Hyperpolarized ^{3}He ADC measurements: Left-Right and Dorsal-Ventral Differences as a function of Lung Volume

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Introduction Hyperpolarized ^{3}Helium MRI Apparent Diffusion Coefficient (ADC) measurements enable probing of the lung microstructure and evaluation of pathological processes that affect airspace size. The aim of this study was to evaluate the effects of various breath-hold volumes on ADC measurements and extract any significant differences between the different regions in the lung field of view.

Methods 26 subjects underwent pulmonary function tests (PFT) to classify them into one of three categories (Never (21)/Normal-Smoker (3)/COPD (2)). Scanning was performed on a Siemens Avanto 1.5T, equipped with broadband capabilities. Each subject was fitted with a dedicated flexible ^{3}He-tuned transmit-receive radiofrequency coil, and ECG, blood pressure and SPO_2 were monitored throughout the study. Based on the subject's vital capacity (VC) measurements obtained from their PFT, three lung volumes were calculated: 20%VC (Forced Residual Capacity;FRC), 60%VC & 100%VC (Total Lung Capacity;TLC). Subjects were guided through a series of expiratory maneuvers reaching residual volume (RV), followed by a two part inspiration, a predetermined volume of air to act as filler and a 1 liter mix of 700ml ^{3}He/300ml N_2, the combination of which yielded the desired lung capacities. Images were acquired with a centrically ordered FLASH sequence (128x128 matrix, 6 slices with 15mm thickness and 7.5mm gap, 2.5mmx2.5mm pixels, 8º flip angle), during a 10-15 second breath-hold.

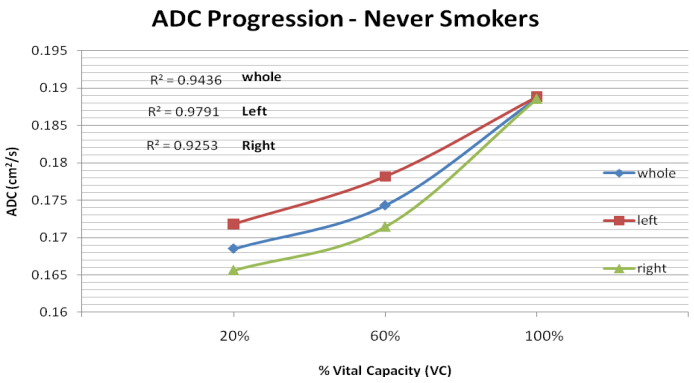

Figure 1. HP ^{3}He ADC vs. lung volume (whole, Left & Right). As the inflation level increases so does its respective ADC along with a more homogenous distribution through the lungs.

Results Imaging was performed successfully for all three lung volumes on 17 of 26 subjects, with inability to breath-hold and improper volume-control being the primary limitations. In never-smoker subjects, a significant ventral - dorsal gradient was observed only at 20% VC, with lower ADC values in the dependent (dorsal) regions and higher values in the non-dependent (ventral) regions. A significant difference in both left and right lung ADCs at 20% & 60% VC were observed and not at 100% VC, with consistently higher ADC values in the left lung throughout both lung volumes (figure 1). A strong positive correlation was observed with respect to ADC change in response to lung volume changes in the never-smoker (12 subjects) population.

ADC vs. Lung Volume		**Ventral - Dorsal Differences**	
	Significance	**20% VC**	**Significance**
20% VC & 60% VC	0.003	*Right Lung*	0.001
60% VC & 100% VC	0.002	*Left Lung*	0.003
20% VC & 100% VC	0.002	**60% VC**	
Left & Right Differences		*Right Lung*	0.145
	Significance	*Left Lung*	0.022
20% VC	0.002	**100% VC**	
60% VC	0.012	*Right Lung*	0.537
100% VC	0.883	*Left Lung*	0.824

Discussion ADC values vary slightly across the different lung volumes, but all measurements were within the expected ADC range for the sub-populations as reported in previous literature. Nevertheless, as the differences were significant, the study demonstrates the importance of controlled lung inflation to enable longitudinal assessment of lung changes. Dependent lung regions had a significantly lower ADC value than their respective non-dependent regions. Furthermore, the existence of a significant ventral-dorsal gradient in the 20% VC volume and not the higher lung volumes follows proper inflation and ventilation patterns. It was also observed that a more homogenous distribution is achieved at 100% VC and not the lower lung volumes.