

Comparison of Hyperpolarized Xenon-129 MR and Tc-99m DTPA Aerosol Lung Ventilation Imaging in Patients with COPD and Asthma

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Target Audience: Physicians and scientists with an interest in lung imaging.

Purpose: Chronic Obstructive Pulmonary Disease (COPD) is the fourth leading cause of mortality and morbidity in the U.S. and third world wide. COPD has seen a 250% increase in prevalence in the past 50 years. Asthma has a lower fatality rate than COPD, but a higher prevalence which is also increasing. Because it often appears in children, asthma sufferers may require a lifetime of care and management. Although nuclear medicine ventilation scans are the clinical gold standard for assessing regional lung ventilation, hyperpolarized Xe-129 MR provides higher spatial and temporal resolution images of lung ventilation which may lead to enhanced understanding of obstructive lung diseases such as COPD and asthma. The purpose of this study is to compare the ability of hyperpolarized Xe-129 MR imaging for identifying ventilation abnormalities in both asthma and COPD to the current clinical standard, Tc-99m DTPA aerosol ventilation scintigraphy.

Methods: Fourteen subjects with obstructive lung disease, 7 asthma and 7 COPD, were imaged using both Tc-99m DTPA aerosol ventilation scintigraphy and Xe-129 MRI within a 3 day window. All subjects also performed spirometry on the day of MR imaging. Tc-99m DTPA was delivered using an aerosol delivery system (40 mCi Tc-99m DTPA in 4-5 ml of 0.9% NaCl solution) and at an oxygen flow rate of 15 L/min. All subjects inhaled Tc-99m DTPA aerosol during normal tidal breathing in supine position for 3–5 minutes. SPECT imaging was performed on a dual head gamma camera (Symbia, Siemens) with a low energy high resolution collimator. Images were acquired using 128 tomographic projections (64 per head) with 10 seconds per stop. Images were reconstructed in 3 planes using iterative reconstruction (OSEM), 8 subsets, and 2 iterations. Coronal Xe-129 ventilation images covering the whole lung were acquired at 1.5T (Avanto, Siemens) during a breath hold following the inhalation of ~700mL of polarized isotopically enriched Xe-129 (Xemed LLC, NH) using a rapid spiral-based acquisition (TR/TE 11.4/1.2 ms, flip angle 20°, 15 interleaves + 2-interleave field map, voxel volume 4 x 4 x 15 mm³). During the same breath hold, spatially-registered proton images of the chest were also acquired (TR/TE 4.8/0.9 ms, flip angle 15°, 22 interleaves + 2-interleave field map, voxel volume 4 x 4 x 15 mm³). The total acquisition time for both image sets was less than 5 seconds. A reader experienced in nuclear medicine scored the scintigraphy exams, and a reader experienced in body MRI scored the Xe-129 MR exams. The readers were blinded to all other data about the subjects. Exams were scored for overall image quality, clumping of imaging agent, ventilation defect number and conspicuity, and lung disease.

Results: The mean (SD) FEV1 %predicted was 73% (24.5%) for the entire group, and 70% (24.5%) and 75% (12.6%) for the COPD and asthma subjects, respectively. Overall exam quality was acceptable or excellent in 14 of 14 MRI exams and in 9 of 14 scintigraphy exams (p=0.041), Figure 1. Moderate or severe clumping of radiotracer was present in 8 of 14 subjects. No clumping was observed with Xe-129 MRI. More ventilation defects were visualized on MRI with 12 of 14 subjects having >10 defects on MRI while only 4 of 14 on scintigraphy (p=0.014), Figures 2, 3, 4. All subjects had ventilation defects apparent on MRI but 5 had no defects detected on scintigraphy (p=0.041), Figure 5. The specific lung disease was correctly identified in 8 subjects on MRI and 1 subject on scintigraphy (p= 0.0768).

Conclusions: As compared with the standard clinical test (Tc-99m DTPA aerosol SPECT scintigraphy), Xe-129 MR ventilation imaging appears to depict ventilation abnormalities in COPD and asthma with better image quality, and shows greater number and conspicuity of ventilation defects.



Figure 1: Human reader scores of image quality.

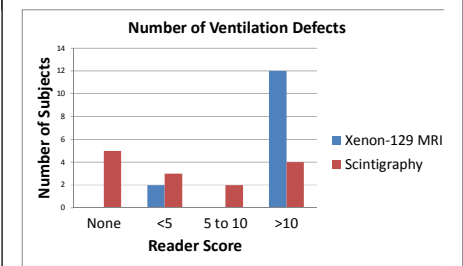
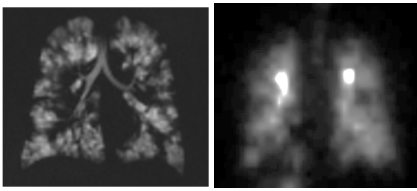
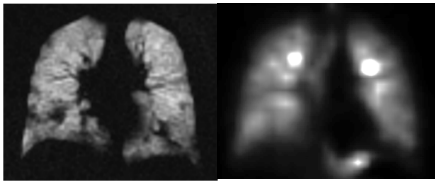
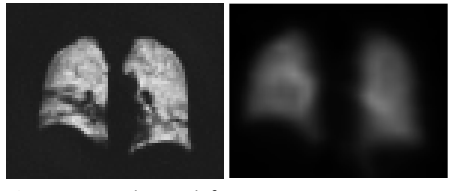


Figure 2: Human reader scores of the number of ventilation defects.

<p>COPD (FEV₁ 39%predicted)</p> <p>Xe-129 MRI Tc-99m DTPA</p>  <p>Figure 3: Coronal MRI and Tc-99m DTPA scintigraphy ventilation images from a subject with COPD both show multiple small ventilation defects. The defect number and conspicuity is greater on MRI.</p>	<p>Asthma (FEV₁ 77%predicted)</p> <p>Xe-129 MRI Tc-99m DTPA</p>  <p>Figure 4: Coronal MRI and Tc-99m DTPA scintigraphy lung ventilation images from an asthmatic both show small ventilation defects. The defect conspicuity is greater on MRI.</p>	<p>Asthma (FEV₁ 83%predicted)</p> <p>Xe-129 MRI Tc-99m DTPA</p>  <p>Figure 5: Ventilation defects are apparent on Xe-129 MRI (right lower lobe) but no defects were seen on Tc-99m DTPA scintigraphy.</p>
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