Helium-3 apparent diffusion coefficient MRI compared to CT in emphysema patients

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Purpose:

Clinical usefulness of any method for patient care ultimately requires a correlation with an established technique, in this case computed tomography. The goal of this study is to compare the Apparent Diffusion Coefficient (ADC) of hyperpolarized ^{3}He -Inhalation MRI with Emphysema Index of multislice CT in patients with early emphysema.

Material and methods:

The study group (in total 22 patients) consisted of 9 smokers, 9 ex-smokers, 4 subjects with alpha-1-antitrypsin(AAT)deficiency (PiZ), whom all had mild to moderate emphysema (FEV_1 40-70% predicted, FEV1/FVC < 70%) and 4 asymptomatic AAT-deficient (PiZ) subjects. The latter had normal pulmonary function except for a reduction in diffusion capacity of carbon monoxide (DLCO) <85 % predicted.

All subjects were examined with hyperpolarized ^{3}He inhalation (^{3}He mixed with N_2) in a 1.5-T whole-body imaging system (Siemens Magnetom Sonata, software: Syngo MR 2002 B; Siemens Medical Solutions, Erlangen, Germany). 3He ADC MRI was performed using a diffusion-weighted 2D gradient echo pulse sequence (TR/TE 9.6/5.9 ms, flip angle 7°, FOV 382 x 470 mm, matrix 80 x 128, slice thickness 15 mm, interslice distance 5 mm, number of slices 10, bandwidth 250 Hz/pixel, time of acquisition 15 sec). The slices were acquired in sequential order. At each slice position, two images were acquired: one without (b0) and one with a bipolar diffusion sensitizing gradient waveform applied in the slice direction (b1). The signal attenuation constant for the bipolar gradient waveform was b1 = 1.6 s/cm2. The phase encoding for the b0- and b1-image was interleaved. Coronal slices covered the whole lungs from anterior to posterior. The volume ^{3}He used was 15% of each subject's total lung capacity (TLC) with a net activity of 3.5 to 4.5 mmol hyperpolarized ^{3}He. The administration of the He/ N_2 mixture started with the subject's lung at functional residual capacity (FRC). Imaging was done in the coronal plane during a 15 s breathhold. ADC-values, pixel-by-pixel color maps and pixel/ADC-value histograms were calculated per slice and subject. All subjects also underwent multi-slice CT of the whole lungs (Siemens Sensation 64, Siemens Medical Solutions, Erlangen, Germany), and Emphysema index (EI) was calculated. All findings were compared to spirometry and diffusion capacity of carbon monoxide (DLCO).

Results:

The comparison of the overall mean ADC value with the EI for each subject (fig 1) showed a good correlation (Corr. coeff. =0.90). Mean ADC versus %predicted DLCO (fig. 2) also showed a good correlation (Corr. Coeff. =-0.86) while EI versus %predicted DLCO (fig.3) did not show as good a correlation (Corr. Coeff. =-0.72). The main difference between the ADC and EI measurements in this study (fig. 3) was that more patients with a small change in %predicted DLCO had normal EI .but increased ADC.

Conclusion:

The mean ADC from MRI correlates well with the EI calculated from CT, showing the validity of ^{3}HeMRI compared to an established imaging method. However, the correlation with the physiological measure of emphysema, the DLCO, is stronger for the mean ADC than for the EI, which together with the fact that MRI does not use ionizing radiation should be an advantage especially as emphysema patients may be examined many times during their life-span.

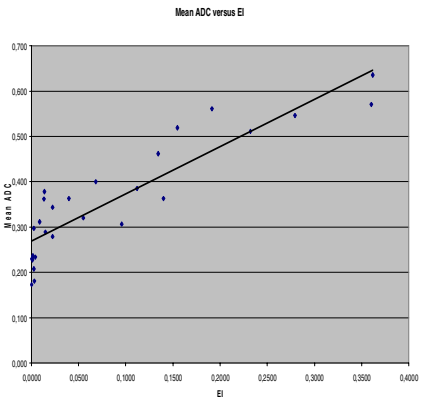

Fig. 1

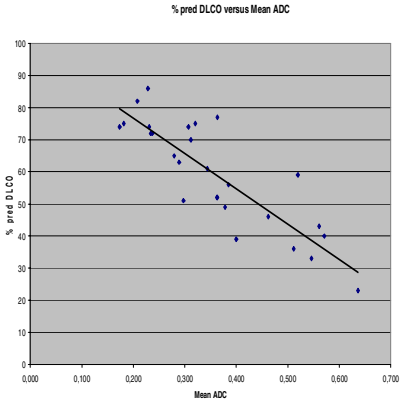

Fig.2

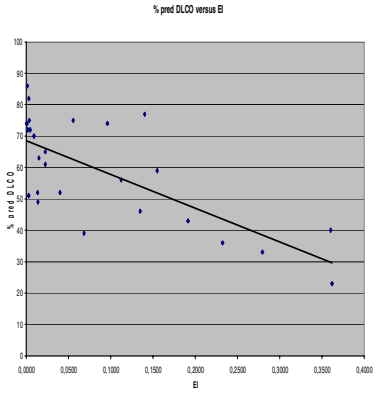

Fig.3