Regional Mapping of Gaseous Uptake by Lung Tissue and Blood in Subjects with Asthma using Hyperpolarized Xenon-129 MRI

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Target audience: Physicians and scientists interested in functional lung imaging or obstructive lung diseases such as asthma.

Introduction: Asthma is characterized by reversible bronchial obstruction. Ventilation perfusion mismatch is common in patients with asthma suggesting that there is a vascular component to the disease, a component that is not evaluated with spirometry—the standard clinical test in asthma. Three-dimensional Xe-129 dissolved-phase imaging provides a non-invasive method to directly map gas uptake by tissue and blood in the human lung. For this study, we used this technique to investigate functional changes in the lungs of subjects with asthma, and compared the results to those from healthy subjects.

Methods: The study group included 12 healthy subjects (age 19-59 yrs, FEV1/FVC 0.81±0.05) and 10 asthmatics (age 22-56 yrs, FEV1/FVC 77%±18%; FEV1/FVC 0.65±0.10). A multi-echo 3D radial pulse sequence was used for acquiring dissolved- and gas-phase Xe129 images. Sequence parameters were: TR 19 ms, TE1/TE2/TE3 0.74/2.36/3.98 ms (dissolved) and TE1/TE2 0.74/2.36 ms (gas), flip angle 23° (dissolved) and 0.4° (gas), acquisition time ~10 s, and voxel volume 7.6 x 7.6 x 17 mm³. The Hierarchical IDEAL method was used to separate the tissue and RBC components from the multi-echo dissolved-phase images. For quantitatively analyzing lung function, four ratios were generated: total dissolved-phase-to-gas, tissue-to-gas, RBC-to-gas, and RBC-to-tissue (the latter three shown as maps). In a subset of the subjects (two healthy, eight asthmatics), coronal Xe129 diffusion-weighting images were also acquired for calculation of apparent diffusion coefficient (ADC) values using the following pulse-sequence parameters: TR/TE 13.8/9.4 msec, flip angle 8.5°, voxel volume 6 x 6 x 25 mm³.

Results & Discussion: Healthy subjects showed generally homogeneous signal distribution in all images (Fig.1). All ratios were relatively low in the two asthmatics older than 50 (age 53 and 56, red in Fig. 2, A10 shown in Fig. 1). Specifically, the tissue-to-gas ratios were 0.94%, lower than that for healthy (p<0.001). In a subset of the subjects (two healthy, eight asthmatics), coronal Xe129 diffusion-weighting images were also acquired for calculation of apparent diffusion coefficient (ADC) values using the following pulse-sequence parameters: TR/TE 13.8/9.4 msec, flip angle 8.5°, voxel volume 6 x 6 x 25 mm³.

Conclusions: The relatively high RBC-to-tissue ratio, low tissue-to-gas ratios, and normal ADC values measured in these two subjects were higher than normal (0.049 cm²/s and 0.053 cm²/s). All of these findings are similar to those seen in COPD.

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