Will the ultra-low-dose intraoperative X-ray imager change thoracoscopic surgery?

Yoshikane Yamauchi

Department of Surgery, Teikyo University School of Medicine, Tokyo, Japan
Correspondence to: Yoshikane Yamauchi, MD, PhD. Department of Surgery, Teikyo University School of Medicine, 2-11-1 Kaga, Itabashi-ku, Tokyo 173-8605, Japan. Email: yoshikaney@med.teikyo-u.ac.jp.
Comment on: Park H, Han KN, Choi BH, *et al*. Ultra-low-dose intraoperative X-ray imager for minimally invasive surgery: a pilot imaging study. Transl Lung Cancer Res 2022;11:588-99.

Lung cancer is the most frequent cancer worldwide and is the leading cause of cancer-related death (1). Most lung cancers are already in an advanced stage at the time of their diagnosis and are difficult to treat even with the administration of recent molecular-targeted chemotherapy and immune checkpoint inhibitors. In contrast, early-stage lung cancer, such as stage IA, can be treated with a very high 5-year survival rate (2). The introduction of lung cancer screening using low-dose computed tomography (CT) is expected to increase the early detection of lung cancer, as randomized trials have found that mass CT screening of high-risk groups is beneficial (3-5). The increased detection rate of early-stage lung cancer has led to an increase in the popularity of minimally invasive techniques such as video-assisted and robot-assisted thoracoscopic surgery. In comparison with traditional open thoracotomy, these minimally invasive techniques allow the removal of early lung cancer lesions with decreased postoperative pain, air leak duration, length of hospital stay, and overall complication rates, with equivalent oncologic results (6-8).

One of the clinical challenges in minimally invasive techniques is the intraoperative localization of small tumors. The skin incision for video-assisted thoracoscopic surgery is usually too small to enable the detection of tumors via tactile sensation. Furthermore, sublobar resection is considered less reproducible because the surgical margins in sublobar resection are unclear, more subjective, and less reproducible compared with lobectomy, which is anatomically well-defined. Therefore, there is a need for techniques to not only identify lesions intraoperatively, but also to perform sublobar resection while ensuring that the margins are appropriate.

Many marking techniques have already been proposed, such as percutaneous CT-guided hook-wire placement (9,10), microcoil placement (11), or CT-guided lipiodol marking (12,13), virtual-assisted lung mapping (14), and a radiofrequency identification marking system (15). However, these techniques require preoperative invasive preparations that carry risks of pneumothorax, intrapulmonary hemorrhage, or air embolism. The marker may also migrate to another position between preoperative placement and surgery, potentially causing the surgeon to resect the incorrect part of the lung. Moreover, the use of fluoroscopy exposes both patients and staff to intraoperative radiation in the catheterization laboratory or the operating theater.

Park *et al*. described the use of an ultra-low-dose X-ray imager to identify lung nodules intraoperatively (16). This device is a hand-held, clamp-shaped endoscopic instrument that employs a carbon nanotube, which allows a compact design. The authors assembled this device from small components and demonstrated its feasibility by applying it to an animal model in which a simulated tumor was created in swine lungs. Furthermore, the authors confirmed that the device could identify lesions in surgically resected human lung specimens, suggesting the usefulness of the device.

The ultra-low-dose X-ray imager may have several positive aspects. (I) The lesion can be identified in real time during surgery, enabling sublobar resection to be performed with adequate margins. (II) There is no risk of a marker being intraoperatively dislodged or lost. (III)

The radiation dose is only 0.1 µSv/h, which is extremely small compared with conventional C-arm fluoroscopy and virtually eliminates the need to worry about radiation exposure of patients and medical staff. (IV) If the tumor can be detected without contrast agents there is no need for extra preoperative procedures. This avoids complications associated with percutaneous puncture (e.g., pneumothorax, intrapulmonary hemorrhage, air embolization), which are a concern with other methods.

Based on our experience, I believe that the ultra-low-dose X-ray imager has another advantage. We conducted a clinical study in which we used a very small intrathoracic ultrasound probe to intraoperatively identify lung tumors (17), similarly to the purpose of the ultra-low-dose X-ray imager. This ultrasound probe was equally satisfactory regarding the abovementioned four advantages of the ultra-low-dose X-ray imager. However, it was impossible to identify the lesion via ultrasonography when the lung was insufflated. Therefore, when using ultrasonography intraoperatively, it is important to know how to achieve a totally collapsed lung. In clinical practice, we intraoperatively use cone-beam CT in the hybrid operating room to roughly locate the lesion in an insufflated lung, and then use ultrasonography to accurately identify the location of the lesion in a collapsed lung and perform sublobar resection. I believe that the ultra-low-dose X-ray imager could have a great advantage in that it is expected to allow the procedure to proceed without the need for pulmonary collapse.

I believe that the proposed ultra-low-dose X-ray imager also has the following issues. One issue is the large size of the device. The authors report that it is 46 mm in the "with shields" condition. A 20-mm skin incision must be made to prepare the port, as in many cases it is necessary to remove the lung through the port hole. Thus, assuming that the device is inserted through that port, it would need to be reduced to about 15 mm in diameter. The size of the ultrasonography probe used in the aforementioned report (17) is less than 10 mm in size. A reduction in the size of the ultra-low-dose X-ray imager is essential for clinical application.

