Correlation Between Oxygen Enhanced MR Imaging, Quantitative CT and Lung Function Tests: Before and After Endobronchial Valve Deployment

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Introduction

Lung volume reduction surgery is an effective palliative treatment for breathlessness in emphysema patients [1]. Recently, bronchoscopic lung volume reduction by endobronchial valve deployment has been successfully used as a non-surgical alternative [2]. An endobronchial (one-way) valve is placed in the airway supplying the most hyper-inflated segment of the lung resulting in focal atelectasis and lung volume reduction. Recent studies have shown good correlation between lung function tests and enhancement on oxygen-enhanced MR ventilation imaging (MRVI) [3] and quantitative CT thoracic imaging [4]. This study was aimed at correlating the serial changes in pulmonary functional tests, enhancement on MRVI and quantitative CT of the thoracic in patients before and after endobronchial valve deployment.

Materials and Methods

Emphysema patients scheduled for endobronchial valve deployment from Sept 2004 to Aug 2005 were recruited. Before and after valve deployment the patients underwent clinical lung function tests, oxygen-enhanced MR ventilation imaging, inspiratory and expiratory CT of the thorax. This study was approved by our institution's review board. Informed consent was obtained from all patients prior to the study.

MRVI was performed on a 1.5-T unit (Gyroscan Intera, Philips, Best, the Netherlands) using a transmit and receive body-coil. Patients were scanned supine, wearing a tight-seal full-face mask (Mirage NV full face mask series 2, ResMed, Sydney, Australia) connected to either 100% oxygen or room air at a rate of 15 L/minute. We used an imaging sequence similar to that described by Ohno et al. [3], based on a T1-weighted imaging protocol, using a respiratory-synchronized half-Fourier centrically reordered inversion-recovery single-shot turbo spin-echo pulse sequence. Imaging parameters were: slice thickness 10 mm, 256 x 256 matrix, FOV 450 x 450 mm, 132 phase-encoding steps (four steps for phase correction), 3 NEX. Inter-echo spacing was 4.0 ms, effective TE 4 ms, TI 900 ms. Forty dynamic scans were acquired in the oblique coronal plane (lung apex to posterior costophrenic angle). Room air was administered via the mask for the first 20 dynamic scans followed by 100% oxygen for the second 20 scans. Images were reviewed on a workstation (Philips ViewForum) and regions of interest drawn manually to include each lung. Relative enhancement ratios were determined by comparing the average signal intensity while the patient breathed air with the average signal intensity during pure oxygen breathing (Figs 1 and 2).

CT of the lungs was performed on a 16-detector system (GE, LightSpeed 16, Milwaukee, USA) using 1.25 mm thickness, 1.75 pitch, 120 kV, 250 mA. Images were reviewed on a workstation (GE Advantage Windows). Coronal (matching the MRI scan plane) density (Fig 3) and whole lung volumetric [5] (Fig 4) measurements were performed for both expiration and inspiration.

The lung function tests were performed using American Thoracic Society standards [6], to measure forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC) and diffusing capacity of the lungs for carbon monoxide (DLCO) and the percentage of the expected values calculated.

A relative change was calculated for each parameter (lung function test values and relative change in: dynamic-MRI enhancement, CT density and CT volume) using the formula: Δ(parameter) = (post-procedure value - pre-procedure value) / pre-procedure value * 100%. Pearson correlation coefficients were calculated between the imaging and lung function parameters.

Results

Nine out of ten patients had a complete set of pre and post-procedure investigations (all males with mean age of 68 years). One patient defaulted follow-up and was excluded from this analysis. There were differences between pre- and post-procedure results for imaging and lung function parameters. The change in dynamic-MRI enhancement (Table 1) showed a strong correlation with change in % predicted FVC (r=0.67) and DLCO (r=0.68), and a weak correlation with change in % predicted FEV1 (r=0.42). The change in CT density difference (expiration - inspiration) correlated moderately with change in predicted FEV1 (r=0.57). The change in CT volume difference showed a weak correlation with change in % predicted FVC (r=0.46), % predicted FEV1 (r=0.46) and % predicted DLCO (r=0.41).

Pearson correlation	Δ(MRVI)	Δ(CT density)	Δ(CT volume)
Δ(% predicted FVC)	r=0.67*	r=0.18	r=0.46
Δ(% predicted FEV1)	r=0.42	r=0.57	r=0.46
Δ(% predicted DLCO)	r=0.68*	r=-0.21	r=0.41

* signifies correlation showed significance at the p<0.05 level

Table 1: Correlation of imaging parameters with clinical measurements

Discussion and Conclusion

This study has shown that the pre- versus post-procedure change in MRVI signal correlated better than the CT parameters with the FVC and DLCO. This suggests that MRVI better reflected serial changes in vital capacity and lung surface area in these patients. On the other hand, serial FEV1 changes were better correlated with coronal CT density measurements. Volumetric CT measurements did not perform as well in a similar correlation with the lung function tests.

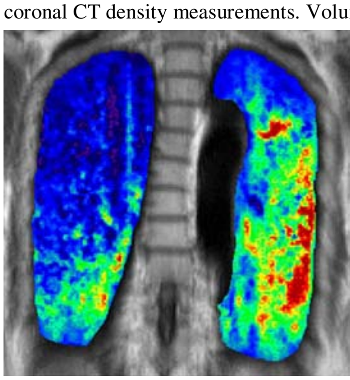

Figure 1

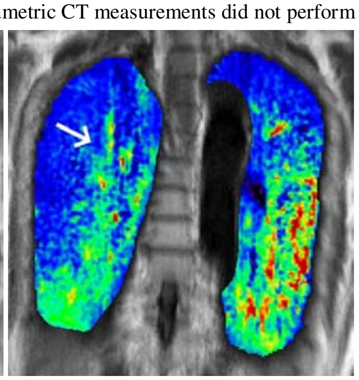

Figure 2

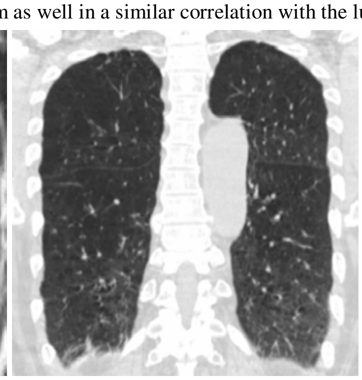

Figure 3

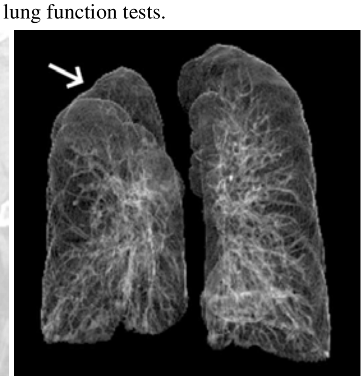

Figure 4

Fig. 1: MR enhancement map before endobronchial valve deployment. **Fig. 2**: MR enhancement map after valve deployment (same patient as in Fig 1) in the right upper lobe (arrow) showing an increase in right upper lobe oxygen enhancement. **Fig. 3**: CT coronal slice for density measurement. **Fig. 4**: CT volume rendering for volumetric measurement of the lungs. Focal atelectasis (arrow) is present in right upper lobe after valve deployment.

References

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