Lung nodule detection by intraoperative ultrasound during robotic surgery

Alfonso Fiorelli, MD, PhD,[a] Stefano Forte, MD,[b] Vincenzo Di Filippo, MD,[a] Davide Pica,[a] Emanuele Martorana, MD,[b] Riccardo Villa, MD,[b] Beatrice Leonardi, MD,[a] Mario Annechiarico, MD,[c] Francesca Capasso, MD,[a] and Gaetana Messina, MD,[a] Naples, Viagrande, and Benevento, Italy

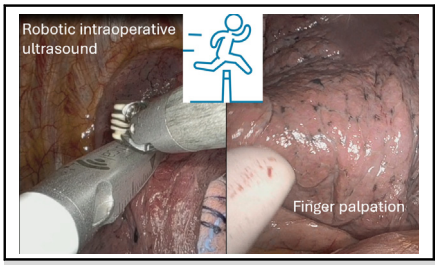
From the [a]Thoracic Surgery Unit, University of Campania "Luigi Vanvitelli", Naples, Italy; [b]Istituto Oncologico Mediterraneo, Viagrande, Italy; and [c]General Surgery Unit, San Pio Hospital, Benevento, Italy.

Received for publication Oct 6, 2024; revisions received Jan 5, 2025; accepted for publication Jan 8, 2025; available ahead of print Feb 20, 2025.

Address for reprints: Alfonso Fiorelli, MD, PhD, PD, FEBTS, FACS, FCCP, Thoracic Surgery Unit, University of Campania "Luigi Vanvitelli", Piazza Miraglia, 2, Naples, I-80138, Italy (E-mail: alfonso.fiorelli@unicampania.it).

JTCVS Techniques 2025;30:148-50
2666-2507

https://doi.org/10.1016/j.xjtc.2025.01.028



Intraoperative ultrasound overcomes digital palpation.

CENTRAL MESSAGE

Intraoperative ultrasound may be the "surgeon's finger" to locate small and deep lung lesions during robotic procedures.

Video clip is available online.

CASE SERIES

This strategy was performed in 9 consecutive patients with SPN who met the criteria for RATS lung resection (Table 1). All the nodules were solid, and the average depth from the visceral pleura was 20 mm, making them difficult to digitally palpate. Computed tomography (CT)-guided biopsy and/or transbronchial needle aspiration biopsy (TBNA) failed to obtain a definitive diagnosis. All patients provided written informed consent for the procedure, and they were aware that their anonymized data could be used for scientific purposes only. Institutional Review Board approval was not required.

A standard 4-arm approach was used for the procedure. A dedicated robotic ultrasound probe (BK Medical) was inserted into the chest through the assistant port and fixed with a bipolar clamp to scan the pulmonary surface. The lesion was visualized in real time through the images obtained from ultrasound probe and reported in the console screen (Figure 1). The probe was then removed, and the nodule was lifted with Cadier forceps, resected using robotic staplers, and sent to Pathology for frozen section analysis. Video 1 summarizes the procedure.

RESULTS

In all cases, the intraoperative ultrasound successfully identified the target lesion without significantly increasing the operative time. Among the resected nodules, 7 were diagnosed as non–small cell lung cancer, and these patients underwent RATS lobectomy with radical lymph node resection in the same setting. In the other 2 patients, the nodules were identified as metastases, and no additional resection was performed, as all surgical margins were negative on pathologic examination.

DISCUSSION

The increased use of low-dose CT scans and lung cancer screening have led to detection of greater numbers of SPN. Video-assisted thoracoscopic surgery (VATS) resection remains the main strategy for obtaining a definitive diagnosis of SPN when other, less invasive procedures (ie, CT-guided lung biopsy or TBNA) fail, as in our patients. RATS has become increasingly popular over the last 2 decades owing to some technical advantages over VATS (ie, the tremor filtration, degree of manipulative freedom, and the 3-dimensional view).[1] Nonetheless, the detection of SPN that likely would be palpable during routine VATS may be challenging during RATS because of the lack of tactile feedback. Intraoperative ultrasound has been used to detect small lesions and guide tumor resection during robotic abdominal surgery,[2] but its use during RATS had remained unexplored.

TABLE 1. Study population

Patient	Nodule			US time, min	Diagnosis
	Size, mm	Distance to pleura, mm	Site		
1	11	18	LLL	20	Lung adenocarcinoma
2	8	15	LLL	15	Metastasis from colon adenocarcinoma
3	13	21	RLL	22	Lung adenocarcinoma
4	9	22	RLL	21	Lung adenocarcinoma
5	15	23	LLL	15	Lung adenocarcinoma
6	16	20	LLL	18	Lung adenocarcinoma
7	12	23	RUL	20	Lung squamous carcinoma
8	11	24	LLL	15	Metastasis from renal cancer
9	10	18	LLL	20	Lung squamous carcinoma
Mean ± SD	1.66 ± 2.6	20.4 ± 0.9	—	18.4 ± 2.7	—

US, Ultrasound; *LLL*, left lower lobe; *RLL*, right lower lobe; *RUL*, right upper lobe; *SD*, standard deviation.

