Case Report

# Imaging-guided thoracoscopic resection of a ground-glass opacity lesion in a hybrid operating room equipped with a robotic C-arm CT system

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**Abstract:** The intraoperative identification of small pulmonary nodules through video-assisted thoracoscopic surgery remains challenging. Although preoperative CT-guided nodule localization is commonly used to detect tumors during video-assisted thoracoscopic surgery (VATS), this approach carries inherent risks. We report the case of a patient with stage I lung cancer presenting as an area of ground-glass opacity (GGO) in the right upper pulmonary lobe. He successfully underwent a single-stage, CT-guided localization and removal of the pulmonary nodule within a hybrid operating room (OR) equipped with a robotic C-arm.

**Keywords:** Video-assisted thoracoscopic surgery (VATS); pulmonary nodule; hybrid operating room; robotic C-arm CT

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## Introduction

Lung cancer screening using CT scans is increasingly being used in apparently healthy individuals, leading to an increased detection of small pulmonary nodules (1,2). Because transthoracic or transbronchial biopsy has inherent limitations (3-5), patients with small lung nodules are frequently referred for surgical consultation when a malignancy is suspected. Video-assisted thoracoscopic surgery (VATS) remains the approach of choice for lung resection. However, the identification of small pulmonary nodules through VATS is still challenging. Although preoperative CT-guided nodule localization is frequently required before entering the operating theater (6), the approach carries substantial risks (7). This issue can theoretically be overcome through a single-stage, CT-guided localization and removal of the pulmonary nodule within a hybrid operating room (OR) environment. Here, we report the case of a patient with stage I lung cancer presenting as an area of ground-glass opacity (GGO) in the right upper pulmonary lobe. He successfully underwent a single-stage, CT-guided localization and removal of the pulmonary nodule within a hybrid OR equipped with a robotic C-arm.

## Case presentation

During a routine health examination, a GGO lesion (0.8 cm in size) was identified in the right upper lung field of a 55-year-old man (*Figure 1*). A follow-up CT scan performed after 3 months revealed a slightly enlarged lesion with an increased local tracer uptake on PET imaging. Lung cancer was suspected, and the patient was offered surgery in a hybrid OR equipped with a robotic C-arm CT (Artis zeego, Siemens Healthcare GmbH, Erlangen, Germany). The patient underwent a double-lumen endotracheal intubation and was subsequently placed into a lateral decubitus position. After successful docking of the C-arm, an initial CT scan with a 6-sec protocol (syngo DynaCT)

was acquired for intervention planning. The access path was laid out in the isotropic data set using the syngo Needle Guidance of a syngo X-Workplace (Siemens Healthcare GmbH). The needle path was initially calculated (*Figure 2A*) and then projected with a laser beam (*Figure 2B*). While maintaining the lung inflated, ventilation was arrested and a hook wire was positioned under laser-supported guidance. Upon completion of the procedure, a second DynaCT scan with a 5-sec protocol was acquired to confirm the proper placement of the hook wire. A VATS wedge resection was subsequently performed under wire guidance. A frozen section test confirmed the presence of a lung adenocarcinoma, and the patient underwent segmentectomy accompanied by mediastinal lymph node dissection. He had an uneventful postoperative course and was discharged on the third postoperative day. The final pathologic stage was pT1aN0.

