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Accelerated Diffusion-Weighted Hyperpolarized 129Xe Gas Lung MRI

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Hyperpolarized $^3\text{He}/^{129}\text{Xe}$ 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 ^{129}Xe coupled with clinically used gradient strengths, dictate that rapid acquisition strategies be developed to facilitate clinical uptake of ^{129}Xe DW imaging. We hypothesize that the ^3He method can be adapted to provide whole lung ^{129}Xe 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 ^{129}Xe 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 ^{129}Xe 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 500 μs , 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 T2map. 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 ^{129}Xe MRI morphometry measurements with AF=7. We have demonstrated that accelerated ^{129}Xe 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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