Our previous experience with intraoperative ultrasound localization of SPN during VATS[3,4] led us to evaluate this strategy during RATS as well. The noninvasiveness, real-time feedback, repeatability, and the lack of specific complications (ie, pneumothorax, hemothorax and lung hemorrhage) and the need for sophisticated equipment (ie, hybrid operating room) are the main strengths of intraoperative ultrasonography compared to standard percutaneous techniques for SPN localization. In contrast, the need for a surgeon with sonographic experience and a collapsed lung for ultrasound examination are the main limitations of this method that could counteract the advantages. To overcome these limitations, careful suctioning of the airways and using the probe to press on the visceral pleura to deflate the lung can facilitate nodule detection. Additionally, the first procedures should be performed or supervised by a thoracic surgeon with ultrasonography experience until all surgeons master the basic skills of intraoperative ultrasound.[5] After identification, in all our cases the nodule was grasped with the Cadier forceps and then resected with a stapler. Alternative and more reliable techniques (ie, tipping up or placing a suture in the lung parenchyma) could be used to lift the nodule.

The main limitation of our strategy is that all lesions in our series were solid and thus readily located by ultrasound,

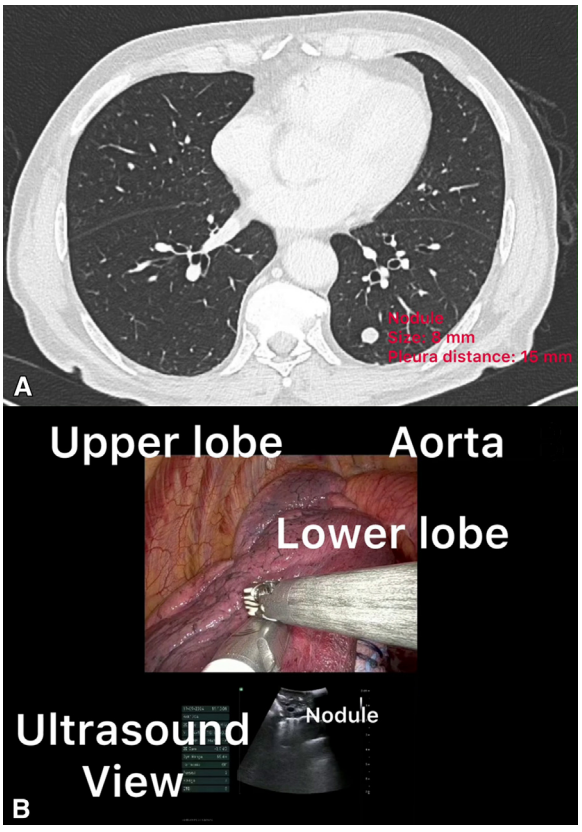
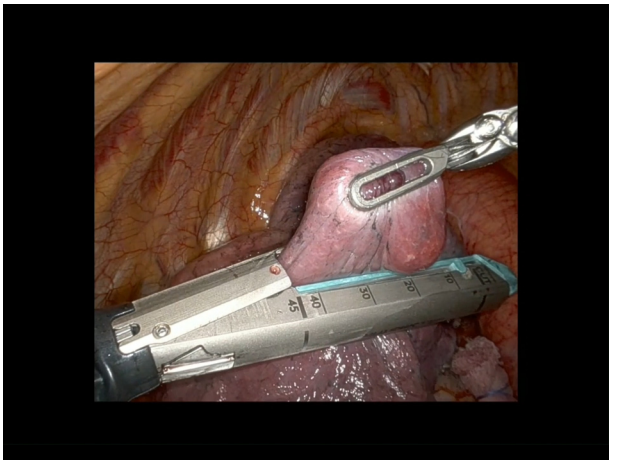


FIGURE 1. A, Computed tomography scan showing an 8-mm nodule (*arrow*) at a distance of 20 mm from the pleura. B, The lesion was successfully identified by intraoperative ultrasound.



VIDEO 1. The main steps of the procedure showing nodule detection by intraoperative ultrasound and its subsequent resection. Video available at: https://www.jtcvs.org/article/S2666-2507(25)00070-7/fulltext.

whereas ground-glass opacities could be undetectable by ultrasound. In previous reports,[4,6] we showed the feasibility of ultrasound for locating ground-glass opacities during VATS, but future studies should confirm these results during RATS as well.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

References

1. Wei B, D'Amico TA. Thoracoscopic versus robotic approaches: advantages and disadvantages. *Thorac Surg Clin*. 2014;24:177-188.
2. Di Cosmo G, Verzotti E, Silvestri T, et al. Intraoperative ultrasound in robot-assisted partial nephrectomy: state of the art. *Arch Ital Urol Androl*. 2018;90(3):195-198.
3. Messina G, Bove M, Natale G, et al. Ultrasound location of ground-glass opacity during thoracoscopic surgery. *Interact Cardiovasc Thorac Surg*. 2022;35(6):ivac234.
4. Gambardella C, Messina G, Pica DG, et al. Intraoperative lung ultrasound improves subcentimetric pulmonary nodule localization during VATS: results of a retrospective analysis. *Thorac Cancer*. 2023;14(25):2558-2566.
5. Zhou Z, Wang Z, Zheng Z, et al. An "alternative finger" in robotic-assisted thoracic surgery: intraoperative ultrasound localization of pulmonary nodules. *Med Ultrason*. 2017;19(4):374-379.
6. Fiorelli A, Messina G, Frongillo E, et al. The use of ultrasound in detecting and defining ground-glass opacities: results of an ex vivo evaluation. *Interact Cardiovasc Thorac Surg*. 2018;26(4):551-558.