follow-up, chest computed tomography showed good lung re-expansion and no residual lesion.

Discussion and conclusions

This case report highlights two practical advantages of aerosolized ICG in adult ILS. First, it enables early lesion mapping during thoroscopic exploration, before commitment to wedge resection, segmentectomy, or lobectomy. In patient 3, broad absence of fluorescence indicated extensive basal segment involvement and supported lobectomy rather than an unsafe limited resection.

Second, aerosolized ICG more precisely reflects the pathologic basis of pulmonary sequestration than intravenous ICG. The defining feature of ILS is isolation of abnormal lung tissue from the normal bronchial tree. Airway-based ICG delivery therefore more directly reflects the lesion boundary. By contrast, intravenous ICG maps perfusion rather than bronchial communication and usually requires prior control of the aberrant systemic artery before boundary assessment.⁴ In Pryce type II ILS with systemic arterial supply, intravenous ICG may inaccurately delineate the lesion boundary because fluorescence reflects perfusion rather than airway isolation. In addition, intravenous ICG cannot effectively distinguish anomalous systemic arterial supply to the normal left lower lobe (ALSLL) from true pulmonary sequestration. In our cases, aerosolized ICG produced durable fluorescence until the end of resection and did not depend on prior division of the aberrant artery.

Prior pediatric studies demonstrated that atomized ICG can guide precise resection of ILS and other congenital lung malformations.⁵ Our protocol adapts this concept for adults by delivering ICG intraoperatively after anesthesia and single-lung ventilation, avoiding preoperative patient discomfort. Fluorescence should complement careful CT angiography and secure management of systemic arteries, but these cases suggest that unilateral intraoperative ICG inhalation may help select the least extensive complete resection in adult ILS.

Abbreviations

CT, computed tomography

ICG, indocyanine green

ILS, intralobar pulmonary sequestration

NIR, near-infrared

VATS, video-assisted thoracoscopic surgery

Declarations

Ethics approval and consent to participate

This study has been approved by the Ethics Committee of Peking University People's Hospital (2024PHB049-002). All patients provided informed consent prior to the procedure.

Consent for publication

Written informed consent for publication of the study data and images was obtained from all patients.

Availability of data and materials

The data underlying this article will be shared upon reasonable request to the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ZW and TX collected the clinical data and drafted the manuscript. ZL, SZ and ZC assisted with data collection and image preparation. QL participated in the surgical procedures. HL and JZ conceived and supervised the study and critically revised the manuscript. All authors read and approved the final manuscript.

