Editorial

Recent advances in electromagnetic navigation bronchoscopy for localization of peripheral pulmonary nodules

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The National Lung Cancer Screening Trial demonstrated the efficacy of low-dose computed tomography (LDCT) screening in reducing lung cancer mortality in the United States. In addition, the Dutch-Belgian lung cancer screening trial (NELSON study) also showed that lung cancer mortality in high-risk patients was significantly lower in the computed tomography (CT) screening cohort than in the no-screening cohort (1,2). Hence, current guidelines for non-small cell lung cancer highly recommend screening with LDCT to reduce lung cancer-related mortality (3). Consequently, the frequency of detecting small pulmonary nodules is increasing, and LDCT screening is becoming widespread in practice. It is becoming increasingly important for thoracic surgeons to accurately localize small pulmonary nodules.

Previously, small pulmonary nodules were identified by the tactile sensation of the surgeon's fingers during thoracotomy. In the 1990s, CT-guided percutaneous marking became widespread, and CT became common in general hospitals. Since then, many markers have been developed, such as hook wires, microcoils, and dyes, owing to the localization of small pulmonary nodules under CT guidance (4-7). These CT-guided marking methods have demonstrated their usefulness with excellent detection rates, but there have been many reports of major and minor complications such as bleeding, pneumothorax, dislodging and migration of the marker, and air embolism (8,9). To overcome these adverse events associated with percutaneous needle marking, a number of bronchoscopic localization techniques have been advocated and validated in clinical trials (10-12). In general, bronchoscopic marking could have a high accuracy in detecting small pulmonary nodules, similar to percutaneous marking, but no major complications occur (13).

Wang *et al.* reported a case of a 47-year-old woman who had an approximately 7×9 mm nodule in the left upper lobe of her lung. She presented with no symptoms and her laboratory examination results were normal. Primary lung cancer was strongly suspected based on the CT images. First, the authors built 3D reconstructed images of the airway tree to plan the navigation path to the nodule. Next, she underwent tracheal intubation under general anesthesia in the operating room, and a single-lumen catheter was inserted into the endotracheal tube. The inserted single-lumen catheter was equipped with a positionable electromagnetic catheter and an extended working catheter. The distance from the pulmonary nodule was measured using an electromagnetic catheter. The electromagnetic catheter could be moved from the nodule to the nearest pleura due to the injection of indocyanine green (ICG) through the extended working catheter. The extended working catheter could be moved from the pulmonary lesion to the nearest pleura under electromagnetic catheter guidance. Finally, limited surgery was performed after the fluorescence staining area of the posterior segment of the left upper pulmonary apex was observed intraoperatively and adenocarcinoma *in situ* was diagnosed pathologically.

Electromagnetic navigation bronchoscopy (ENB) was adopted in this localization method because of the approach to small pulmonary nodules near the visceral pleura, based on thin-section CT reconstructed images. In this way, the ENB system, using an ultrathin bronchoscope (outer diameter: 2.8–3.5 mm), enabled deeper visualization into

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the tracheobronchial tree to reach the right position around the target lesion. Subsequently, dye marking was performed to inject ICG under the guidance of ENB, which can mark the position of the target lesion. In this way, ENB has an advantage in the localization of peripheral small pulmonary nodules, especially for those approximately 1 cm in diameter.

In the expert opinion section, five experts commented on three questions. Question 1 was, "What are the international methods for nodule localization?", and they answered that there were several methods for localizing pulmonary nodules. In summary, there are two major categories of localization: transbronchial (endobronchial) and transthoracic (percutaneous). The most popular method is percutaneous hook-wire localization, followed by other percutaneous marking methods, such as using metals, radionuclides, or dye markings. Standard percutaneous localization before surgery is performed by a radiologist who places a marker using CT, such as cone-beam CT. Typical markers are methylene blue dye, gold fiducial, ICG, or radioisotope. Recently, the use of endobronchial metal fiducial and dye marking guided by navigation bronchoscopy has gained increasing recognition.

Question 2 was "What is the prospect of magnetic navigation for nodule localization?" Dr. Shinagawa and Dr. Sato expected the ENB technique to be one of the useful methods available for bronchoscopic localization, but all experts mentioned some limitations such as a complicated setting, high cost of disposal equipment, and no way to precisely confirm or assess the position of the marking (less accurate). Dr. Min P. Kim was concerned with the patient's position and type of tracheal tube because the ENB technique could be difficult to perform for patients in a lateral position intubated by a double-lumen tracheal tube.

The last question was, "What are the application prospects for fluorescence endoscopy in lung cancer surgery apart from the determination of the plane between segments of lung resection?" Dr. Lachkar and Dr. Baste regarded ICG as a promising technology for intraoperative imaging because it features fluorescence at 800 nm and is the only near-infrared (NIR) contrast agent approved by the Food and Drug Administration. This fluorescence imaging could enable us to perform bronchoscopy more easily and precisely, in order to reach the target lesion or the margin of segmentectomy. Dr. Sato explained the use of ICG not only to localize, but also to indicate an appropriate resection line by multiple markings on the lung. Dr. Kim pointed out that it is a useful marker during robot-assisted pulmonary resection because the robotic camera can easily visualize ICG in the tissue.

According to the comments of five experts, there are practical issues to be resolved in this case. In the literature, guidelines for pre-operative assisted localization of small pulmonary nodules mentioned the disadvantages of the bronchoscopic-assisted localization technique: (I) limited localization accuracy, (II) complicated localization procedure, and (III) higher localization costs in Recommendation 5 (Grade 1B) (13). Furthermore, bronchoscopic marking requires longer time than most traditional localization methods. In conclusion, the ENB technique is a promising localization method; however, it should be improved upon to overcome some of the disadvantages mentioned above.

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