CHEST

A 76-Year-Old Man With a 75 Pack-Year History of Smoking and a Pulmonary Nodule

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VIDEO

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A 76-year-old man with a 75 pack-year history of smoking presented to the pulmonary clinic for evaluation of a right upper lobe 1.4-cm spiculated peripheral pulmonary nodule that was incidentally detected on CT of the chest (Fig 1). PET-CT of the nodule prior to presentation showed avidity at the nodule with a standardized uptake value of 1.55 but no evidence of other metastatic foci.

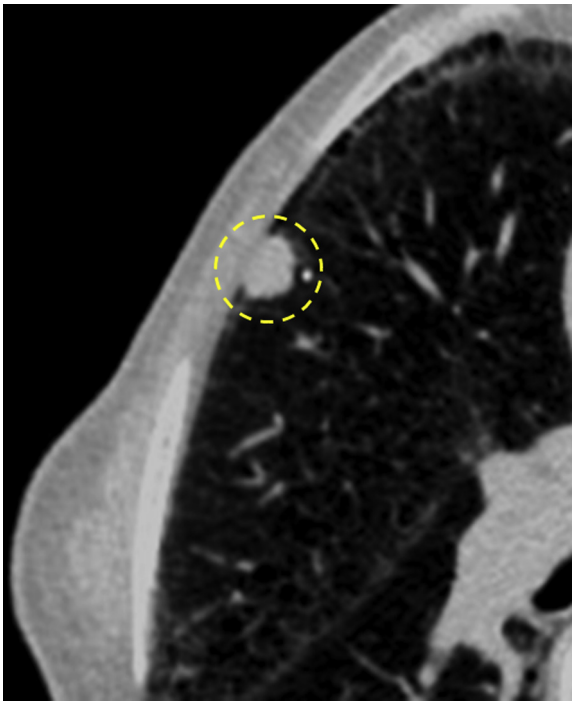

Figure 1 – *CT of the chest with right upper lobe peripheral pulmonary nodule (yellow hatched circle). Image reproduced with the patient's permission.*

Question: How could the patient's nodule be further characterized at the bedside?

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Answer: Bedside ultrasonography can be used to assess peripheral- and pleura-based pulmonary lesions and for transthoracic ultrasonographically-guided biopsy with 3-D ultrasonography to further characterize the peripheral pulmonary lesion.

Subsequent clinical course: The nodule abutted the pleura allowing for ultrasonographic imaging (Video 1). The nodule was imaged in multiple planes and during breath-holding using a free-hand technique and a Phillips CX50 ultrasound unit with a 12-3 MHz linear transducer for further characterization of volume and shape. Furthermore, a data set was obtained for 3-D reconstruction of the nodule (Fig 2). Ultrasonographically-guided transthoracic needle aspiration (TTNA) was performed in the pulmonary clinic followed by mediastinal staging with endobronchial ultrasonographically-guided transbronchial needle aspiration, and the patient was diagnosed with stage Ib adenocarcinoma of the lung (Fig 3, Video 2). Immediately following the biopsy, ultrasonography of the chest was performed to ensure that adequate lung sliding was present and that there was no evidence of pneumothorax.

Discussion

The use of 2-dimensional (2-D) ultrasonography in the evaluation of pleural-based lesions and pulmonary nodules abutting the pleura is well described in the literature.[1] 2-D ultrasonography is useful for facilitating TTNA of pleura-based lesions and nodules that abut the pleura. It can be used to identify the boundaries of a lesion and during breath-holding can be used to facilitate biopsy procedures. After a biopsy, it can be used to assess for adequate lung sliding to rule out pneumothorax. 2-D imaging is, however, limited by a single image plane that can be difficult to localize and replicate for follow-up imaging. Furthermore, 2-D imaging has limitations regarding accurately tracking nodule morphologic characteristics and volume.[2] Although the clinical applications of 3-D ultrasonography are being recognized in many organs of the human body, 3-D ultrasonographic reconstruction of peripheral lung lesions have not been described previously.

