

## Hyperpolarized Xenon-129 Ventilation MRI: Preliminary Results in Normal Subjects and Patients with Lung Disease

T. A. Altes<sup>1</sup>, J. P. Mugler<sup>1</sup>, I. M. Dregely<sup>2</sup>, S. Ketel<sup>3</sup>, I. C. Russet<sup>2,3</sup>, E. E. de Lange<sup>1</sup>, F. W. Hersman<sup>2,3</sup>, and K. Ruppert<sup>1</sup>

<sup>1</sup>Radiology, University of Virginia, Charlottesville, VA, United States, <sup>2</sup>Physics, University of New Hampshire, Durham, NH, <sup>3</sup>Xemed, LCC, Durham, NH

**Introduction:** Hyperpolarized helium-3 ventilation (spin-density) imaging has been used to investigate obstructive lung diseases such as asthma and chronic obstructive pulmonary disease (COPD), and has provided some intriguing new insights into the regional patterns of airflow obstruction in asthma<sup>1</sup>. However, the recent increase in demand for helium-3 by the Department of Homeland Security has drastically reduced the available helium-3 for medical imaging. Research with hyperpolarized xenon-129 MRI has lagged compared to hyperpolarized helium-3, largely because of the difficulties in designing polarizers that produce relatively large quantities of hyperpolarized xenon-129 with sufficiently high polarization for medical imaging. However, these difficulties have been essentially overcome recently<sup>2</sup>. The purpose of this study was to assess the currently achievable quality of ventilation imaging of the lungs with hyperpolarized xenon-129 and compare with previously acquired ventilation images using hyperpolarized helium-3.

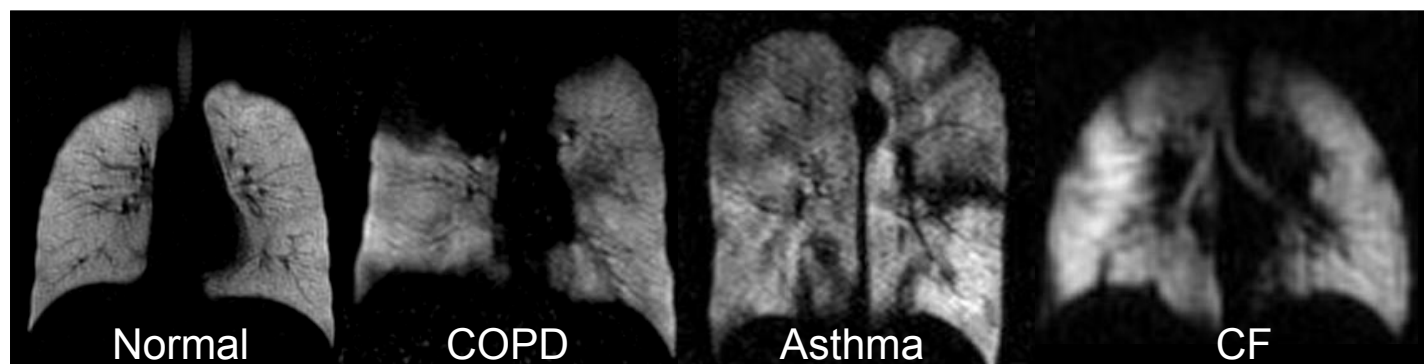
**Methods:** Hyperpolarized xenon-129 ventilation MRI was performed in 19 subjects [normal (n=7), asthma (n=5), chronic obstructive pulmonary disease (COPD) (n=4), cystic fibrosis (CF) (n=1), and sickle cell disease (SCD) (n=2)] using 2D-GRE and/or 3D-SSFP (TrueFISP) pulse sequences on a 1.5T (Avanto, Siemens) or 3T (Trio, Siemens) whole-body MR scanner during a single breath hold following the inhalation of 300-700 mL of polarized, isotopically enriched xenon-129 (87% xenon-129, 10-35% polarization) mixed with room air and oxygen. The xenon was polarized in a prototype commercial system (Xemed, LLC). Flexible chest RF coils were used for imaging at 1.5T and a 32-channel array chest RF coil (custom built)<sup>3</sup> was used at 3T. 2D-GRE parameters were: TR/TE, 9-12/2.5-4 ms; flip angle, 10-15°; and voxel size, 2.1-5.9 x 2.1-5.9 x 10-20 mm. TrueFISP parameters were: TR/TE, 2.9-4.8/1.3-2.1 ms; flip-angle, 9-12°; and voxel size, 4.5-6.4 x 4.5-6.4 x 4.5-6.4 mm<sup>3</sup>. Images from patients with similar disease severity that were previously acquired using hyperpolarized helium-3 were identified by retrospectively searching our research database. These images were acquired at 1.5 T (Sonata or Avanto, Siemens) using a 2D-GRE sequence with parameters TR/TE, 7/3 ms; flip angle, 9°; and voxel size, 3.3 x 3.3 x 10 or 15 mm following the inhalation of ~300 mL of hyperpolarized helium-3 mixed with ~700 mL of nitrogen<sup>1,4,5</sup>.

