Progression of emphysema evaluated by hyperpolarized ^{3}He ADC measurements

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Introduction: Hyperpolarized ^{3}He apparent diffusion coefficient (ADC) is a sensitive measure of the lung microstructure. The ADC values correlate with alveoli dimensions [1] and it has been suggested that ^{3}He ADC can be used as an early marker for emphysema [2]. The progression of ADC for individual patients with time has not been reported for longer timescales. In this study we studied the progression of the ^{3}He ADC values over a period of 2 years in a group of patients known with alpha-1-antitrypsin deficiency (A1AD) to evaluate whether the method is applicable to monitor emphysema progression.

Methods: Nine A1AD patients (M/F: 5/3, age: 41-61 years) were MRI scanned using hyperpolarized ^{3}He at baseline, after one (n=8) and two years (n=7). A lung healthy volunteer (female, 45 years) was scanned five times during the two year study period. In addition pulmonary function tests were performed at inclusion. The ^{3}He gas was polarized in Mainz, Germany and shipped to Copenhagen by air transport [3]. A Siemens Vision scanner 1.5 T equipped with a ^{3}He/^{1}H coil (Fraunhofer Institute, St. Ingbert, Germany) was used for imaging the subjects in supine position. Diffusion measurements were performed during a 12 s breathhold using a 2D FLASH sequence with a bipolar gradient (TR/TE 16.1ms/6.0ms, $\alpha<10^o$, FOV 470 mm, slice thickness 20 mm, matrix 64x128, diffusion gradient 12mT/m, b=3.89s/cm^2). Four images (no diffusion weighting and diffusion weighting along three orthogonal directions) for each of three axial slices (3 cm above, at the level of and 5 cm below carina, see Fig.1) were acquired after inhalation of a bolus of hyperpolarized ^{3}He (220ml±40ml) followed by normal room air inhalation to TLC. The ADC maps were calculated by an in-house developed Matlab® program.

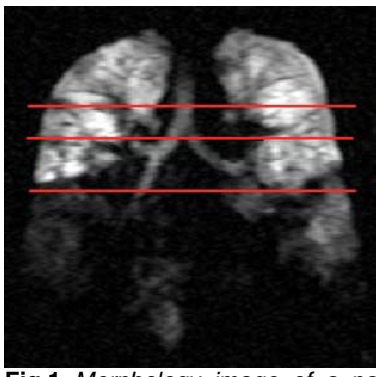

Fig.1 *Morphology image of a patient showing the typical pattern of lower lung destruction in A1AD patients. The red lines indicate the positions of the axial slices for ADC measurements.*

Results: Histograms of ADC values for three patients are presented in Fig.2. The mean ADC for all patients is presented in Fig. 3. All patients had elevated mean ADC values (0.35cm^2/s±0.10cm^2/s) as compared to the lung healthy subject (0.15cm^2/s) [4]. The average increase in mean ADC for patients A-F at the 2 year follow-up scan was 0.0072cm^2/s ±0.0090cm^2/s compared to the baseline scan ($p<0.05$).

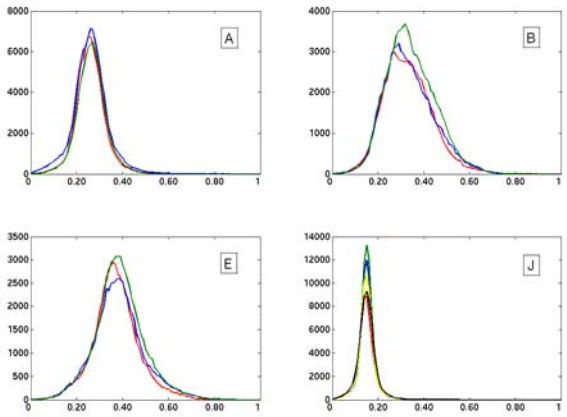

Fig. 2 *ADC (in cm^2/s) histograms for three patients (A,B,E) and the lung healthy volunteer (J). Red, blue and green line show baseline, year one and year two results for the patients.*

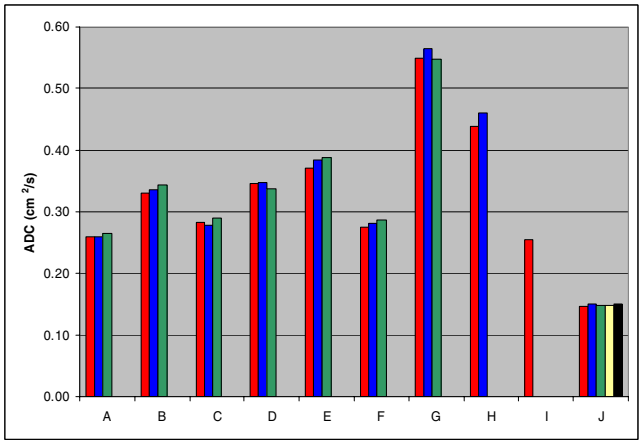

Fig. 3 *Mean ADC for all patients (A-I) and the healthy volunteer (J). The colours of the bars correspond to the histograms in Fig.2*

Discussion: In this pilot study we investigated the potential of ^{3}He ADC measurements to monitor the progression of emphysema in patients with A1AD. We found that even though the inhalation method was not spirometrically controlled, the ADC value histograms appear very similar for each patient and for the lung healthy person (fig.2) indicating good reproducibility.

Despite the small sample size the present results indicate a trend towards increasing ADC with time in patients with progressive emphysema (Fig 3), with an average increase in mean ADC of 0.0072cm^2/s±0.0090cm^2/s. This result is excluding patient G who had highly degenerated lung tissue as indicated by the elevated ADC value (> 0.5 cm^2/s) and thus the ADC measure is expected to be less sensitive to yet more lung destruction. Areas with severe lung destruction are poorly or not ventilated, and as a drawback of the method ADC measurements can not be performed in these lung areas. In conclusion we present some of the first longitudinal ^{3}He ADC measurements in A1AD patients showing promise in monitoring progression of emphysema.

References

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