Electromagnetic Navigation Diagnostic Bronchoscopy: A Prospective Study

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Online Data Supplement

Procedure

The details of the equipment and configuration have been previously described (14-15) . In general, ENB is composed of four components: 1) electromagnetic location board is installed under the bronchoscopy table that emits low frequency electromagnetic waves; 2) a 1 mm in diameter and 8 mm long steerable probe, 3) an extendable working channel (EWC), and 4) the computer software.

All subjects had CT scans of the chest configured with slices of 3 mm thickness at 1.5 mm intervals in DICOM format. The CT data was loaded from a CD-rom into a laptop computer (Dell^{TM}- Pentium 4 -2.0 GHz, 512KB cache, 512MB DDR266 RAM) containing the planning software. Four to six markers were made in the virtual bronchoscopy to correspond to actual major anatomic landmarks (e.g. main carina, left and right upper lobe carina etc.). The lesions of interest either mediastinal lymph nodes or peripheral lesions were also marked to identify the target center. The bronchoscope was an Olympus 1I160, 2.8mm working channel, adult therapeutic bronchoscope.

Conscious sedation

Conscious sedation was performed according to our institutional guidelines. 200 mg of 4% lidocaine is delivered via nebulizer prior to the patient entering the procedure room. Once in the procedure room the patient was attached to cardiopulmonary monitoring equipment including ECG leads and pulse oximetry. The nose is prepared with 2% lidocaine jelly. 2 mg boluses of morphine and midazolam are given at three minute intervals until adequate sedation is achieved and repeated as necessary titrated to patient comfort. Additional lidocaine is delivered via the working channel of the bronchoscope topically with 2 mL of 2% lidocaine (20mg/ml) not to exceed 0.6mg/kg.

Registration

Once the subject was placed under conscious sedation and local anesthesia the flexible video bronchoscope (Olympus 1T160 with a 2.8mm working channel) was inserted through the nose. An airway exam was performed and washing or BAL was performed in the bronchus of interest prior to navigation.

Registration was performed by placing the steerable probe through and EWC and through the channel of the bronchoscope (Fig 1.). Each marker identified in the planning

phase was identified on the virtual bronchoscopy images on the ENB computer and correlated to the image from the video bronchoscope in the next window (Fig 2). The steerable probe was placed at the same site of the marker and a foot pedal marked the position. This was repeated for each marker identified during the planning. Upon registration completion, the average fiducial target registration error (AFTRE) score was given in mm. The AFTRE is the radius of expected difference of the location of the tip of the steerable probe in the actual patient compared to where it is expected to be in the virtual patient. Repeating registration on some or all of the marks can be done to improve the AFTRE.

After registration was complete, the navigation was initiated. The computer was switched to a navigation mode with the ENB screen showing the multiplanar CT images with the position of the steerable probe in each and the fourth panel showed the "tip view" from the steerable probe relative to the target center. The simultaneous advance of the steerable probe toward the target and squeezing of the directional instrument corresponding to the arrows on the screen help direct the steerable probe tip to a distance from lesion center recorded on the right corner of that window. When navigation was completed (assuming that the closest distance to the target was reached), the steerable probe was removed leaving the EWC wedged in the airway as a conduit directly to the lesion. Through this EWC, brush, transbronchial biopsies were performed, and when possible, a TBNA was also used. On occasion the TBNA was not able to negotiate the bend in the bronchoscope or EWC due to the acute angle at its inflexible length.

Specimen sampling

Bronchial washing to obtain 25 mL of aspirated solution is collected for routine cytology. BAL was performed in the wedged position to obtain 50 mL of aspirated saline for cultures, cell counts, and cytology. Both washing and BAL were performed in through the working channel of the bronchoscope.

After navigation, the steerable probe is removed and locked in position. A C-arm fluoroscopy unit was brought into the field. Through the EWC, at least two passes with the cytology brush were performed under fluoroscopic vision. The cytology brush was used first since it was less likely to dislodge the EWC. Next, TBBX was performed to obtain at least four pieces of tissue under fluoroscopic vision. If the EWC appeared to be

displaced while the TBBX forceps were being introduced (figure 4a and 4b), the fluoroscopy unit was removed and navigation with the steerable probe was repeated. If peripheral TBNA was possible using a 22G needle, at least two passes were made under fluoroscopic vision. Again, if EWC displacement was observed navigation was repeated. After completing all biopsies the EWC remained locked in position and the bronchoscope in the wedged position for four minutes to allow adequate clot formation.

TBNA was performed after navigation with a combination of 22G and 19G needles to accomplish at least four passes at each lymph node station starting at the highest (N3>N2>N1) nodal station. TBNA was performed through the bronchoscope working channel but not utilizing the EWC. ROSE (rapid on-site cytopathologic evaluation) was not used in any case as it is not routinely available in our institution.