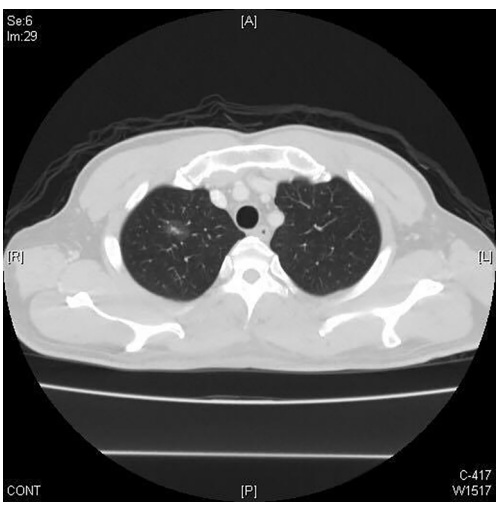


**Figure 1** Area of ground-glass opacity in the patient's right upper pulmonary lobe.

## Discussion

Owing to the loss of tactile sensing, the identification of small lung nodules during VATS is still challenging especially in presence of minute, nonpalpable GGO lesions. Consequently, large lung parenchyma resections and/or conversion to thoracotomy may be necessary to ensure complete tumor removal (8). Before entering the OR, numerous localization methods (e.g., CT-guided placement of hook wires, use of methyl blue dye, and microcoil localization) have been proposed (9-12) to facilitate the subsequent VATS removal. However, current approaches have considerable limitations. Although the time elapsed between tumor localization and subsequent surgery should be kept as short as possible, an optimal synchronization is not always possible. Importantly, the complication rates (including hemothorax, pneumothorax, hemoptysis, and wire dislodgement) of CT-guided biopsy or CT-guided localization of pulmonary nodules vary between 9.7% and 32% (7,13,14). The inability to detect and manage complications in a timely manner may jeopardize the patient's safety. In this context, localization and surgery performed in a single stage within a hybrid OR may be a helpful risk-minimizing strategy.

Differently from previous reports focusing on the use of conventional MDCT in hybrid OR, the localization procedure used for our patient was performed through a

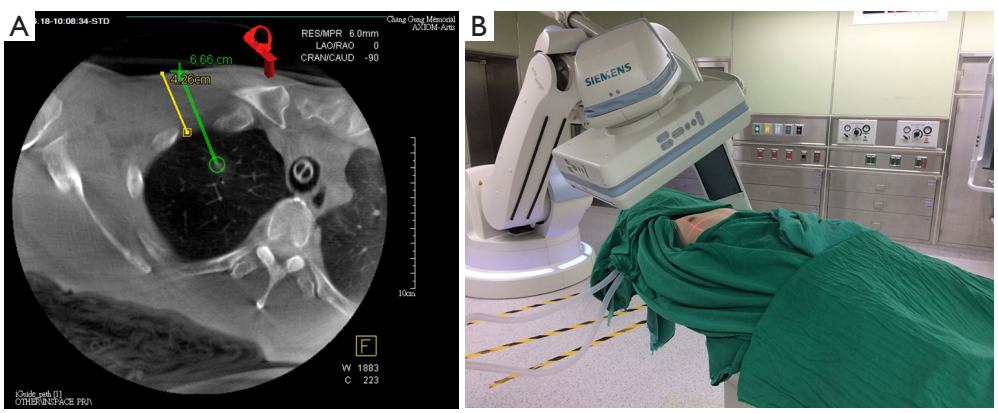


**Figure 2** Imaging-guided needle pathway planning. (A) Path planning of the needle from the skin toward the target lesion on a C-arm CT image; (B) planned path projected with a laser beam.

robotic C-arm CT. The advantages of the latter approach over conventional MDCT include (I) the lack of restriction to a single plane allowing localization to be performed in the lateral decubitus position; and (II) a careful path planning of the needle from the skin toward the target lesion. Unfortunately, the single-stage approach is not without limitations. First, hybrid ORs are not yet widely available because of their high costs. Second, the anesthesia equipment may necessitate a time-consuming and cumbersome repositioning aimed at minimizing the risk of collision with the C-arm. Third, the risk of life-threatening air embolism caused by needle positioning is not negligible and may even increase when general anesthesia is used (15). The incidence rate of systemic air embolism as reported in previous large case series is 0.02–0.06%, with endotracheal anesthesia being an independent risk factor (15-17). Definitive conclusions on the utility of this approach will no doubt be expanded by prospective trials comparing different intraoperative lung localization techniques.

## Conclusions

Hook wire localization and surgery in a single stage within a hybrid OR equipped with C-arm CT may be a helpful risk-minimizing strategy in patients with small pulmonary nodules.

## Acknowledgements

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## Footnote

*Conflicts of Interest*: The authors have no conflicts of interest to declare.

*Informed Consent*: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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