Assessing the Temporal Changes of the Regional Ventilation in the Lungs of Asthmatics with Hyperpolarized Helium-3 MR Imaging

T. A. Altes[1,2], J. J. Battiston[2], A. P. Juersivich[3], J. P. Mugler[2], T. A. Platts-Mills[4], E. E. de Lange[2]

[1]Radiology, Children's Hospital of Philadelphia, Philadelphia, PA, United States, [2]Radiology, University of Virginia, Charlottesville, VA, United States, [3]University of Virginia, Charlottesville, VA, United States, [4]Internal Medicine, University of Virginia, Charlottesville, VA, United States

Introduction: Asthma is a chronic inflammatory disease with variable airway obstruction and symptoms that characteristically change with time. With hyperpolarized helium-3 (H^3He) MR imaging the regional ventilation can be depicted without the use of ionizing radiation, and thus scanning can be repeated in the same subject without significant risk. The purpose of this study was to determine the variability of the regional H^3He ventilation within the lungs of asthmatics with time.

Methods and Materials: 37 asthmatics underwent H^3He MR twice: 20 on the same day (time between scans mean 4.3 min, SD 3.1 min) and 17 on two different days (time between scans mean 78 days, SD 130 days). Spirometry was performed on each day of imaging. MR imaging was performed using a commercial 1.5-T whole-body scanner (Magnetom Sonata; Siemens Medical Solutions, Malvern, PA) modified to operate at the ^3He resonant frequency of 48 MHz by the addition of a broadband radio-frequency amplifier and a flexible ^3He chest radio-frequency coil (IGC Medical Advances, Milwaukee, WI). Contiguous axial MR images covering the entire lung (FLASH; TR/TE, 7/3 ms; flip angle, 10°; matrix, 80x128; FOV, 26 x 42 cm; section thickness, 10 mm; interslice gap, none) were collected during a 15-20 sec breath hold immediately following inhalation of approximately 300 mL H^3He gas mixed with approximately 700 mL of nitrogen. For each scan the number of ventilation defects was counted by two radiologists, and the mean ventilation defects per slice (VDS) was calculated. Subsequently, the percent of defects present on the first scan that were also present in the same location on the second scan, regardless of size, was calculated for each subject (%same). The percent of new defects on the second scan that were not present on the first scan was also determined (%new).

Results: The mean (SD) of the %same and %new was 86% (23%) and 20% (28%), respectively, for subjects scanned on the same day, and 67% (25%) and 44% (29%) for subjects scanned on two different days, Figs. 1-4. There was poor correlation of the time between scans with %same (R=-0.13) or %new (R=0.06) for subjects scanned on two different days. The mean (SD) of FEV_1 %predicted was 91% (19%) and 95% (19%) for subjects scanned on the same and different days, respectively. There was a trend toward increasing ventilation defects on the first scan in patients with lower FEV_1 %predicted (R=-0.44).

Discussion: Although there was some variability in the regional ventilation within the lungs, a surprisingly large number of ventilation defects persisted or recurred in the same location even on scans widely separated in time. These findings indicate that asthma is a regional disease with some areas in the lung being more prone to abnormalities of ventilation than others.

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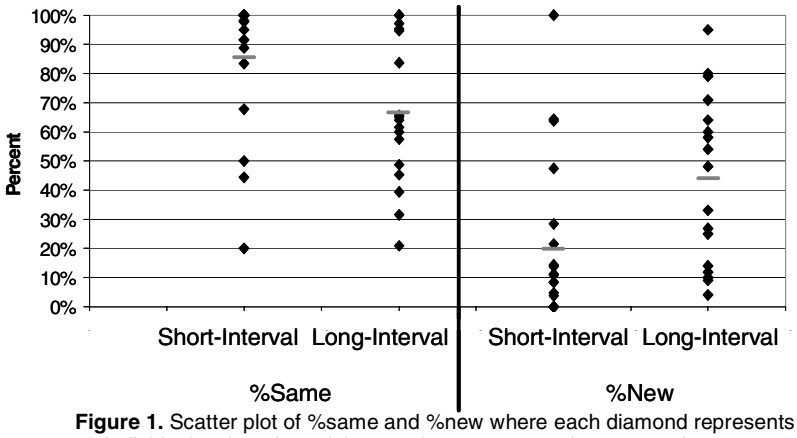

Figure 1. Scatter plot of %same and %new where each diamond represents an individual asthmatic and the grey bars represent the mean values.

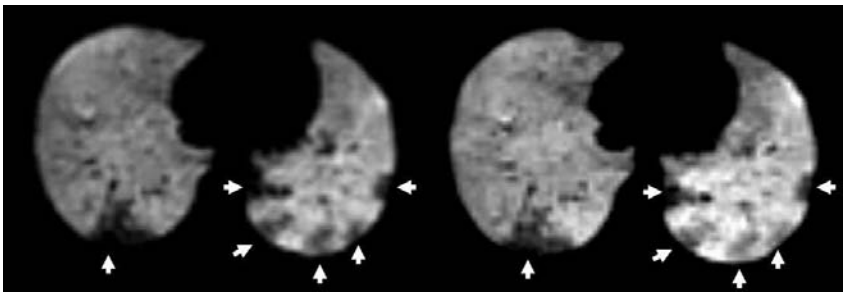

Figure 2. Axial H^3He MR images obtained a few minutes apart demonstrate little variability in location of the ventilation defects.

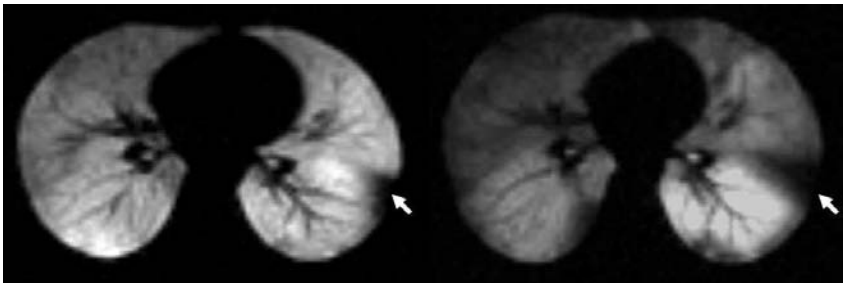

Figure 3. Axial H^3He MR images obtained 30 days apart demonstrate a persistent or recurrent left lower lobe ventilation defect.

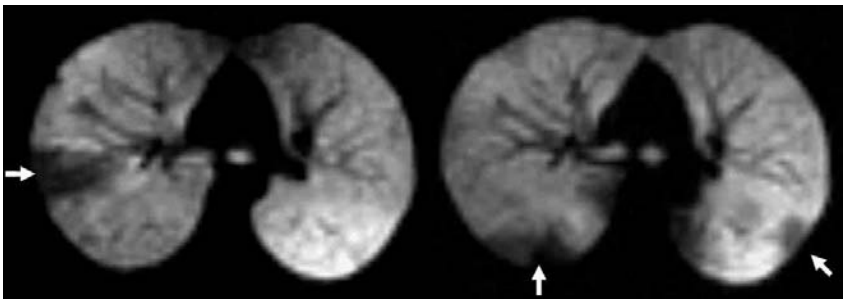

Figure 4. Axial H^3He MR images obtained 12 days apart demonstrate resolution of a right lower lobe ventilation defect and development of new ventilation defects.