**Results and Discussion:** All subjects tolerated the hyperpolarized xenon-129 MRI exams well although approximately 50% experienced mild, transient alterations in sensation or affect following the xenon inhalation. All normal subjects had homogeneous ventilation on xenon-129-inhaled images with few, if any, focal ventilation defects, **Figure 1**, similar to prior reports using hyperpolarized helium-3<sup>1</sup>. Furthermore, focal ventilation defects were present in all patients with obstructive lung disease, **Figure 1**. The xenon-129 images were of similar quality although not identical in appearance to previously acquired hyperpolarized helium-3 ventilation images in different patients with similar diseases, **Figure 2**.

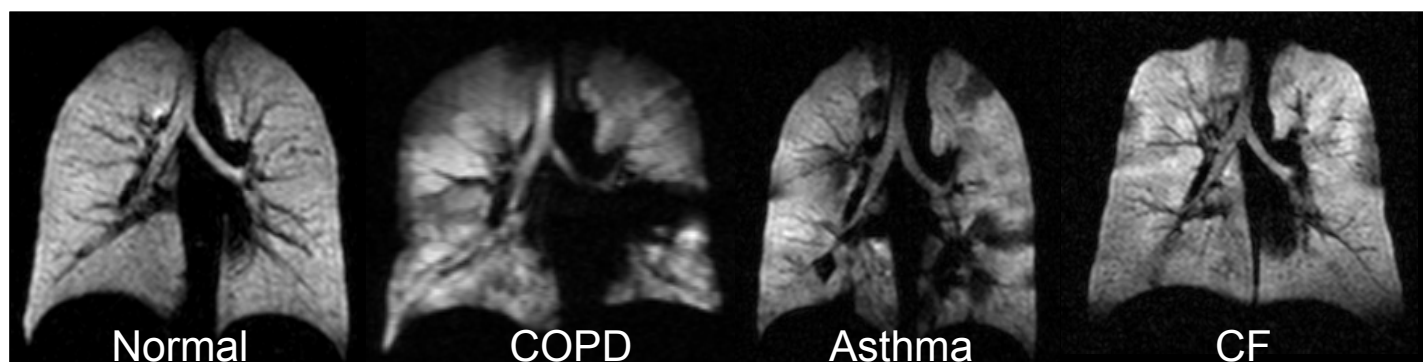
**Conclusions:** Using current technology, it is possible to obtain hyperpolarized xenon-129 ventilation images in healthy subjects and patients with lung disease. The images were of similar quality compared to previously obtained hyperpolarized helium-3 ventilation images, and focal ventilation defects were found in patients with obstructive lung disease (COPD, asthma, CF) on xenon-129 ventilation imaging, as expected.

**References:** 1. de Lange EE, et al. *J Allergy Clin Immunol* 2007; 119:1072 2. Hersman FW et al. *Acad Radiol* 2008; 15:683 3. Dregely IM et al. *ISMRM* 17 (2009); 2203 4. Mentore K., et al *Academic Radiology*. 2005; 12: 1423 5. Altes TA, et al. *J Magn Reson Imaging* 2001; 13: 378.

**Acknowledgements:** Supported by NIH grants R41 HL091578, R01 EB003202 and R01 HL079077, UVA Children's Hospital, Society of Pediatric Radiology. CHR and Siemens Medical Solutions.



**Figure 1:** Coronal xenon-129 ventilation images of 4 representative subjects demonstrate that it is possible with current technology to acquire high quality images. Note the multiple ventilation defects (darker regions) in the three patients. Due to relatively lower polarization values on the days of imaging, the images of the patient with CF were acquired at lower spatial resolution and there was a lower SNR on the images from the asthmatic, which reduced the image quality.



**Figure 2:** Coronal helium-3 ventilation images<sup>1,4,5</sup> of 4 different subjects are similar in character to the hyperpolarized xenon-129 ventilation images.