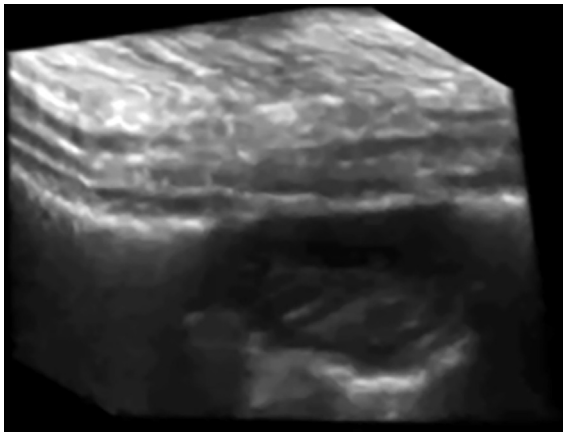

Figure 2 – *3-D ultrasonographic image of peripheral lung nodule obtained with a Philips CX-50 and 12-3mHz linear transducer. Image reproduced with the patient's permission.*

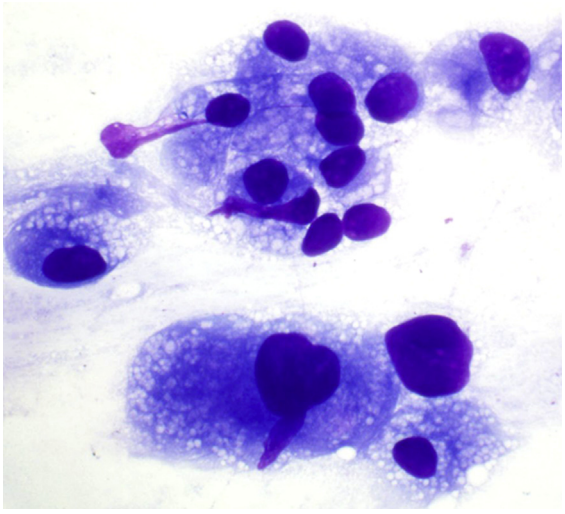

Figure 3 – *Histologic appearance of peripheral lung nodule with classic adenocarcinoma pattern. Image reproduced with the patient's permission.*

3-D ultrasonography has shown utility in cardiac, gynecologic, urologic, and breast imaging.[3] It is an emerging modality for characterization of liver metastasis as well as renal lesions. The use of 3-D ultrasonography has demonstrated clinical utility in volumetric assessment of a number of malignant lesions and has been used to improve biopsy yield for certain solid organ tumors. These organs provide excellent acoustic windows that favor ultrasonography as an imaging modality. The lungs, as air-filled organs in their healthy state, provide poor acoustic windows, with the exception of the pleura and opacities that abut the pleura. The ultrasonographic appearance of peripheral pulmonary nodules and masses has been well described. Until now, 3-D ultrasonography has not been used to characterize pulmonary nodules.

This imaging technique has been used for characterization of a number of tumor types in two specific ways: (1) when tumor volume has prognostic significance and (2) when 3-D images can assist with biopsy for tissue diagnosis by describing tumor morphologic features and vascularity. In staging of prostate cancer, 3-D ultrasonographic reconstruction can be used to spare patients the radiation associated with CT and can allow for in-office assessment of tumor volume as well as tracking of changes in tumor size and morphologic characteristics over time.[4] In the evaluation of liver metastases, 3-D ultrasonography is being used in animal models to noninvasively track tumor volume and metastatic growth in response to therapeutic interventions.[5] This method has demonstrated good correlation with histologic examination of tumor growth and size for liver metastases.

