Letter to the Editor

Mobile 3-dimensional C-arm system–assisted localization and resection of pulmonary nodules: a case description

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Introduction

Screening for early-stage lung cancer with low-dose computed tomography (CT) reduces associated mortality while increasing the detection rate of small pulmonary nodules and ground-glass nodules (GGNs) (1). Currently, the most common method for diagnosing and resectioning small pulmonary nodules and GGNs is video-assisted thoracoscopic surgery (VATS). For pure GGNs, mixed GGNs, and small nodules not adjacent to the pleura, preoperative localization is usually required to ensure that these nodules can be found during surgery. Otherwise, failure of surgical resection, extended resection, or conversion to thoracotomy may ensue. Pulmonary nodules can be localized using various methods, including electromagnetic navigation bronchoscopy (2), ultrasound-guided approaches (3), and CT-guided approaches (4). The most common method is preoperative CT-guided localization using different marker materials. However, CT-guided localization technology has a unique characteristic that the patient must be positioned in the CT room before surgery and then transferred to the operating room for VATS. Some risks, such as pneumothorax, pulmonary hemorrhage, and wire shedding, cannot be ignored during transport. Although hybrid operating rooms equipped with cone-beam CT can achieve one-stop localization of small pulmonary nodules, there are site constraints and high assembly costs. Here, we report a case in which planning the localization path was combined with preoperative 3-dimensional (3D) reconstruction of the lung, with one-stop pulmonary nodule localization and VATS wedge resection being completed using the mobile 3D C-arm system. This provided a preliminary experience in exploring the shortening of the localization time of pulmonary nodules, improving the success rate of localization, and reducing complications.

Case presentation

A 49-year-old Chinese man who had presented to The First Affiliated Hospital of Dalian Medical University 3 years prior with a pulmonary pure GGN on CT examination was admitted due to increased nodule density. Postadmission CT examination revealed an 8-mm mixed GGN in the right lower lung (*Figure 1A*). Due to high suspicion of early malignancy, it was decided that VATS right lower lung wedge resection would be performed. We used a mobile 3D C-arm system for preoperative pulmonary nodule localization because the GGN was located next to the spine and was difficult to reach and locate with the hands or surgical instruments during surgery (*Figure 1B*). Before implementation, we planned a localization path using the patient's 3D-reconstructed lung images (*Figure 2*). The purpose of this was to reduce the time required to locate the pulmonary nodules using the mobile 3D C-arm system for the first time. Moreover, if localization had failed, we planned to perform right lower pulmonary lateral and posterior basal (S9+10) segmentectomy based on the 3D reconstruction of the lung.

After general anesthesia and double-lumen tracheal

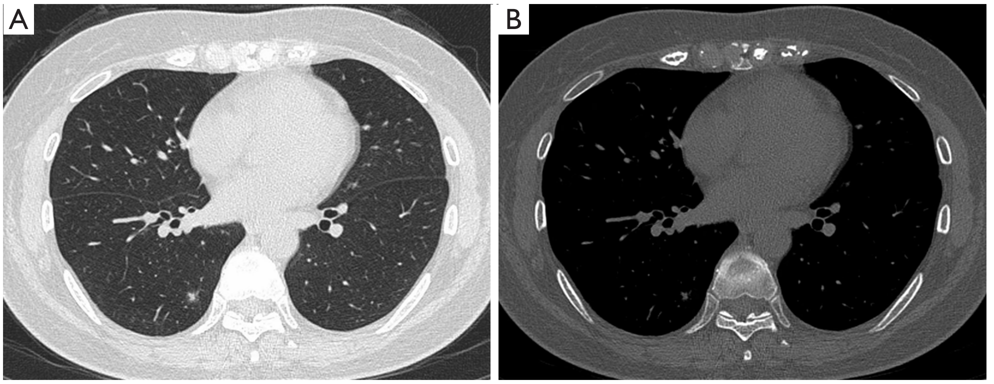

Figure 1 Preoperative conventional CT of the patient. (A) Chest CT image showing an 8-mm mixed GGN in the right lower lung; (B) the GGN was located next to the spine. CT, computed tomography; GGN, ground-glass nodule.

