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Accelerated Diffusion-Weighted Hyperpolarized 129Xe Gas Lung MRI

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Hyperpolarized 3He/129Xe gas pulmonary MRI provides physiologically relevant biomarkers of obstructive lung disease, including emphysema, bronchopulmonary dysplasia and alpha-1 antitrypsin deficiency (AATD). Recently, a stretched-exponential-model combined with under-sampling in the imaging and diffusion direction was used to generate 3He static-ventilation (SV), T2*, multiple b-value diffusion-weighted (DW) MRI ADC and morphometry maps, demonstrating an acceleration factor (AF) of 7 to 10. The low gyromagnetic ratio of 129Xe coupled with clinically used gradient strengths, dictate that rapid acquisition strategies be developed to facilitate clinical uptake of 129Xe DW imaging. We hypothesize that the 3He method can be adapted to provide whole lung 129Xe MRI-based emphysema biomarkers, including SV, T2*, ADC and morphometry maps. Therefore, in this proof-of-concept study, our objective was to extend the 3He method for accelerated 129Xe lung morphometry using single breath measurements for validation in a small group of patients.

Three healthy volunteers (<25yr>) and six AATD (<65yr>) patients provided written informed consent to participate in an ethics-board approved study protocol and underwent spirometry, plethysmography, and accelerated 129Xe MRI morphometry using a single xenon dose. Imaging was performed at 3.0T using whole-body gradients and a commercial human-sized xenon quadrature flex RF coil. For xenon measurements the diffusion-sensitization gradient pulse ramp up/down time was 500μs, constant time=2ms and diffusion time=5.2ms, providing five b-values of 0, 12.0, 20.0, 30.0, and 45.5s/cm2. For accelerated acquisition, a multi-slice (six interleaves) centric 2D FGRE DW sequence under-sampled in the imaging and diffusion direction for seven 30mm coronal slices. An extra interleave without DW (b=0) with significantly reduced TE (2ms) was utilized to generate a short-TE SV image and T2*map. A 7.4 degree constant-flip-angle (120 [20 per b-value] RF pulses-per-slice) was used for the AF=7 (all participants, 12sec single breath-hold) acquisitions.

To the best of our knowledge this is the first demonstration of 129Xe MRI morphometry measurements with AF=7. We have demonstrated that accelerated 129Xe MRI morphometry permitted to generate whole lung SV, T2, ADC and morphometry maps within a single 12sec breath-hold with typical spatial resolution.

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