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Augmented Endobronchial Fluoroscopic Navigation and Localization System: Comparison with Cone Beam CT

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Abstract:

Background: Augmented endobronchial fluoroscopic navigation (LungVision, Body Vision Medical Ltd, Israel) is a new method for the bronchoscopic diagnosis of pulmonary nodules. This real-time technology, integrating the preoperative CT data with intraoperative fluoroscopy, has distinct advantages over current virtual electromagnetic navigation approaches and has offered a possibility of increased diagnostic yield. As shown by reference studies, the ability for real-time lung motion tracking is critical for navigation to small pulmonary nodules, due to the challenges of respiratory related lung tissue movement during bronchoscopy. We present the benefits of this novel navigation system in quantitative terms of diagnostic yield and accuracy of localization compared with cone beam CT.

Methods: This study was approved by the institutional review board and informed consent was obtained. Forty-six patients with solitary pulmonary nodules referred for bronchoscopy were included in the study (FirstHealth Moore Regional Hospital, Pinehurst N.C.). Before the procedure, CT scans were imported into the LungVision planning software, where physicians identified the target nodules and selected the desired pathways. General anesthesia was utilized in all patients. LungVision was used for real-time localization of the airways and lesion and for directional guidance during biopsy. A flexible bronchoscope was directed to the lobe of interest, and a fluoroscopically visible, steerable catheter was introduced through the working channel (Medtronic, Edge FT). The catheter was guided to the electronically highlighted target by following a pathway overlaid on the fluoroscopy image. When the LungVision display showed the nodule had been reached, cone-beam computed tomography (CBCT, Philips Allura Xper FD20) was used to acquire a 3D image of the area of interest and tissue samples were taken. The target localization accuracy was measured by calculating the distance between the location of peripheral nodules as shown by CBCT and the LungVision system. Lung tissue movement was tracked and recorded for post procedure analysis.

Results: 46 patients were included in the study with average age of 71.6±STD (range 48-85). Average lesion size was 19 mm ± STD (range 10-33mm), and 80% of the lesions were located in the upper lobes (RUL/LUL). 90.6% of these lesions were located in the middle or peripheral third of the lung.

No peri-procedural adverse events were reported. The average pulmonary nodule movement caused by respiratory motion was measured as 17.6mm (ranging from 5 to 25 mm) during bronchoscopy. It was correlated with respiratory motion and anatomical location of the lesion. Successful navigation to the pulmonary nodule, according to the LungVision display, was achieved in all technically successful cases (42/46).

In 100% of these cases (42/42), the lesion size and location shown by the LungVision system matched CBCT imaging (accuracy 5mm±STD). The diagnostic yield was 90% (38/42).

Conclusion: Augmented endobronchial fluoroscopic navigation with the LungVision system is safe, feasible and provides lesion localization accuracy of 5mm ±STD as measured with CBCT. Lesion movement caused by respiratory motion was high compared to average lesion size. This factor may significantly affect the diagnostic yield with virtual navigation systems. A. Unlike other image-based navigation modalities, augmented real-time fluoroscopic imaging offers the advantages of dynamic target tracking which compensates for respiratory motion during both navigation and biopsy. This represents a novel tool, which appears to significantly increase the diagnostic yield of guided bronchoscopy. Further large-scale studies are indicated to assess the possible role of LungVision as the method of choice for the image-guided biopsy of peripheral lung lesions.

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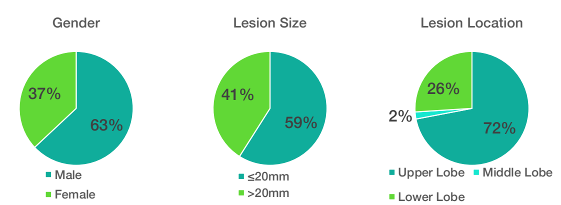
INTRODUCTION

Augmented endobronchial fluoroscopic navigation (LungVision, Body Vision Medical Ltd, Israel) is a new method for the bronchoscopic diagnosis of targeted pulmonary nodules. This real-time technology, integrates preoperative CT data with intraoperative fluoroscopy which enables dynamic target tracking during navigation to pulmonary nodules. Nodule position seen on pre-procedure CT scan changes significantly during bronchoscopy due to multiple factors that include differences in patient positioning, deformation of the airway by the scope and biopsy tools, presence of atelectasis, breathing motion, and physiologic changes that may occur in the time period between scans. Nodule position change can impact both localization and diagnostic success. This study focuses on patient positioning and quantify CT to patient divergence.

