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Robot-assisted thoracoscopic surgery resection of a ground-glass nodule in the right middle lobe

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TO THE EDITOR:

Small peripheral lung tumors presenting with ground-glass opacity (GGO) components have recently become more common. Most of these lesions are early-stage adenocarcinomas and have a promising prognosis. Although minimally invasive surgery is commonly used in order to diagnose and treat these lesions, video-assisted thoracoscopic surgery and robot-assisted thoracoscopic surgery (RATS) resection of small or low-attenuation pulmonary nodules can be difficult because of the difficulty in locating or palpating them. Microcoils, hook wires, and liquid markers such as methylene blue and indocyanine green (ICG) are used in perioperative localization techniques.

Here, we discuss the case of a patient with stage I lung cancer presenting with an area of GGO in the middle lobe, corresponding to an adenocarcinoma. Using a robotic C-arm (Artis zeego; Siemens Healthineers, Erlangen, Germany) in a hybrid operating room and a robotic platform (da Vinci Si; Intuitive Surgical, Sunnyvale, CA, USA), we successfully performed single-stage, CT-guided localization and resection of the lung nodule.

A 77-year-old male patient with a history of two lung resections for lung cancer presented with a solitary pulmonary nodule. During the follow-up period, a pure GGO showing slow, progressive growth and measuring 24 mm was found in the middle lobe, raising a high suspicion of lung cancer. The patient was offered surgical treatment. The planned procedure was a middle lobe segmentectomy with perioperative localization of the nodule by CT-guided placement of a fiducial marker (a 3.7-mm VortX 18 coil; Boston Scientific, Marlborough, MA, USA) and ICG injection. The CT scans were acquired with the Artis zeego robotic C-arm (Siemens Healthineers). The Firefly® fluorescence imaging feature of the da Vinci Si robotic platform (Intuitive Surgical) was also used during the perioperative period, together with C-arm fluoroscopy.

An initial CT scan (6-s *syngo* DynaCT; Siemens Healthineers) was performed for surgical planning. The needle path was laid out with the *syngo* Needle Guidance software (Siemens Healthineers); a laser beam was used in order to project the estimated needle position. Subsequently, ventilation was stopped, and the lung was kept inflated. The fiducial marker was placed with a 19-gauge needle under fluoroscopy, which was followed by ICG injection with biological glue.

With the patient in the left lateral decubitus position, wedge resection was performed in the middle lobe. We used a 4-arm robotic platform and placed the robotic 8-mm ports in the usual position for lung resection. Because the patient had previously undergone surgery, there were many thick pleural adhesions, pulmonary decortication therefore being necessary. Because it was impossible to determine the needle entry point into the middle lobe, we used the Firefly® fluorescence imaging feature of the robotic platform in order to detect ICG in the nodule. Subsequently, the robotic C-arm was docked (Figure 1A), and fluoroscopy was used in order to localize the fiducial marker. An endoscopic stapler was positioned under radioscopic and near-infrared imaging to ensure adequate surgical margins (Figure 1B), and the nodule was resected. The specimen was removed, and the fiducial in the frozen section confirmed the presence of a neoplasm. The final pathological stage was lepidic pT1a adenocarcinoma.

A general correlation exists between GGOs seen on chest CT scans and microscopically lepidic growth patterns.[1,2] Surgical resection constitutes an excellent diagnostic and therapeutic option. However, pure GGOs can be difficult to localize intraoperatively because they are rarely visible in the visceral pleura and are mostly nonpalpable. Preoperative localization techniques are recommended in such cases, with dye injection, fluorescence imaging, and fiducial marker placement being the most commonly used techniques. They all have limitations, and the decision regarding the most appropriate method should be made in the context of a multidisciplinary discussion with the goal of achieving success.

ICG is a nontoxic dye that can be visualized under near-infrared fluorescence, even in deeper tissues. Although we were able to detect ICG fluorescence in the middle lobe, the presence of pleural adhesions and the need for decortication were complicating issues that were encountered in the case reported here and that have been reported elsewhere.[3] Because it is not always possible to determine the presence of pleural adhesions, alternative strategies must be available. Our goal was to perform complete hilar and mediastinal lymphadenectomy. On the basis of our previous experience with thick pleural adhesions and the difficulty in performing lymphadenectomy in this setting, we chose RATS over video-assisted thoracoscopic surgery.

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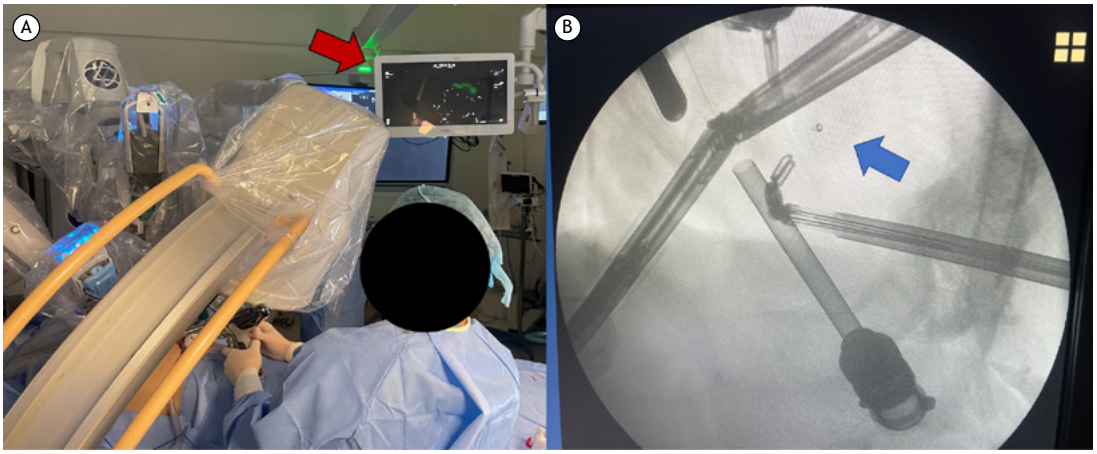

Figure 1. Intraoperative images showing the final position of the robotic arms, the robotic C-arm, and the bedside assistant. In A, photograph of the operating room layout, showing the robotic platform positioning the lung. Note indocyanine green fluorescence in the lung parenchyma (red arrow). Note also the bedside assistant placing an endoscopic stapler in the target area. In B, intraoperative radioscopy showing the position of the endoscopic stapler, with good surgical margins. Note the fiducial marker (blue arrow).

Because the robotic arms used for RATS occupy considerable space in the operative field, docking a C-arm to localize a fiducial can be troublesome, especially in the thoracic apex. However, in our case, because the nodule was in close proximity to the oblique fissure separating the lower lobe from the rest of the lung, the robotic C-arm was placed below the robotic ports without the need to undock the robotic system. This allowed us to manipulate the lung and position the lobe for endoscopic stapling. One difficulty that we encountered when performing the procedure was inserting the stapler through the assistant port. As can be seen in Figure 1, the robotic C-arm was in close proximity to the stapler, and we had to place it carefully to avoid collision. The use of a robotic stapler arm could be helpful in this setting.

This report shows that C-arm fluoroscopy and near-infrared fluorescence can be used for robotic lung surgery. However, a multidisciplinary approach is recommended to plan an appropriate strategy and evaluate feasibility.

AUTHOR CONTRIBUTIONS

All authors participated in the drafting and revision of the manuscript, as well as in the approval of the final version.

CONFLICTS OF INTEREST

None declared.

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