Quantification of Regional Lung Dysfunction in Distal Airway Disease with Tissue Tracking MRI

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Introduction: When airway abnormalities are localized only to the distal airways clinical-pathologic correlation between patient illness and lung disease has been difficult to establish. The current study establishes differences in regional lung measurements for patients with known or suspected distal airway dysfunction from controls based on a tissue tracking MRI technique and optical flow method.

Methods:

Data acquisition: MRI data were acquired on a Siemens 3T whole-body MR scanner (Magnetom TIM Trio) at a frame rate of 9-10 images per second using a gradient echo sequence with a very short TR/TE that was developed for lung imaging. Seven subjects were studied: normal controls (n=2), patients with large airway disease (n=3), and individuals with suspected isolated distal airway dysfunction (n=2) due to either toxic dust exposure and/or cigarette smoking. The study was IRB approved and all participants provided proper informed written consent. Spirometry data were also obtained from all subjects. Measurements were made in sagittal imaging planes in which subjects were instructed to take a series of normal tidal breaths followed by maximal inspiration and maximal forced expiration. 400-500 images per imaging plane were obtained during each respiratory maneuver (Fig. 1).

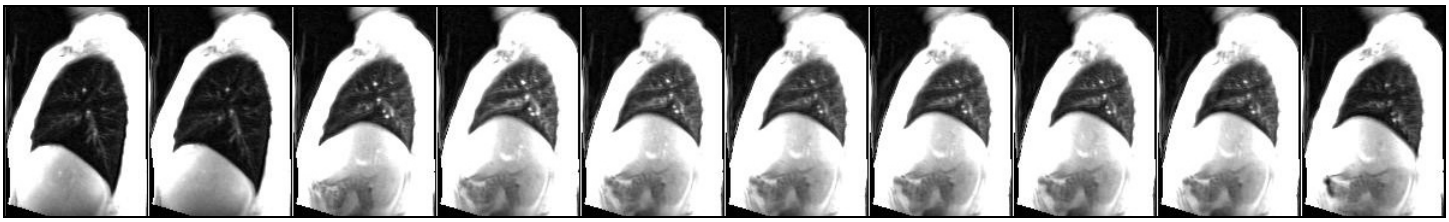

Figure 1. Sample images acquired at different time during forced expiration following maximal inspiration.

Data Analysis: Pixel displacements were estimated using an optical flow method by comparing sequential images during exhalation [1]. Sequential displacements were used to calculate the change in volume (3 x 3 pixel region) to produce local volume vs. time curves (Fig. 2). FEV1/FVC was determined for each region based on these local volume-time curves and a histogram of FEV1/FVC was constructed for each subject. The mean value ± SD of the regional FEV1/FVC histogram was used as an MRI derived metric of distal lung dysfunction.

Results:

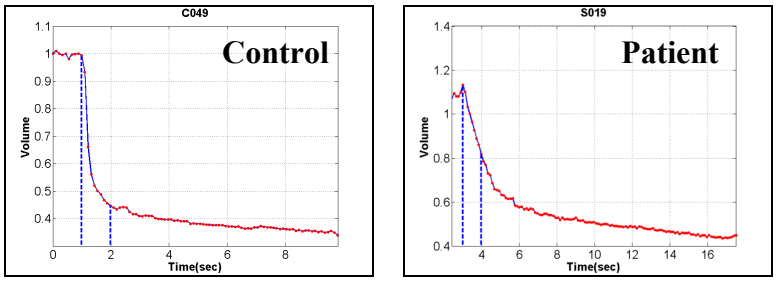

Figure 2. Two representative regional volume-time curves obtained from a control (left) and a patient with known airway disease (right). Note the much slower forced expiration pattern for the patient as compared to that of the control.

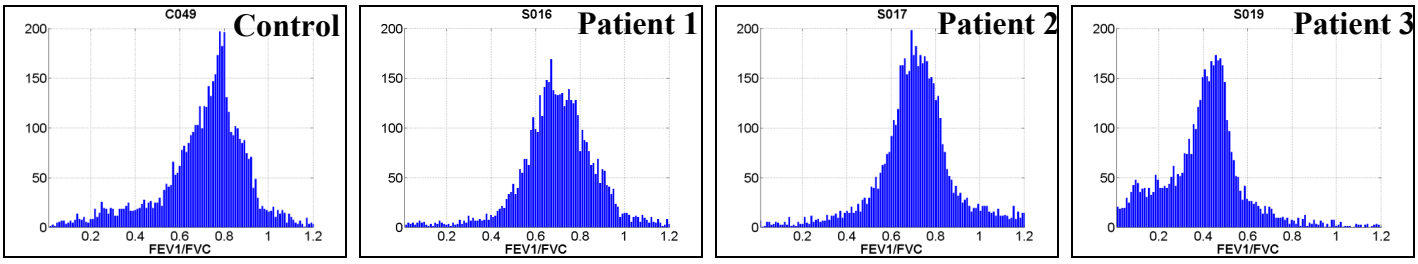

Figure 3. Histograms obtained from one control and three patients demonstrating marked differences in the distribution of regional FEV1/FVC.

Conclusions: The combination of tissue tracking MRI technique and optical flow method provides a unique means for the measurement of regional lung dysfunction that is inaccessible with standard whole lung spirometry. Our results show that while additional improvement in both data acquisition and data analysis are still required to make the current approach robust, the potential of using tissue tracking MRI for early detection of distal airway appears to be significant.

References: 1. Xu C, et al. Utility of the optical flow method for motion tracking in the lung. Proc ISMRM 16, 2008:2638.