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# Mobile 3D Intraprocedural Fluoroscopy in Combination With Ultrathin Bronchoscopy for Biopsy of Peripheral Lung Nodules

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*Summary:* **Despite development of multiple technologies, distinguishing benign from malignant lung nodules when they are still small in size is challenging. A high yield and minimally invasive bronchoscopic technology with low cost for diagnosis of small lung lesions is needed in pulmonary and lung cancer clinical practice. Peripheral airway bronchoscopy using thin and most recently ultrathin bronchoscopes improve visualization of small airways. The novel mobile 2D/3D C-Arm fluoroscopy system is a complementary tool along with radial endobronchial ultrasound in detecting small lung nodules with real-time high-quality multidimensional image confirmation during bronchoscopy. This combined technology can be easily acquired in any bronchoscopy room, and potentially affect lung nodule practice significantly.**

**Key Words:** bronchoscopy, lung nodule, radial EBUS, fluoroscopy, ultrathin bronchoscopy, 3D imaging

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Identification of lung nodules is increasing in clinical practice, making the use of minimally invasive techniques to diagnose and treat them more important than ever.[1] Bronchoscopy has the least amount of complications among sampling modalities, but different bronchoscopy methods provide a wide range of diagnostic outcomes.[2,3]

Radial endobronchial ultrasound (r-EBUS) is used for real-time confirmation of lung nodules during a bronchoscopy.[4,5] We have found that the ultrathin bronchoscope maneuvers incredibly well in peripheral airways and can visualize small airways that traditional bronchoscopes never reached.[6,7] The new mobile hybrid 2D/3D C-Arm fluoroscopy system can be effective for intraprocedure multidimensional image confirmation of the tools in target and optimize airway navigation.

Here we report on the combination of intraprocedural 3D imaging with ultrathin bronchoscopy and how this may affect diagnosis of lung nodules.

## METHODS

In 4 consecutive cases of patients with peripheral lung nodules, we combined our routine peripheral airway bronchoscopy with use of Cios Spin mobile hybrid 2D/3D C-arm system (Siemens Medical Solutions USA Inc.). Patient consents were secured as part of routine practice before the bronchoscopy. The data report is part of the study (2017-8587) which was approved by our institution's IRB.

A bronchoscopy was conducted using an Olympus ultrathin BF-MP190 scope in combination with an Olympus r-EBUS probe (UM-S20-17S) and 2D fluoroscopy surveillance. Before the bronchoscopy, the segment of the lung with the nodule was identified through the computed tomography (CT) scan images. Under fluoroscopy surveillance and direct bronchoscopic visualization, each small bronchus in that segment was examined by r-EBUS. Frequently, the ultrathin scope can find multiple small airways, not seen by a CT scan, leading to the discovery of a small nodule. The airway leading to the best r-EBUS view of the nodule is then selected.

To ensure accurate positioning of the bronchoscopic tools inside the nodule, a 30 second rotary scan by the Cios Spin mobile C-arm is done to achieve a multidimensional image. If navigation to a target is unsuccessful, the 3D image can still guide the adjustment of the r-EBUS probe position around the nodule and optimally into the target. After satisfactory intraprocedural imaging, the r-EBUS probe

