1. Background

Reliable biopsy of peripheral nodules is important for lung cancer diagnosis. Peripheral procedures are difficult, however, as the bronchoscopist must navigate through many airway generations to reach an appropriate biopsy site and the target nodule, which is typically hidden behind the airway walls. CT fluoroscopy and electromagnetic-navigation bronchoscopy have been proposed to assist the bronchoscopist.2,3 Recently, however, Virtual Bronchoscopic (VB) guidance derived solely from a patient’s multidetector CT (MDCT) chest scan has shown promise towards improving peripheral bronchoscopy performance without requiring significant additional hardware.4,5 We had previously shown that our computer-based virtual navigation (VN) system provides reliable guidance and is feasible for human peripheral nodules.6 We now present final results for a human study of the VN system for peripheral lesion biopsy.

2. Materials and Methods

We consented and enrolled 30 patients with focal lesions, suspected lung cancer and available MDCT scans. The chest scans, generated by either a Siemens Sensation or Emotion scanner, were reconstructed at a resolution of 0.5 mm spacing with 0.75-mm thick 2D axial-plane sections; axial-plane resolution was between 0.52 and 0.92 mm. We used the VN system for offline procedure-planning and live bronchoscopic guidance, as described below.6 Primary study outcomes for each region of interest (ROI) were: 1) Navigation success: ability of the system to lead the bronchoscopist along the correct route; 2) Sampling success: collection of a satisfactory tissue sample (pathologist interpretation).

Stage 1: Procedure planning

The bronchoscopist identified a ROI on a patient’s MDCT chest scan. Next, automatic computer-based methods extracted the 3D airway-tree, computed the endoluminal surfaces of the airways, defined a 3D endobronchial route leading to the ROI, and produced an interactive pre-bronchoscopy report enabling pre-procedure review of images by the bronchoscopist.

Stage 2: Live image-based bronchoscopic guidance

In the bronchoscopy suite, a guidance computer interface to the bronchoscope. We employed either a 2.9-mm-diameter Olympus BF Type XP16F ultrathin videobronchoscope, a 4.9-mm-diameter Olympus BF Type P180 true-color videobronchoscope, or a 6.0-mm-diameter Pentax EB150K videobronchoscope. Sampling procedures involved either a brushing, bronchial lavage, or a needle (only available with the 4.9-mm Olympus bronchoscope or the Pentax bronchoscope). During the procedure, the bronchoscopist maneuvered the bronchoscope along the predefined endobronchial route using the continuously-updated graphical information provided by the computer (Figure 1). The computer also displayed unambiguous graphical information at the final biopsy site (Figure 2).

The VN system fits smoothly into the clinical workflow, with required physician interaction limited to indicating target ROIs and previewing the image-guided procedure with the pre-bronchoscopy report. The system functioned properly and introduced no safety issues for all cases. A summary of the results appears below.

• 69 target ROIs considered for the 30 patients:
  ➢ 62 diagnostic sites requiring a tissue sample (22 nodules, 4 masses, 16 infiltrates, 3 ground-glass opacity, 4 BAL sites, 7 lymph nodes, 13 other (including cavitory lesions, collapsed airways, 1 cavity wall, 1 foreign body))
  ➢ 7 sites where only visual inspection was required.

• Navigation success: 91% (63/69)

• 84% bronchoscope navigated to within 2 generations of ROI

• 67% bronchoscope navigated to within 1 generation of ROI

• 27% bronchoscope navigated to the final airway generation

• Satisfactory sample rate for diagnostic sites: 90% (58/62) (TNA, brushing, forceps, in BAL)

• Mean time until first sample: 5.15 ± 5.06 (median: 3.40 range: 0.28 – 32.07)

The VN system is effective for sampling peripheral lesions, with planning, navigation, and yield results exceeding those of previously reported studies.

4. Conclusion

The image-guided bronchoscopic system was effective for sampling peripheral sites, with planning, navigation, and yield results exceeding those of previously reported studies.

References


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