It has been reported that surgeons who are highly skilled in thoracoscopic surgery can palpate any tumor during thoracoscopic maneuvers (18). In our clinical experience, solid lesions are often palpable. In contrast, the lesions that require imaging assistance are often pure ground-glass opacity nodules or partially solid ground-glass opacity nodules with a small solid part. In such cases, it is presumed that lesion identification will be difficult unless the lungs are still somewhat insufflated. Therefore, it is expected that the ultra-low-dose X-ray imager will be used in the limited space of the chest cavity, necessitating a reduction in the size of the device.

The second issue with the ultra-low-dose X-ray imager is that Park *et al.* identified lesions containing contrast media (16). In clinical practice, the insertion of a contrast agent into a lesion involves an extra procedure, which involves additional radiation exposure and procedural risks. Ideally, lesions should be identifiable in the absence of contrast. Improvements in image resolution are necessary to achieve such a result.

Aside from these issues, I believe that the ultra-low-dose X-ray imager is very promising. The authors have used this device as a prototype, and further improvements are expected in the future. If the size and resolution can be improved, this device has the potential to change minimally invasive thoracic surgery, and I hope that further progress will be made in the development of this device.

Acknowledgments

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Translational Lung Cancer Research*. The article did not undergo external peer review.

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at https://tlcr.amegroups. com/article/view/10.21037/tlcr-22-241/coif). The author has no conflicts of interest to declare.

Ethical Statement: The author is 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.

Open Access Statement: This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with the strict proviso that no changes or edits are made and the original work is properly cited (including links to both the

Transl Lung Cancer Res 2022;11(4):506-508 | https://dx.doi.org/10.21037/tlcr-22-241

formal publication through the relevant DOI and the license).
See: https://creativecommons.org/licenses/by-nc-nd/4.0/.

References

1. Siegel RL, Miller KD, Fuchs HE, et al. Cancer statistics, 2022. CA Cancer J Clin 2022;72:7-33.
2. Goldstraw P, Chansky K, Crowley J, et al. The IASLC Lung Cancer Staging Project: Proposals for Revision of the TNM Stage Groupings in the Forthcoming (Eighth) Edition of the TNM Classification for Lung Cancer. J Thorac Oncol 2016;11:39-51.
3. National Lung Screening Trial Research Team; Aberle DR, Berg CD, et al. The National Lung Screening Trial: overview and study design. Radiology 2011;258:243-53.
4. National Lung Screening Trial Research Team; Aberle DR, Adams AM, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. N Engl J Med 2011;365:395-409.
5. National Lung Screening Trial Research Team; Church TR, Black WC, et al. Results of initial low-dose computed tomographic screening for lung cancer. N Engl J Med 2013;368:1980-91.
6. Oh DS, Reddy RM, Gorrepati ML, et al. Robotic-Assisted, Video-Assisted Thoracoscopic and Open Lobectomy: Propensity-Matched Analysis of Recent Premier Data. Ann Thorac Surg 2017;104:1733-40.
7. Kent M, Wang T, Whyte R, et al. Open, video-assisted thoracic surgery, and robotic lobectomy: review of a national database. Ann Thorac Surg 2014;97:236-42; discussion 242-4.
8. McKenna RJ Jr, Houck W, Fuller CB. Video-assisted thoracic surgery lobectomy: experience with 1,100 cases. Ann Thorac Surg 2006;81:421-5; discussion 425-6.
9. Dendo S, Kanazawa S, Ando A, et al. Preoperative localization of small pulmonary lesions with a short hook wire and suture system: experience with 168 procedures. Radiology 2002;225:511-8.
10. Ichinose J, Kohno T, Fujimori S, et al. Efficacy and complications of computed tomography-guided hook wire localization. Ann Thorac Surg 2013;96:1203-8.
11. Mayo JR, Clifton JC, Powell TI, et al. Lung nodules: CT-guided placement of microcoils to direct video-assisted thoracoscopic surgical resection. Radiology 2009;250:576-85.
12. Kawanaka K, Nomori H, Mori T, et al. Marking of small pulmonary nodules before thoracoscopic resection: injection of lipiodol under CT-fluoroscopic guidance. Acad Radiol 2009;16:39-45.
13. Watanabe K, Nomori H, Ohtsuka T, et al. Usefulness and complications of computed tomography-guided lipiodol marking for fluoroscopy-assisted thoracoscopic resection of small pulmonary nodules: experience with 174 nodules. J Thorac Cardiovasc Surg 2006;132:320-4.
14. Sato M, Omasa M, Chen F, et al. Use of virtual assisted lung mapping (VAL-MAP), a bronchoscopic multispot dye-marking technique using virtual images, for precise navigation of thoracoscopic sublobar lung resection. J Thorac Cardiovasc Surg 2014;147:1813-9.
15. Sato T, Yutaka Y, Nakamura T, et al. First clinical application of radiofrequency identification (RFID) marking system-Precise localization of a small lung nodule. JTCVS Tech 2020;4:301-4.
16. Park H, Han KN, Choi BH, et al. Ultra-low-dose intraoperative X-ray imager for minimally invasive surgery: a pilot imaging study. Transl Lung Cancer Res 2022;11:588-99.
17. Yokote F, Yamauchi Y, Uehara H, et al. Intrathoracic use of a small ultrasonic probe for localizing small lung tumors in thoracoscopic surgery: Empirical results and comparison with preoperative CT images. Gen Thorac Cardiovasc Surg 2021;69:516-24.
18. Ichinose J, Mun M, Matsuura Y, et al. Efficiency of thoracoscopic palpation in localizing small pulmonary nodules. Surg Today 2019;49:921-6.