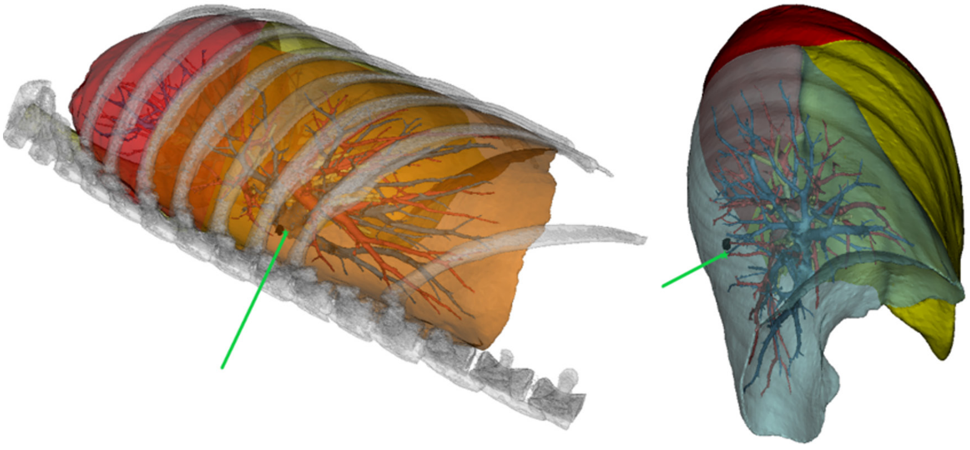

Figure 2 Preoperative 3-dimensional reconstruction of the lung to plan the puncture path.

intubation in the operating room, the patient was placed in the left lateral decubitus position, and a metal fence needle was placed on the patient's skin surface for marking. As the patient's breath was held with the assistance of an anesthesiologist, we acquired CT images of the patient's initial spin scan using the high-quality image acquisition protocol of the Cios Spin system (Siemens Healthineers AG, Erlangen, Germany; *Figure 3A*). In addition to the preoperative planning of the puncture positioning path and the initial CT image, we determined the needle entry point and used the hookwire needle to puncture the patient's lung (*Figure 3B*). We acquired CT images of the patient once more using the Cios Spin system. The CT image revealed that the hookwire was accurately placed next to the GGN in the patient's right lower lung and that there was no pneumothorax or hemothorax (*Figure 4*). The entire positioning process took 25 min.

We immediately performed a VATS right lower lung wedge resection, and postoperative pathology revealed a minimally invasive adenocarcinoma. The patient recovered well after surgery, the drainage tube was removed on the third day, and the patient was discharged 4 days later.

All procedures performed in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). 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 editorial office of this journal.

Figure 3 Puncture localization guided by the mobile 3-dimensional C-arm system. (A) Acquisition of the initial computed tomography images in the patient; (B) placement of hookwire needle in the patient.

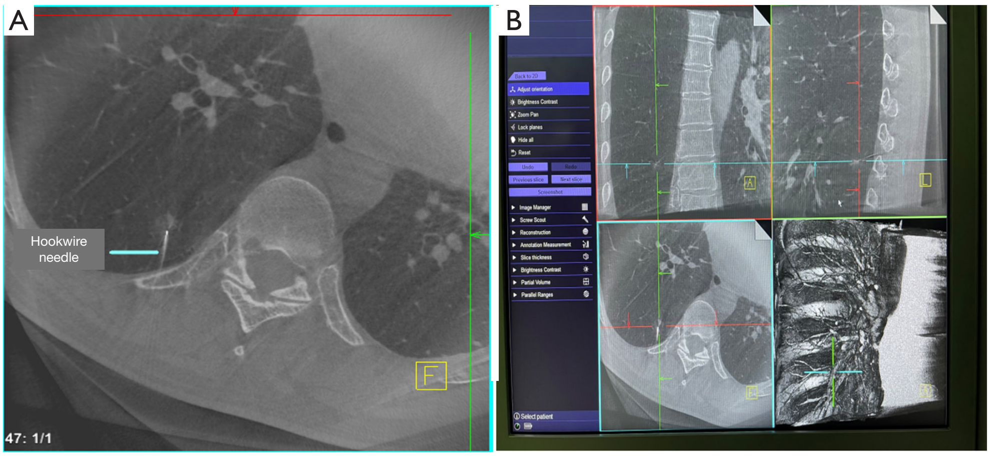

Figure 4 Computed tomography (CT) images of the patient after puncture localization obtained by the mobile 3D C-arm system. (A) The hookwire needle was located next to the ground-glass nodule; (B) there was no pneumothorax or hemothorax.