METHODS

This study was approved by the institutional review board and informed consent was obtained. Thirty-five patients with thirty-nine solitary pulmonary nodules referred for bronchoscopy were included in the study (FirstHealth Moore Regional Hospital, Pinehurst N.C.). Before the procedure, CT scans were imported into the LungVision planning software, where the physician identified the targeted nodule and selected the desired pathway. General anesthesia was utilized in all patients. During the procedure, cone-beam computed tomography (CBCT, Philips Allura Xper FD20) was used to acquire 3D images of the area of interest showing real-time localization of the airways and nodule prior and after navigation. Once nodule location has been confirmed, tissue samples were taken. The difference of nodule location between the pre-procedural CT scan and the interprocedural CBCT image prior to navigation was calculated to evaluate CT to patient divergence.

FIGURE 1: PATIENT DEMOGRAPHICS



RESULTS

Thirty-nine fluoroscopic guidance navigations to peripheral lung nodules were performed. All lobes were represented in the study. The age average of the patients was 70.5± 9.8. The nodules median size was 20 mm. The average nodule divergence between the patient's targeted area during bronchoscopic procedure to the preoperative CT scan was 23.1 mm (with an STD of 13.4 mm and maximal divergence of 57.19 mm). Successful nodule localization and navigation verified by CBCT was achieved in 97% of the cases. Tissue samples were successfully acquired under augmented fluoroscopic guidance with a diagnostic yield of 80%. No adverse events were reported.

FIGURE 2: A GRAPHIC DESCRIPTION OF THE LUNGVISION SYSTEM

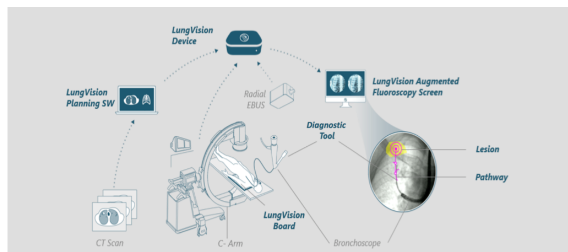
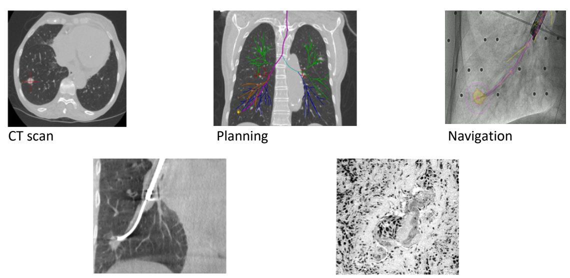


FIGURE 3: LUNGVISION PROCEDURE FLOW



CT scan
Planning
Navigation
CBCT Verification
Biopsy

DISCUSSION

Augmented endobronchial fluoroscopic navigation with the LungVision system is safe and feasible. Nodule movement impacted by patient positioning at the CT scan and during bronchoscopy was high compared to the average nodule size. This CT to patient divergence may significantly affect the diagnostic yield with virtual navigation systems. Unlike other image-based navigation modalities, augmented real-time fluoroscopic imaging offers the advantages of dynamic target tracking which overcomes the challenge of CT to patient divergence during both navigation and biopsy. This represents a novel tool, which appears to significantly increase the diagnostic yield of guided bronchoscopy. Further large-scale studies are indicated to assess the possible role of LungVision as the method of choice for the image-guided biopsy of peripheral lung nodules.

TABLE 1: LOCALIZATION AND DIAGNOSTICS YIELD

Nodule localization verification	97%
Diagnostic yield	80%

TABLE 2: CT TO PATIENT DIVERGENCE IN FULL INHALATION POSITION

	N=11	Target nodule CT to patient divergence [mm]	
	n	Mean ± SD	Max
Upper lobes	6	25.2±18.6	32.19
Lower lobes	5	22.4±9.1	57.19

FIGURE 4: SUBJECT 171018LW

Targeted nodule marked on a CT scan

Targeted nodule marked on a CBCT scan