



A Simple Method to Improve Intraoperative Localization of Fiducial Markers during Lung Resections

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Abstract

Keyword

- ▶ thoracoscopy/VATS
- ▶ lung cancer
- ▶ diagnosis
- ▶ lung cancer treatment
- ▶ surgery/incisions

Background Lung cancer screening programs have increased the detection of early-stage lung cancer. High-resolution computed tomography can detect small, low-density pulmonary nodules, or ground-glass opacities. Obtaining a tissue diagnosis can be challenging, often necessitating surgical diagnosis. Preoperative localization and intraoperative fluoroscopy are valuable tools to guide resections for small pulmonary nodules.

Case Description We present three cases using intraoperative fluoroscopy and Faxitron Bioptics that enhanced our certainty of resection of nonpalpable nodules.

Conclusion We support the use of intraoperative fluoroscopy with the unique addition of Faxitron BioVision as safe and reliable methods to enhance the certainty of resection.

Introduction

The detection rate of pulmonary nodules has dramatically increased with the widespread use of lung cancer screening programs and high-resolution computed tomography (CT).¹ These advances have proven to be invaluable in the early diagnosis of lung cancer, which is the leading cause of cancer deaths worldwide.² Early-stage lung cancer can present as a small ground-glass opacity (GGO). Traditional diagnostic approaches, that is, transthoracic or transbronchial needle biopsy, have been known for their low diagnostic yield in such cases.^{3,4} Thus, a surgical diagnosis is often necessary.

Minimally invasive lung resections have allowed for faster recoveries and fewer complications without compromising patient safety or oncological efficacy compared with open approaches.^{5,6} However, the identification of GGOs can be challenging, particularly when they are small, deep, or low-density nodules.

Several preoperative localization techniques have been used to aid in the identification of pulmonary nodules. These methods include radioisotopes, dyes, and localizing markers such as fiducials.^{1,3–5} Fiducial markers can often be visualized and palpated intraoperatively. However, their visibility can be limited if not placed near the visceral pleural surface.

Intraoperative fluoroscopy has been proposed as a useful method for identifying fiducial markers.^{1,3–8} We present three cases using fluoroscopy with the addition of the Faxitron BioVision system to enhance the certainty of resection of nonpalpable nodules.

Case Description

Three patients with suspicious lung nodules were selected for preoperative localization and intraoperative fluoroscopic identification based on their small and low-density appearances (▶ **Figs. 1A, 2A, and 3A**). Electromagnetic navigational bronchoscopy was used to identify the targets. Fiducial

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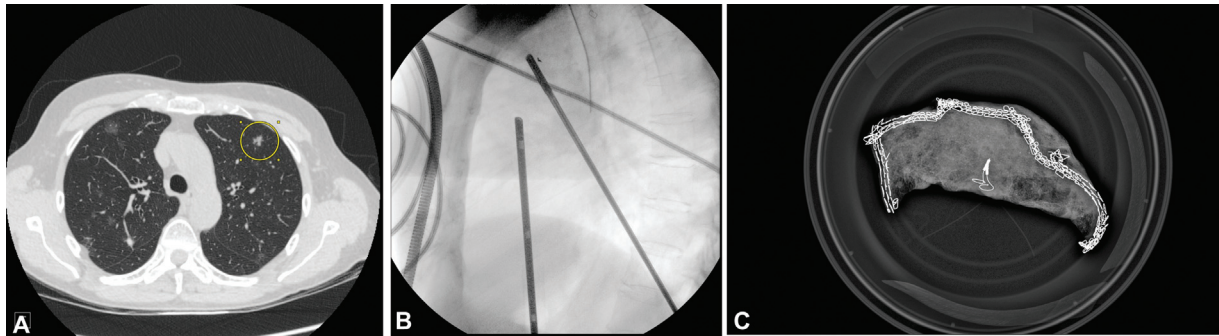


Fig. 1 (A) Preoperative computed tomography (CT) scan of left upper lobe nodule. (B) Intraoperative fluoroscopic identification of fiducial marker. (C) Intraoperative identification of fiducial marker using the Faxitron Bioptics system.

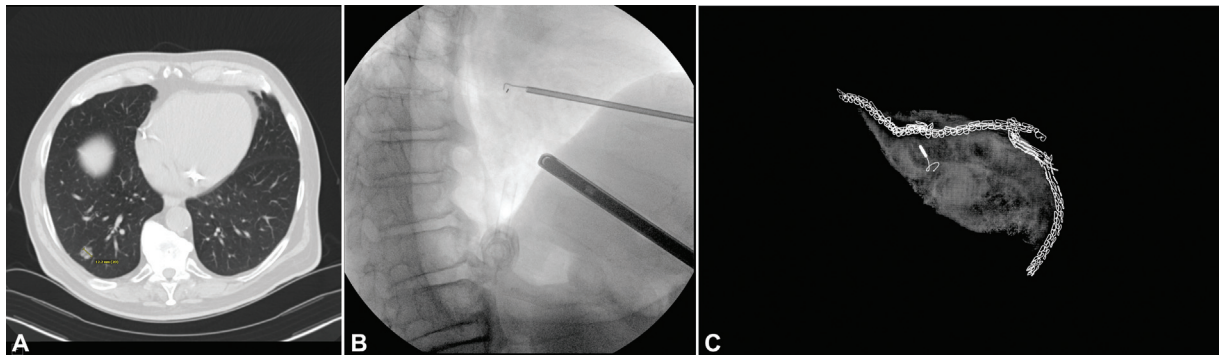


Fig. 2 (A) Preoperative computed tomography (CT) scan of right lower lobe nodule. (B) Intraoperative fluoroscopic identification of fiducial marker. (C) Intraoperative identification of fiducial marker using the Faxitron Bioptics system.