Discussion

As the number of small pulmonary nodules detected by low-dose CT screening increases, so does the need for preoperative localization. This case shows the potential value of the mobile 3D C-arm system for one-stop pulmonary nodule localization and VATS lung resection.

Cios Spin, a new generation of mobile 3D C-arm system, is currently primarily used in orthopedics for precise intraoperative guidance (5). It acquires 3D images in 3 projections (lateral, coronal, and sagittal) through complementary metal oxide semiconductor detectors. The high resolution of the 3D image allows the observation of very tiny anatomical structures around the target. The radiation dose for a single 3D scan can vary from 6 to 38 mGy (6). The mobile 3D C-arm system has a lower upfront cost and a smaller footprint than does the cone beam CT system (7), and can easily shuttle between operating rooms. In recent years, there have been a few research reports on using the mobile 3D C-arm system in the field of pulmonary nodule intervention. Both Avasarala *et al.* (8) and Sadoughi *et al.* (7) reported successful transbronchial biopsy of lung nodules using a mobile 3D C-arm system. Chen *et al.* (9) demonstrated the feasibility and clinical value of the mobile 3D C-arm system for assisting transbronchial biopsy and ablation of GGN lesions. Although Hsieh *et al.* (10) were the first to report clinical experience with the mobile 3D C-arm system for preoperative pulmonary nodule localization, our team improved the process by using a series of more optimized localization protocols.

This case study explored a complete one-stop pulmonary nodule localization and VATS lung resection procedure. First, we performed 3D reconstruction of the patient's lung using the patient's conventional CT imaging data and through Mimics software (version 20.0; Materialise, Leuven, Belgium) before performing puncture localization. We used 3D lung reconstruction to plan the optimal puncture positioning path for the patient. We then selected the shortest possible puncture line while avoiding important vessels and tissues. Moreover, in the event of puncture and positioning failure, we had an alternative surgical plan, namely VATS segmentectomy based on lung 3D reconstruction technology. Second, to reduce the number of scans and radiation exposure, before starting, we moved the C-arm to a suitable rotational scanning position through the built-in laser positioning line and a 2D image of the Cios Spin system and adjusted the operating table, patient position, and C-arm position through the prerotation function to avoid collisions. Furthermore, to obtain clear and reliable CT images and reduce artifacts, we used the high-quality image acquisition protocol of the mobile 3D C-arm system and after the patient was anesthetized, the anesthesiologist gave the patient positive pressure ventilation to keep the lungs inflated.

There are some caveats to our case study. Disadvantages of transthoracic needle insertion include higher associated risks of pneumothorax, bleeding, and (rarely) broncho/alveolar-pleural fistula (11). Despite the safety of operating in the operating room and endotracheal intubation, localization failure or complications may have a negative effect on surgical outcomes. Therefore, we recommend that this procedure be performed by a chest surgeon or a chest radiologist with extensive experience in CT-guided lung biopsy. This limits the use of the technology in less experienced teams, increasing the learning curve and cost of the technology. The transbronchial approach is also a good option for pulmonary nodules that are difficult to locate via the thoracic approach. Through the combination of ultra-thin bronchoscopy, robot-assisted bronchoscopy, and electromagnetic navigation bronchoscopy with 3D images (7), the standard markers and staining markers were placed to locate the small pulmonary nodules.

In conclusion, we report our initial experience using a mobile 3D C-arm system to provide one-stop pulmonary nodule localization and resection. However, large-scale cohort studies are needed to further determine the feasibility, localization accuracy, localization time, and economics of using a mobile 3D C-arm system to localize pulmonary nodules. However, it is foreseeable that this system will provide a paradigm shift in pulmonary nodule localization and resection, with the one-stop mode becoming increasingly popular.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-22-1134/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). 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 editorial office of this journal.

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