Diffusion weighted ^{3}He-MRI in the assessment of pulmonary emphysema

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Rationale:

Computed tomography (HR-CT) is the standard imaging method for the assessment of parenchymal lung diseases. Diffusion weighted ^{3}He-MRI is a new method for the assessment of the microstructure of the lung avoiding the burden of ionizing radiation. By determination of the apparent diffusion coefficient (ADC) of the inhaled ^{3}He it provides a possibility to quantify pathologic enlargement of the alveolar space as it occurs in pulmonary emphysema. The method has been shown to sensitive enough to detect differences in ADC-distribution in different postures [1]. This study intends to investigate the usefulness of diffusion weighted ^{3}He-MRI in different forms of pulmonary emphysema in comparison with healthy volunteers.

Materials and Methods:

In a European multicenter trial a total of 116 study participants were included. Of these, 62 suffered from chronic obstructive pulmonary disease (COPD), 17 from pulmonary emphysema due to alpha-1-antitrypsin deficiency (A1AD) and 37 were healthy volunteers. There were 78 male and 38 female participants in the age of 42 to 79 years (mean 62 years). All subjects received diffusion weighted ^{3}He-MRI and, as standard methods for comparison, high resolution computed tomography (HR-CT) and pulmonary function tests (PFT)[2]. ^{3}He-MRI was performed on 1.5 T clinical scanners (Magnetom Vision, Siemens Medical Solutions; Eclipse, Philips Medical Systems) equipped with broadband amplifiers and special ^{3}He-coils (Fraunhofer Institute, St. Ingbert, Germany; Medical Advances, IGC, Milwaukee, WI, USA). Imaging was performed in three transverse slices at the level of the carina, 3 cm above and 5 cm below it. The pulse sequences used for diffusion weighted imaging was a spoiled gradient echo pulse sequence with TR=16.1 msec, TE=6.0 msec, $\alpha<10°$, and a bipolar diffusion weighting gradient with a b-value of 3.89 s/cm². Images were post processed on a personal computer with an in-house developed software based on PV-Wave (Visual Numerics, Boulder, Ca, USA). HR-CT was performed with a slice thickness of 1 mm and an increment of 10 mm (Siemens Medical Solutions, GE Medical Systems). In volunteers scans were restricted to three slices positioned according to ^{3}He-MRI. For comparison between the different methods, the mean ADC was calculated from diffusion weighted ^{3}He-MRI, emphysema index (EI) and mean lung density (MLD) were calculated from HR-CT and the FEV1/VC ratio and the CO-diffusion were used of the PFT.

Results:

A total of 87 data sets from diffusion weighted ^{3}He-MRI were evaluable (COPD, n=46, alpha-1-antitrypsin deficiency, n=12, volunteers, n=29). The box-whisker-plot of mean ADC showed statistically significant higher ADC values in patients than in healthy volunteers ($p<0.001$) and no difference between the COPD and A1AD group (Fig. 1). Spearman correlation coefficients between mean ADC and indexes derived from computed tomography were r=0.52 (EI) and r=–0.56 (MLD). Correlation between mean ADC and results from pulmonary function tests was r=–0.75 (FEV1/VC) and r=–0.8 (CO-Diffusion, n=76). Correlation between PFT and HR-CT was r=-0.45 (FEV1/VC vs. EI, n=105), and r=-0.37 (CO-Diffusion vs EI, n=99).

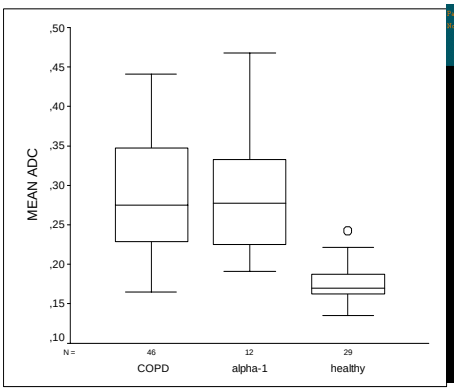

Fig. 1.: Box Whisker Plot of Mean ADC

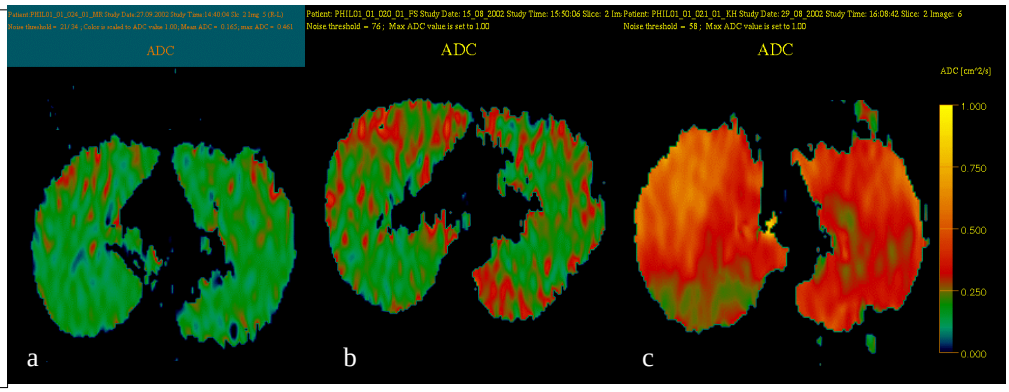

Fig. 2: ADC maps of a healthy volunteer (a), patients suffering from COPD (b) and alpha-1-antitrypsin deficiency (c).

Discussion and Conclusion:

Diffusion weighted ^{3}He-MRI was able to differentiate between healthy volunteers and patients suffering from pulmonary emphysema. Correlation of ^{3}He-MRI to HR-CT was fair, although the ADC is a parameter with an expected dependance on morphologic changes of the lung parenchyma. The mean ADC may not be the best parameter as pulmonary emphysema is an inhomogeneously distributed disease. On the other hand correlation of ^{3}He-MRI to pulmonary function tests was better, especially to CO-diffusion, and correlation between CT and PFT was low. The ADC determined from ^{3}He-MRI obviously does not simply describe morphology of the lung. The good correlation to PFT emphasizes the functional character of ^{3}He-MRI. Future work should look for better parameters of ADC distribution and will show if diffusion weighted ^{3}He-MRI can detect the subtle progress of emphysema in follow-up studies. Diffusion weighted ^{3}He-MRI is an evolving method to quantitatively determine the extent and distribution of pulmonary emphysema.

References: [1]Fichele S, Woodhouse N, Swift AJ, et al. J Magn Reson Imaging. 2004;20:331-335. [2]Ley S, Zaporozhan J, Morbach A, et al. Invest Radiol 2004;39:427-434

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