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Figures

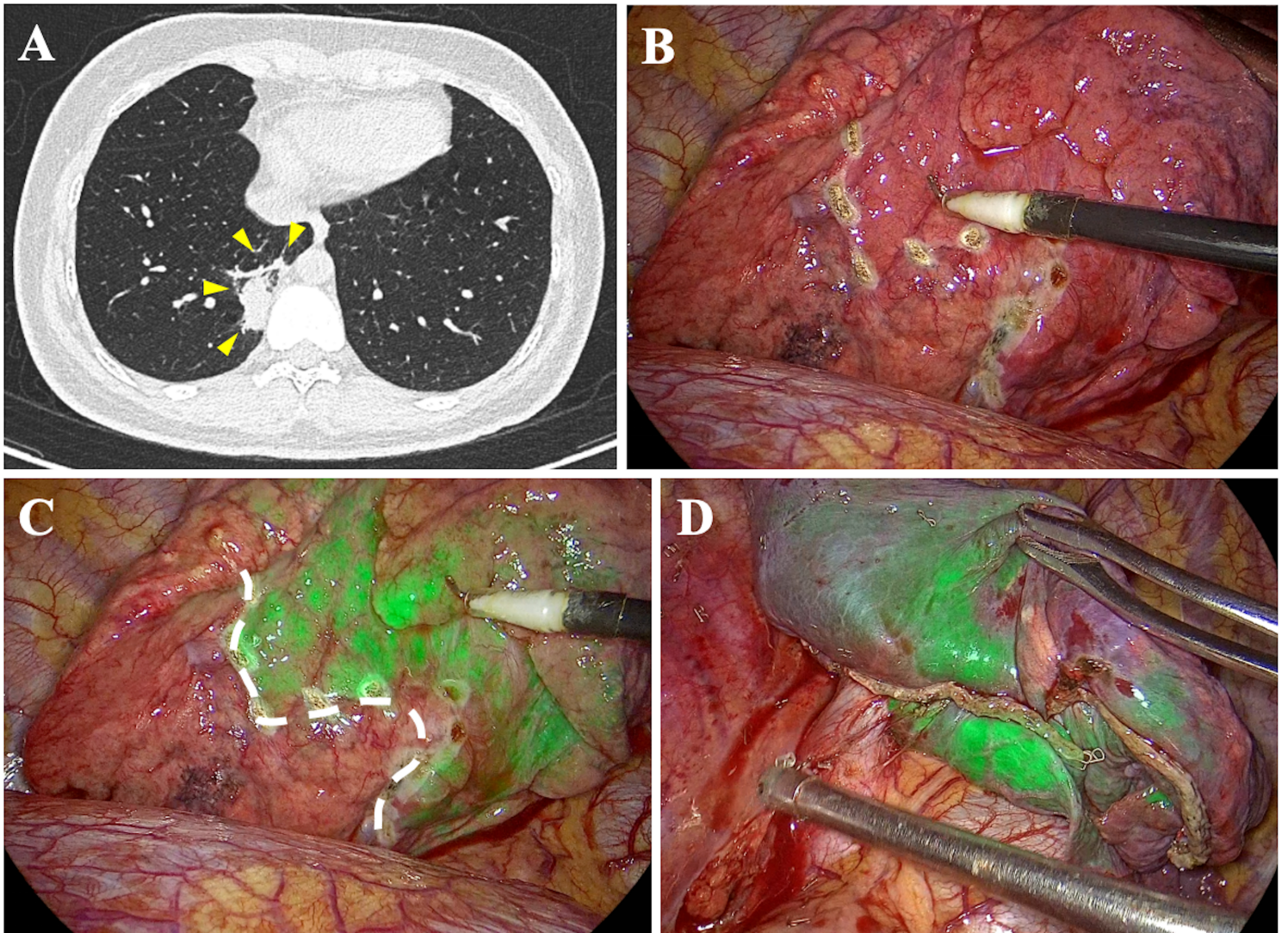


Figure 1

Patient 1 received wedge resection. A, CT showing right lower lobe consolidation(yellow arrow). B, White-light thoracoscopy shows an indistinct border. C, NIR fluorescence demonstrates fluorescent normal lung and nonfluorescent sequestered lung. D, Completed wedge resection.

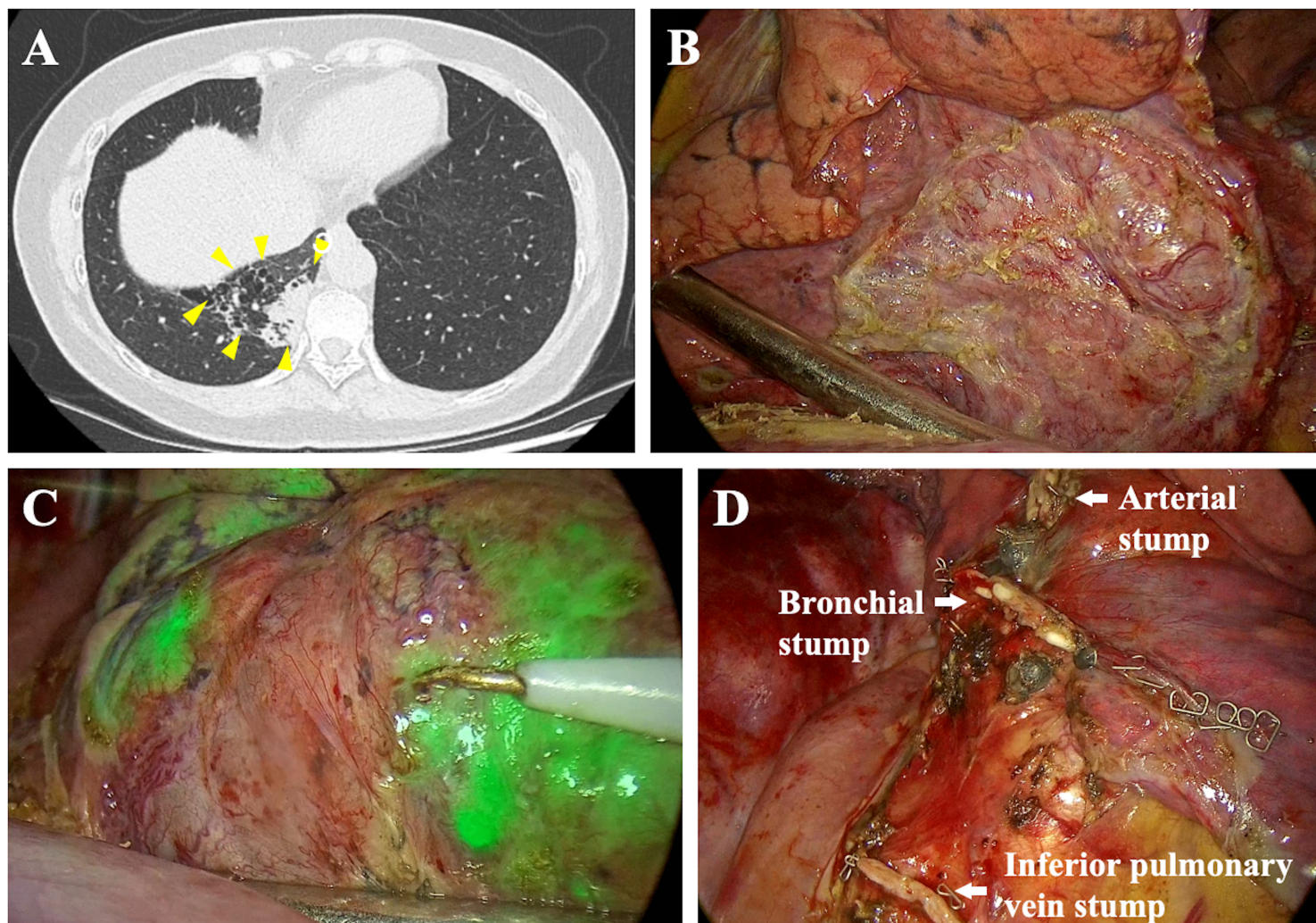


Figure 2

Patient 3 received lobectomy. A, CT showing an irregular right lower lobe lesion with lucencies (yellow arrow). B, White-light thoracoscopy shows adhesions and an unclear border. C, NIR fluorescence shows absent fluorescence across multiple basal segments. D, Completed right lower lobectomy.

Supplementary Files

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