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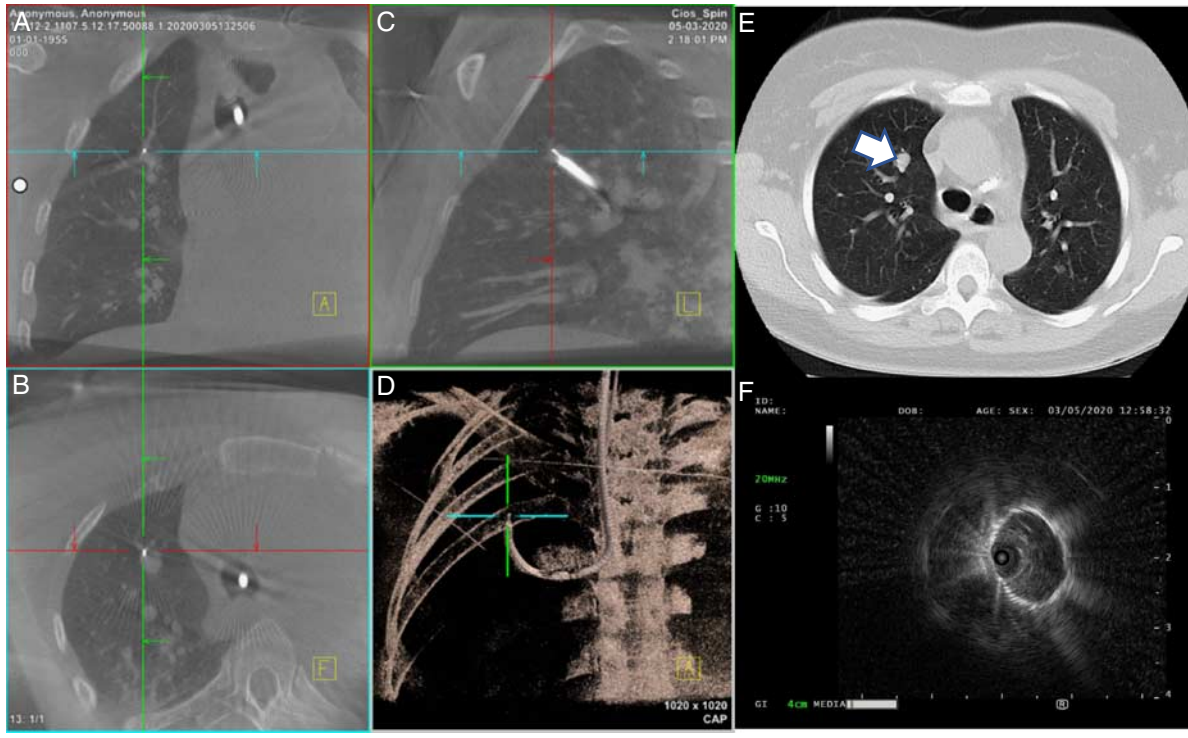


**FIGURE 1.** Bronchoscopy with the ultrathin scope, radial endobronchial ultrasound (r-EBUS) and 2D/3D fluoroscopy of a 12 mm right upper lobe (RUL) lung nodule. A, Coronal plane view showing r-EBUS probe inside the nodule and cross section of bronchoscope in trachea. B, Axial plane view showing r-EBUS probe inside the nodule and cross section of bronchoscope in trachea. C, Sagittal plane view showing r-EBUS probe inside the nodule and the distal end of bronchoscope touching the nodule. D, 3D configuration with bone enhancing view showing the entire bronchoscope in lung. E, A representative axial plane cut of the CT scan showing the RUL anterior segment nodule (white arrow). F, Concentric r-EBUS view of the lung nodule.

is withdrawn from the bronchoscope working channel while maintaining view of the airway. Under direct bronchoscopic airway visualization and 2D fluoroscopy surveillance, multiple samples can be obtained; routinely 5 needle aspirations and 5 forceps specimens and sometimes brushing.

## RESULTS

Four patients who were referred for small lung nodules underwent a bronchoscopy in one day. None of the targeted lesions had a bronchus sign in CT scan imaging. The position of the r-EBUS probe and the tip of the ultrathin bronchoscope were confirmed to be inside the nodules in the first 3 cases and adjacent to the nodule in fourth case. In the last case, 3D imaging showed local lung atelectasis in the surrounding area and separate from the nodule. The targeted nodule was seen attached to the major fissure. 3D spinning scan was done only once in the first 3 cases and twice during the fourth case.

Case 1 was a 64-year-old woman with multiple slow growing lung nodules. The largest nodule, located in the right upper lobe, had a dimension of 12×9 mm. The pathology exam showed a low-grade neuroendocrine neoplasm consistent with carcinoid tumor (Fig. 1).

