CLINICAL VIGNETTE

Electromagnetic Navigation Bronchoscopy

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Case 1

A 76-year-old man with emphysema and hypertension presented to his primary physician with coughing and chest congestion. He had smoked up to two packs of cigarettes a day for 42 years and quit smoking at age 60. A chest x-ray showed bilateral vague abnormalities in the upper lobes. Subsequent chest CT showed a 14 x 8 mm right upper lobe nodule adjacent to the pleura (Figure 1) and a 13 mm spiculated left upper lobe nodule surrounded by significant emphysematous changes (Figure 2). A transthoracic CT-guided needle biopsy of the right upper lobe nodule revealed squamous cell lung carcinoma. Because of the location deep in the left upper lobe and the surrounding emphysematous changes, a CT guided lung biopsy could not be obtained. Instead, the patient was referred for electromagnetic navigation bronchoscopy (ENB). With ENB guidance, transbronchial lung biopsies also confirmed squamous cell cancer in the left upper lobe.

Case 2

A 68-year-old woman with COPD with a 36 pack-year history of smoking was found to have a 17 x 10 mm nodule in the superior segment of the left lower lobe. A PET scan did not show significant hypermetabolism in the nodule. She was observed and a chest CT four months after the initial study showed a slight increase in the size of the nodule to 19 x 12 mm (Figure 3). At that point, she was referred for ENB and transbronchial biopsies demonstrated well differentiated adenocarcinoma with a lepidic growth pattern. She subsequently underwent a left lower lobe resection and was found to have Stage Ia disease.

Pulmonary nodules and lung lesions are common findings that pulmonologists often encounter. Given the large numbers of CT scans which are performed, incidental lung nodules are exceedingly common, not only on chest CTs but also on neck or abdominal CTs. In addition, the NLST demonstrated the benefit of lung cancer screening with low-dose chest CT with a 20% reduction in lung cancer mortality compared to screening with chest x-ray.[1] Increased screening with low-dose chest CT will certainly increase the number of peripheral lung lesions that will require further evaluation.

The optimal management of a pulmonary nodule or peripheral lesion can be a challenging and complex problem. Decisions must take into account many factors including pre-test probability of cancer, nodule size and location, comorbid conditions (especially emphysema and COPD), the ability of the patient to tolerate treatment if cancer is discovered, and patient preferences.

In general, management consists of three options: watchful waiting with serial imaging, nonsurgical biopsy, or surgical biopsy/excision.[2] Very small nodules are frequently benign and are usually followed with serial imaging. While this strategy reduces unwarranted procedures and complications, it can potentially delay the diagnosis of malignancy in some patients. On the other hand, patients with larger nodules, which are highly suspicious for cancer and have a low risk for perioperative complications, are often referred directly for surgery. However, approximately 20% of peripheral nodules that are resected are found to be benign.[3,4] In patients whose nodules are felt to have an intermediate risk for cancer, a nonsurgical biopsy can assist in making decisions regarding surgery versus continued observation. In the past, unfortunately, many nodules were considered too small or were located in areas too difficult to biopsy.

Traditionally, CT guided needle biopsy or aspiration has been the usual method for diagnosing small, indeterminate, peripheral lung nodules. The sensitivity of CT guided needle aspiration is high, approximately 90%.[5] However, pneumothorax is a common complication reported in up to 15% of cases with 7% requiring chest tubes.[6] In addition, the probability of pneumothorax is greater in patients with emphysema or deeper nodule location, as in the patient presented in case 1. While conventional bronchoscopy with transbronchial biopsy has a low complication rate, diagnostic yields are low. The sensitivity for transbronchial biopsy is dependent on lesion size and is only 34% for peripheral lesions <2 cm and is 63% for peripheral lesions >2 cm.[5] The yield decreases further to only 14% for nodules <2 cm located in the peripheral third of the lung.[7] ENB was developed to improve the diagnostic yield of bronchoscopy in the evaluation of peripheral lung nodules and has enabled us to biopsy nodules, which were previously inaccessible with conventional bronchoscopy.

There are four main components to the ENB system: 1) Software that enables CT data to be reconstructed into a 3D image of the bronchial tree and show the relationship of the nodule to the airway anatomy; 2) A location board that is placed under the patient during the bronchoscopy and produces a low frequency electromagnetic field around the patient's torso; 3) A locatable guide (LG), which is placed within the guide sheath and indicates its location and orientation within the airway; and 4) A steerable guide sheath

that allows placement of the LG and tools to sample the lesion once appropriate navigation has been achieved.

The planning phase occurs prior to the navigation bronchoscopy and requires a chest CT with thin, overlapping slices. The images are converted into a DICOM format and are loaded into the planning computer. The software reconstructs the data into virtual images of the lung parenchyma and airways. The target lesion is identified and a map is generated, which allows navigation to the area during the procedure.

During the procedure, the patient's actual and virtual anatomy must be matched for accurate navigation to occur. This process is termed registration and can be performed manually by matching multiple registration points, such as the main and secondary carinas, or can occur automatically (with recent versions of the software) as the bronchoscope and locatable guide are driven through the airways. Once registration has been achieved, a virtual bronchoscopy image appears and the pathway that was produced in the planning phase is followed to the target peripheral nodule. When the target is reached, the guide sheath is locked in place, the locatable guide is removed and sampling of the lesion through the guide sheath takes place. Multiple sampling techniques are available including transbronchial biopsy, needle aspiration, brushings, and small-volume BAL. In addition, a radial ultrasound probe can be inserted into the guide sheath and provide real-time confirmation of accurate positioning within or adjacent to the target lesion.