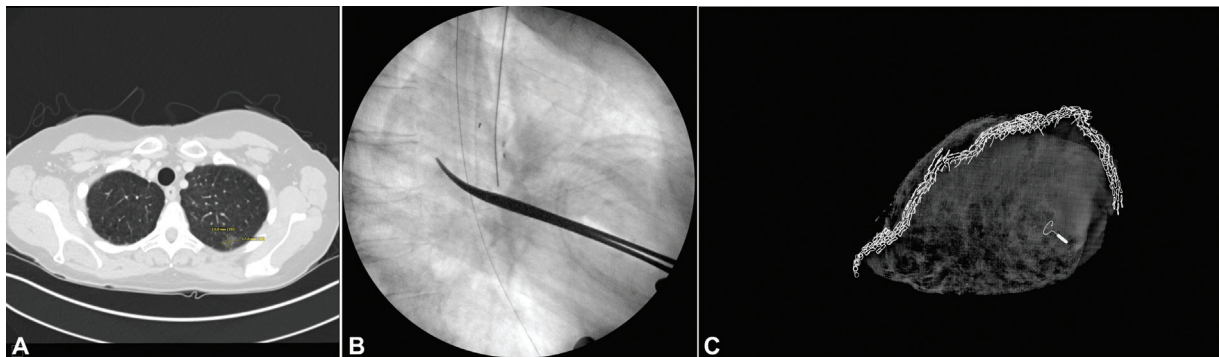


Fig. 3 (A) Preoperative computed tomography (CT) scan of left upper and lower lobe nodules. (B) Intraoperative fluoroscopic identification of fiducial marker. (C) Intraoperative identification of fiducial marker using the Faxitron Bioptics system.

markers were deployed under fluoroscopic guidance. The patients were then taken to the operating room electively. Intraoperative fluoroscopy was used to promptly localize the fiducial markers (►Figs. 1B, 2B, and 3B). Thoracoscopic wedge resections were performed. The specimens were analyzed using the Faxitron BioVision system to confirm the presence of the fiducial markers and adequate resection margins before leaving the operating room (►Figs. 1C, 2C, and 3C). The final pathology confirmed pulmonary adenocarcinoma with widely negative resection margins. The patients had uneventful hospitalizations and were discharged home shortly thereafter. Informed consent was obtained for the publication of the study data.

Discussion

The development of lung cancer screening programs has significantly increased the detection rate of early-stage lung cancer. Small, low-density pulmonary nodules, or GGOs, can be monitored on high-resolution CT scans for concerning changes that may necessitate further diagnostic workup.¹ Obtaining a tissue diagnosis can be challenging, as their small size may limit common diagnostic modalities, that is, transthoracic or transbronchial biopsy.⁴ Surgical resection offers the best chance for a histopathologic diagnosis, however, not without its own challenges.

Minimally invasive lung resections, including video- and robot-assisted thoracoscopic surgery, have demonstrated

acceptable oncologic outcomes with less morbidity than traditional thoracotomies. However, studies have quoted failure rates of diagnostic wedge resections as high as 46% with thoracoscopy, prompting a thoracotomy for a successful resection.⁶ Even with intraoperative finger palpation maneuvers, the ability to find small, deep, and low-density nodules can be quite limited with success rates lower than 40%.⁹

Many preoperative localization techniques have been developed to improve the detection of small pulmonary nodules. These methods include the administration of radioisotopes, injection of methylene blue and other dyes, intraoperative ultrasonography, and localizing markers such as microcoils, hook wires, and fiducials.³ Each of these techniques has various limitations and risks, particularly in the case of dye injections, which can be less reliable depending on their timing and distribution.^{1,3-5,8} Without adequate preoperative localization, many lung nodules may not be amenable to successful surgical resection.

Our preference is to use fiducial markers for preoperative localization of GGOs. Fiducials are 3-mm radiopaque gold seeds whose inert state minimizes the risk of allergic or local tissue reactions.¹ These can be identified intraoperatively by direct visualization or palpation. However, in cases limited by distance from the visceral pleural surface, fluoroscopy has been reported to be a valuable adjunct.^{1,3-5,7,8}

While peripheral GGOs can sometimes be palpated without preoperative or intraoperative localization techniques, the risks of failure can lead to serious consequences. Finley et al demonstrated that in patients who underwent preoperative localization with microcoil placement, the success rate of thoracoscopic resection of small pulmonary nodules increased from 48% without fluoroscopic guidance to 93% with fluoroscopic guidance. The patients without a diagnosis required additional procedures, adding morbidity and cost. Overall, the costs were comparable in both groups, as the cost of microcoil insertion and intraoperative localization was offset by that of increased operating room time and additional procedures.¹

We present herein three cases using preoperative fiducial marker placement, confirmed intraoperatively with the use of fluoroscopy. Our experience reflects the success of previous authors using this technique, with the unique addition of the Faxitron BioVision system to further enhance our certainty of resection. We performed successful diagnostic and therapeutic lung resections for pathologically confirmed pulmonary adenocarcinoma with wide resection margins and no postoperative complications. While anatomic resections are considered the standard surgical treatment for early-stage lung cancer,⁹ we tailored our approach in these particular cases to preserve parenchyma in patients with marginal pulmonary function tests, multiple adenocarcinoma spectrum lesions, and anticipated future resections. We

support the use of intraoperative fluoroscopy and the Faxitron BioVision system as safe and reliable methods to correctly identify fiducial marker placement and ensure a complete resection in minimally invasive lung surgery.

Disclosures

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Source of Funding

Not applicable.

Informed Consent

Informed consent was obtained for the publication of the study data.

Conflict of Interest

None declared.

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