3-D ultrasonography is also being used to facilitate biopsy procedures and at times cancer treatment. 3-D ultrasonography has been found to improve biopsy yield in the setting of suspected prostate cancer due to improved imaging of prostate anatomy and enhanced tumor visualization.[6] 3-D ultrasonography is currently used as a diagnostic tool in evaluating nodules of the breast and is being used to guide brachytherapy in the place of chest CT.[7]

There are several potential applications for 3-D ultrasonography of peripheral pleura-based and intrapleural lesions. 3-D ultrasonography may assist with radiation-free transthoracic needle biopsy in the future. This imaging modality may improve biopsy yield in the pulmonary clinic by better defining tumor anatomy prior to biopsy. This modality may also be useful in nodule tracking. Literature suggests that tracking of tumor volume may be a more comprehensive method for nodule tracking as opposed to 2-D tracking based on a single-plane diameter.[8]

In our clinic, the nodule was localized using the Phillips CX50 ultrasound unit with a 12-3 MHz linear transducer. The patient was then instructed to inhale and hold the breath. During breath-holding, the probe was used to fan through the entire nodule, and the scan was recorded on the ultrasound machine. The still-frame images were then used to reconstruct the 3-D structure (Videos 3, 4).

The aforementioned uses of 3-D ultrasonography are not without limitations. Many ultrasound units do not provide the software to reconstruct 3-D images from data sets. In addition, although 3-D ultrasonography has proved useful in a number of other malignancies, the effect on clinical outcomes in lung cancer remains unclear at this time. Furthermore, TTNA can be accomplished at the bedside with 2-D imaging, but it is unclear if biopsy yield would improve with the use of 3-D imaging.

Nevertheless, real-time acquisition of images can provide assessment of tumor anatomy, volume, and vascularity with an inexpensive modality that can be performed in a pulmonary clinic. This novel imaging modality might show promise for nodule tracking with volumetric measurements and can be used to facilitate biopsy. We provide the first description of 3-D ultrasonographic imaging of a lung lesion with expectation that further development of this technique will advance the role of ultrasonography in the evaluation of thoracic disease (Video 5, discussion).

Reverberations

1. *3-D ultrasonography is feasible for pleura-based lesions and nodules that abut the pleura.*
2. *In the future, 3-D ultrasonography of pulmonary nodules may be used to describe nodule morphologic features, volume, and vascularity.*
3. *3-D ultrasonography is being used in other malignancies to improve tracking, diagnosis, and treatment and may have similar applications in pleura-based lesions and nodules that abut the pleura.*

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Other contributions: *CHEST* worked with the authors to ensure that the Journal policies on patient consent to report information were met.

Additional information: To analyze this case with the videos, see the online version of this article.

References

1. Sperandeo M, Filabozzi P, Varriale A, et al. Role of thoracic ultrasound in the assessment of pleural and pulmonary diseases. *J Ultrasound*. 2008;11(2):39-46.
2. Slapa RZ, Jakubowski WS, Slowinska-Srzednicka J, et al. Advantages and disadvantages of 3D ultrasound of thyroid nodules including thin slice volume rendering. *Thyroid Res*. 2011;4(1):1.
3. Rotten D, Levaillant JM, Constancis E, et al. Three-dimensional imaging of solid breast tumors with ultrasound: preliminary data and analysis of its possible contribution to the understanding of the

standard two-dimensional sonographic images. *Ultrasound Obstet Gynecol*. 1991;1(6):384-390.

4. Tong S, Downey DB, Cardinal HN, et al. A three-dimensional ultrasound prostate imaging system. *Ultrasound Med Biol*. 1996;22(6):735-746.
5. Graham KC, Wirtzfeld LA, MacKenzie LT, et al. Three-dimensional high-frequency ultrasound imaging for longitudinal evaluation of liver metastases in preclinical models. *Cancer Res*. 2005;65(12):5231-5237.
6. Zhao HX, Zhu Q, Wang ZC. Detection of prostate cancer with three-dimensional transrectal ultrasound: correlation with biopsy results. *Br J Radiol*. 2012;85(1014):714-719.
7. De Jean P, Beaulieu L, Fenster A. Three-dimensional ultrasound system for guided breast brachytherapy. *Med Phys*. 2009;36(11):5099-5106.
8. Ko JP, Rusinek H, Jacobs EL, et al. Small pulmonary nodules: volume measurement at chest CT—phantom study. *Radiology*. 2003;228(3):864-870.