Case 2 was a 71-year-old immunocompromised woman who previously underwent a kidney transplant and had a growing nodule in her right upper lobe, last reported to be 14 mm wide. Pathology results showed fungi with septated hyphae and narrow-angled branching. Chronic inflammation and granulation tissue were also seen. A GMS stain highlighted the fungus (Fig. 2).

Case 3 was a 71-year-old woman with a growing 19 mm left lower lobe sub-solid nodule. Cytopathology results showed clusters of small atypical glandular cells with macrophages and inflammatory cells. The AFB culture came back positive for mycobacterium tuberculosis.

Case 4 was a 64-year-old man with a growing 13 mm left upper lobe nodule abutting the major fissure. Atypical epithelial cells were seen in cytopathology report.

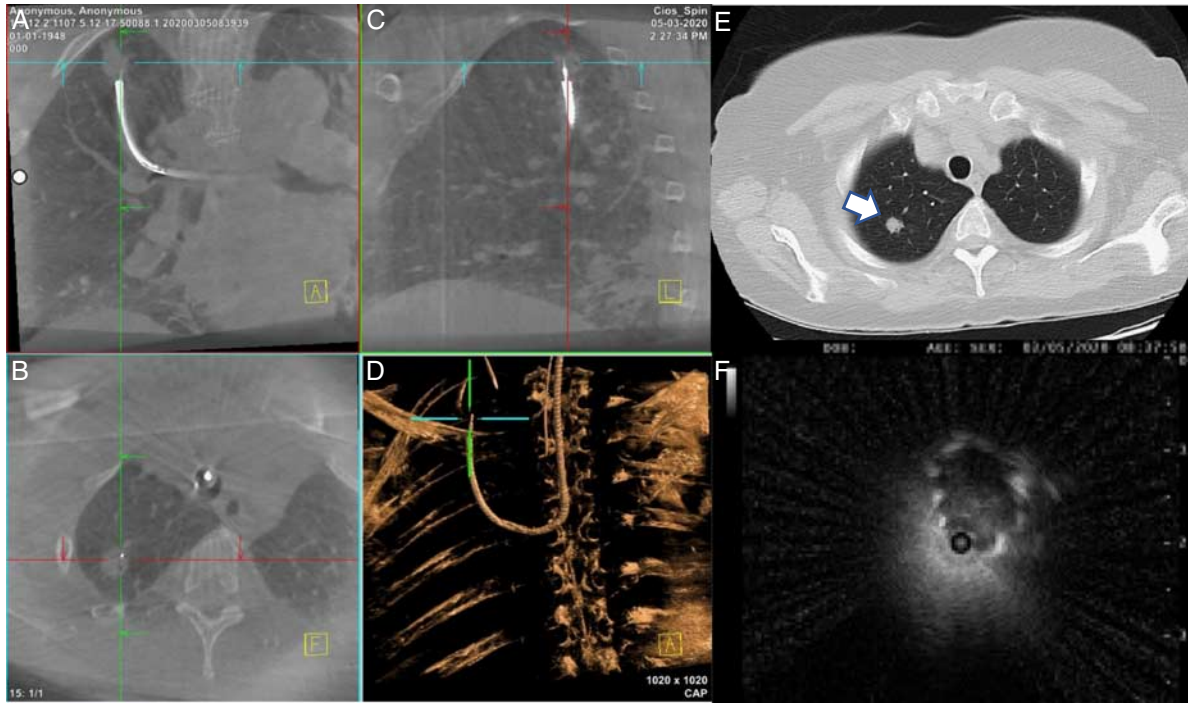


**FIGURE 2.** Bronchoscopy with the ultrathin scope, radial endobronchial ultrasound (r-EBUS) and 2D/3D fluoroscopy of a 14 mm right upper lobe (RUL) lung nodule. A, Coronal plane view showing r-EBUS probe inside the nodule and the distal end of bronchoscope touching the nodule. B, Axial plane view showing r-EBUS probe inside the nodule and cross section of bronchoscope in trachea. C, Sagittal plane view showing r-EBUS probe inside the nodule and the distal end of bronchoscope touching the nodule. D, 3D configuration with bone enhancing view showing the entire bronchoscope in lung. E, A representative axial plane cut of the CT scan showing the RUL apical segment nodule (white arrow). F, R-EBUS view of the lung nodule.