The diagnostic sensitivity of ENB ranges from 63% to 87.5%.[5,8] Several factors can influence the diagnostic yield. The presence of an airway leading to the nodule ("bronchus sign") on CT increased the yield from 31% to 79% when a bronchus sign is present on CT.[9] The addition of endobronchial ultrasound (EBUS) to confirm the position of the LG within or adjacent to the targeted nodule prior to tissue sampling also increases yield. A randomized, controlled trial comparing ENB alone, EBUS alone, or a combination of ENB and EBUS found the sensitivity of the combined procedure to be higher (88%) than either ENB (59%) or EBUS alone (69%).[10] It has been suggested that the availability of rapid on-site evaluation (ROSE) can also increase yields. In a case series that evaluated both peripheral lung lesions and mediastinal adenopathy, the overall yield with ROSE was 89.5%.[11] One study suggested that the higher yield when sampling upper lobe versus lower lobe lesions (77% vs. 29%) was due to enhanced movement in the lower lobes during breathing.[10] A recent study confirmed that the average movement of lung lesions with respiration is greater in the lower lobes (23.8 – 25.3 mm) compared to the upper lobes (10.6 – 12.2 mm)(12).

ENB is a safe procedure. In a recent review and meta-analysis the incidence of pneumothorax was 3.1% with only 1.6% requiring chest tubes.[8] Minor or moderate bleeding was reported in 0.9%.[8] Although ENB occurs within a low frequency electromagnetic field, a recent study of 24 patients with pacemakers found no arrhythmias or pacemaker malfunction.[13]

In addition to diagnosis of peripheral lung lesions, ENB can also be used for other purposes. Fiducial markers for stereotactic radiosurgery have been successfully placed with ENB guidance.[14] Dye marking can also help surgeons identify the location of small peripheral lung lesions, which can be difficult to palpate, when performing sublobar resections. Lastly, endobronchial thermal ablation therapies (radiofrequency and microwave ablation) are in development for the treatment of lung cancer and ENB guidance has been utilized to place these catheters.[15]

In summary, ENB is a useful tool that has enhanced our ability to diagnose lung cancer in small peripheral lung lesions. While it will not replace CT guided needle sampling of lung lesions, it provides an alternative method of diagnosis. Which technique to use may depend on lesion size, number of lesions, location, presence of a bronchus sign, or the presence of emphysema, in addition to local expertise. Further study will be required to better define the most appropriate method for diagnosing peripheral lung lesions based on many of these factors.

Figures

Figure 1. Chest CT showing a 14 x 8 mm right upper lobe nodule adjacent to the pleura.

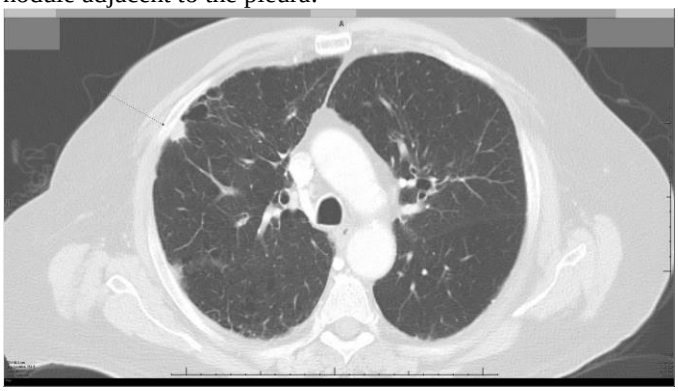


Figure 2. Chest CT showing a 13 mm spiculated left upper lobe nodule surrounded by significant emphysematous changes.

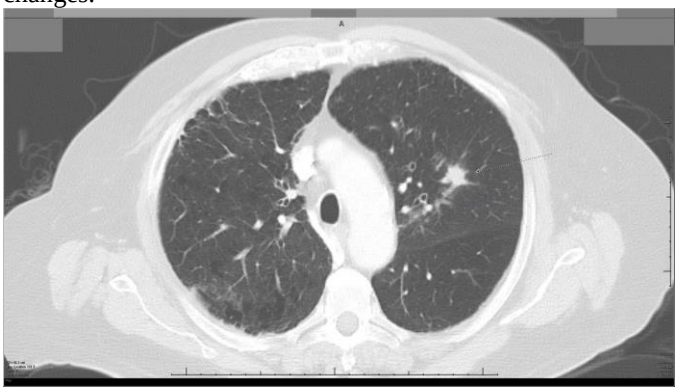
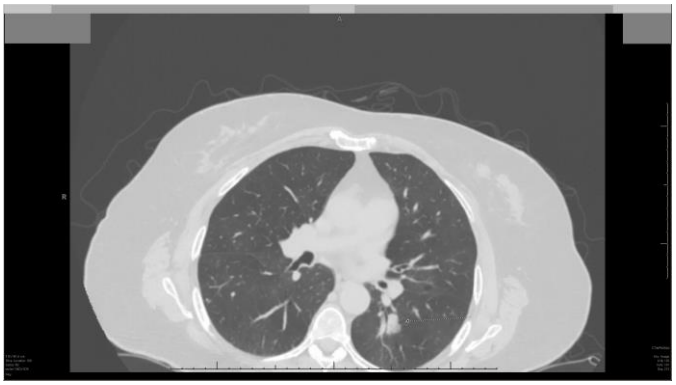


Figure 3. Chest CT four months after the initial study showing a slight increase in the size of the nodule to 19 x 12 mm.



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