Diffusion weighted ^{3}He-MRI in the assessment of pulmonary emphysema: A regional evaluation

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Rationale:

The utilitiy of diffusion weighted ^{3}He-MRI in the assessment of pulmonary emphysema has been shown [1]. Diffusion weighted ^{3}He-MRI was able to differentiate between healthy volunteers and patients suffering from pulmonary emphysema. Correlation of ^{3}He-MRI to pulmonary function tests was good, especially to CO-diffusion. Although the diffusion properties are expected to depend on morphologic changes of the lung parenchyma, correlation of ^{3}He-MRI to HR-CT was limited. It was concluded that the mean ADC may not be the best parameter as pulmonary emphysema is an inhomogeneously distributed disease. To address the inhomogeneity of the disease the present study employs a regional evaluation of the data. The expected result would be a significantly better correlation between HR-CT and diffusion weighted ^{3}He-MRI.

Materials and Methods:

Data from a European multicenter trial were evaluated retrospectively. In this study a total of 87 study participants were included. Of these, 46 suffered from chronic obstructive pulmonary disease (COPD), 12 from pulmonary emphysema due to alpha-1-antitrypsin deficiency (A1AD) and 29 were healthy volunteers. All subjects received diffusion weighted ^{3}He-MRI and, as standard method for comparison, high resolution computed tomography (HR-CT). ^{3}He-MRI was performed on 1.5 T clinical scanners (Magnetom Vision, Siemens Medical Solutions) equipped with broadband amplifiers and special ^{3}He-coils (Fraunhofer Institute, St. Ingbert, Germany). Imaging was performed in inspiratory breath hold after application of 300 ml of ^{3}He with a polarization of approximately 60%, polarized by metastability exchange optical pumping. Imaging was performed in three transverse slices (slice thickness 20mm) 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). In volunteers scans were restricted to three slices positioned according to ^{3}He-MRI. For comparison between the different methods, regions of interest (ROI) with an area of 2 cm², equivalent to the size of a secondary lobulus, were positioned at corresponding anatomic positions in ^{3}He-MRI and HR-CT. Subsequently, the mean ADC was calculated from each ROI in the diffusion weighted ^{3}He-MRI, and mean lung density (MLD) from each ROI were calculated from HR-CT.

Results:

Correlation between diffusion weighted ^{3}He-MRI and HR-CT was low. Overall correlation of ADC_{local} vs. MLD_{local} was r=0.2. Split up in the different disease groups, the correlation was r=0.21 in COPD, r=0.18 in A1AD and r=0.3 in healthy volunteers. A review of the images with the positioned ROI revealed that many of the ROI's were placed in areas of attenuated or absent ventilation on ^{3}He-MRI. In a second evaluation step all poorly ventilated ROI were excluded to eliminate a noise related error. Poor ventilation was defined as a SNR>3 in less than 95% of the pixels of an ROI. In the well ventilated ROI the overall correlation between ADC_{local} and MLD_{local} was r=0.23. Split up in the different disease groups, the correlation was still low (r=0.24) in COPD, whereas in improved markedly in A1AD (r=0.71) and in healthy volunteers (r=0.48).

Discussion and Conclusion:

Correlation of ^{3}He-MRI to HR-CT in regional evaluation is limited. The inhomogeneity of pulmonary emphysema is apparently not the reason for the overall limited correlation of these two methods. Exclusion of noise related errors had no influence on the correlation in COPD, it improves the correlation in healthy volunteers fairly, but in A1AD markedly. Especially in primary airway disease or in absence of lung disease ^{3}He-MRI and HR-CT show differing results. Primary parenchymal disease on the other hand shows a similar behaviour of the two methods. CT density is determined by the amount of alveolar wall tissue attenuating the x-rays, the ADC is determined by the volume of alveaolar space. Thus, an overinflation of lung tissue with collapse of neighbouring alveoli and without destruction of alveolar tissue would explain a part of the unequivocal behaviour of the methods. Furthermore, CT density is influenced by overlying infection as well as perfusion inhomogeneity. Thus, we postulate that diffusion weighted ^{3}He-MRI shows the function of a lung area while CT provides morphologic information which can be influenced by concomittant disease.

References: [1] Gast KK et al. Proc Intl Soc Mag Reson Med 2006

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