## DISCUSSION

Intraprocedural guidance with r-EBUS during bronchoscopy confirms the position of the diagnostic tools inside the target. On occasion, r-EBUS view is not satisfactory due to different reasons, for example, partial atelectasis around the target or a failed navigation toward the target. Ultrathin scope helps exploring small airways close to target lesion and for a better navigation. High precision intraprocedural confirmation can be achieved by using a cone beam CT bronchoscopy. The cone beam CT bronchoscopy, however, is not available in most centers due to its cost.

The Cios Spin mobile hybrid 2D/3D C-arm is relatively more affordable as it is priced around $400,000 in the United States and the ultrathin bronchoscope is around $30,000. Its foot-print is similar to most conventional C-Arm fluoroscopy systems and it can easily be plugged in the outlets of conventional bronchoscopy rooms (Fig. 3). Most of the advanced bronchoscopy rooms are equipped with r-EBUS, so there are no additional costs. Simultaneous images display in three projections (transversal, coronal, and sagittal) and is captured via a complementary metal-oxide-semiconductor detector with a 30 second C-Arm spin (volume size of 16×16×16 cm with resolution of 512×512×512 pixels). In all 4 of our cases, the 3D scanning provided excellent visualization with high resolution of very tiny anatomic structures around the target. The system is currently being used for precise intraoperative guidance in orthopedics and other surgeries. Depending on the patient body size and the desired quality image, different options are available to choose via modification of radiation dose, field of exposure, and scan timing (https://www.siemens-healthineers.com/en-us/surgical-c-arms-and-navigation/mobile-c-arms/cios-spin). The radiation dose for a 3D scan can vary from ~6 to 38 mGy for body protocols by selection of appropriate imaging techniques.[8]

The combination of ultrathin bronchoscopy, r-EBUS, 2D fluoroscopy, and 3D imaging makes an effective method for diagnosing small peripheral lung nodules. The BF-MP190 bronchoscope has a 3.0 mm distal-end outer-diameter (OD) and 1.7 mm working channel. It can maneuver in peripheral airways as small as 3 mm,

**FIGURE 3.** Cios Spin mobile hybrid 2D/3D C-arm.

while its camera provides visualization of even more peripheral branches. Combined with r-EBUS, it can examine the airways with small diameter (as small as 1.4 mm, equal to OD of r-EBUS probe), and can be complimentary to current navigational bronchoscopy systems. Biopsy of lung lesions <2 cm, using currently available virtual bronchoscopy systems, is still challenging (http://www.broncus.com/wp-content/uploads/2018/03/MK-320-LungPoint-Marketing-Brochure_0218.pdf).[9] Having a 3D scan confirms the exact position of the r-EBUS probe and sometimes the tip of the bronchoscope inside the lesion. When navigation to the target lesion is unsuccessful, the Cios Spin system allows for reviewing the 3D reconstructed images during bronchoscopies and ultrathin scope helps identify alternative pathways by visualization of small peripheral airways and adjust the position of tools toward the nodules. This combination of tools will assure the specimen is obtained from the target lesion and not the surrounding tissues.

In this report we do not mean to comment on the diagnostic sensitivity of this method, but to reveal the technical aspects which can give more confidence in how we interpret biopsy results. Further study of this technology may validate a higher sensitivity and specificity of diagnostic bronchoscopy of peripheral lung nodules compared with traditional methods. We think this is a promising start for using advanced bronchoscopies for detecting and treating small peripheral lung lesions.

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