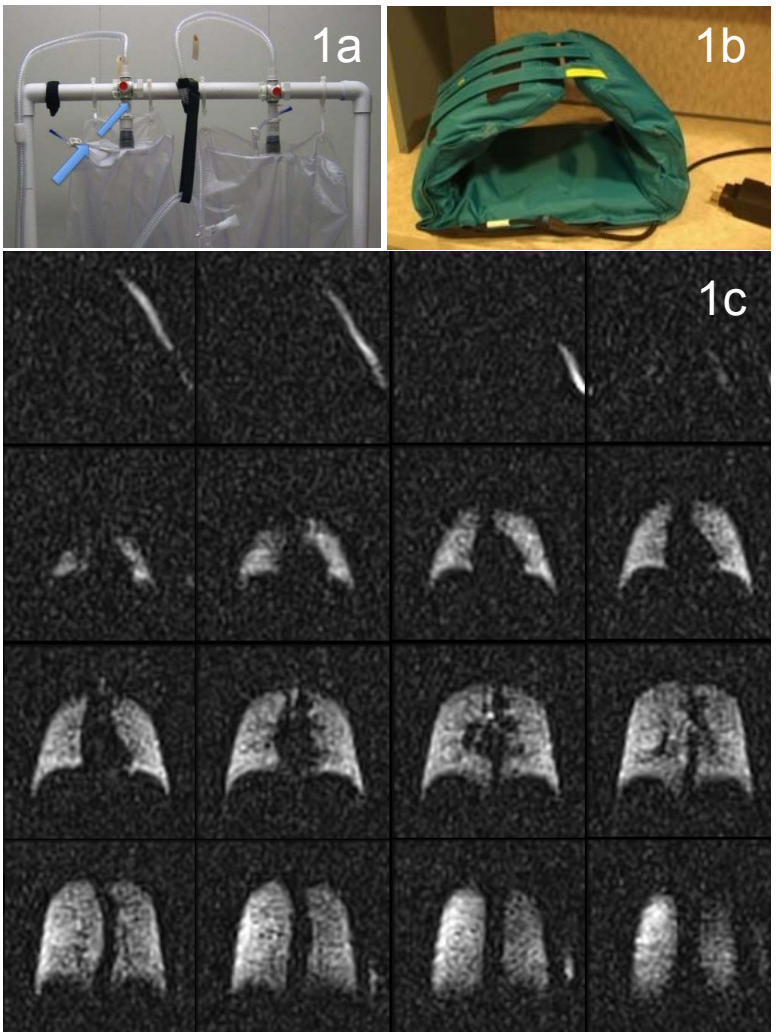
Lung Imaging in Humans at 3T using Perfluorinated Gases as MR Contrast Agents

B. J. Soher[1], M. Ainslie[2], J. MacFall[2], R. Hashoian[3], and H. C. Charles[1]
[1]Radiology, Duke University Medical Center, Durham, NC, United States, [2]Radiology, Duke University Medical Center, [3]Clinical MR Solutions

Introduction In this report we demonstrate for the first time in human subjects the use of conventional 'thermally' polarized perfluorinated gases (PFx) mixed with oxygen for use as inhaled inert MRI contrast agents to image lung ventilation. Chronic lower respiratory diseases (e.g. chronic obstructive pulmonary disease (COPD)) are the 4th leading cause of death in the US [1]. Currently, evaluation of such disorders includes global measures of pulmonary function (e.g. spirometry and plethysmography), lung imaging methodologies (x-ray CT) which offer high anatomic detail but not function, and nuclear techniques (scintigraphy), which provide regional information at low resolution. Both imaging modalities deliver ionizing radiation, which limits their repeat use in patients, especially in clinical trials. Hyperpolarized gas MRI (HPG, using 3He and 129Xe) has promised non-invasive, regional assessment of lung function but is expensive and technically challenging to implement clinically [2]. PFx gases require lower capital expense for implementation versus HPG and fewer raw materials and lower space requirements. Animal studies of PFx have demonstrated promising results including good spatial resolution, high speeds, ventilation defects and ventilation to perfusion ratio [3-4]. Moving beyond animal studies, one group has demonstrated images using excised human lungs [5].



Methods A 79/21% mixture of perfluoropropane (PFP) and oxygen (Air Liquide) were applied via a typical Douglas bag arrangement isolated with spirometry filters with a disposable mouthpiece (Fig.1a). PFP images were obtained on a 3T Siemens Trio system using a wrap around ^{19}F quadrature Tx/Rx coil (Clinical MR Solutions). The coil is actively proton blocked to allow ^{1}H imaging (Fig.1b) through the flex coil while in place on the subject. A 3D gradient refocused echo VIBE technique was used with a TR of 15 ms, TE of 1.2 ms (non-selective excitation), pixel bandwidth of 200 Hz, 64x64 pts, FOV=35cm and coronal slice thickness of 15 mm in a single 15 sec breath hold.

Results and Discussion A complete representation of a lung volume is shown in Fig.1c for a healthy 60 yr old male. Images at top show a cross section of the gas mixture input tube, which may serve in future studies as an external calibration standard. Voxel volume is 0.78 cm^3 with a nominal SNR of 15:1 for the current, non-optimized, acquisition parameters. PFx gases, such as SF_6 and PFP, have extremely short relaxation times (T_1~2ms for SF_6 and 20ms for PFP), which facilitate very rapid imaging. A 3D image (5 mm in-plane resolution and 15 mm slice thickness) can be sampled in a few seconds, which allows a full 3D volumetric reconstruction. A further benefit is having multiple gases to choose from. The T_1 (and T_2) of PFP is about 10 times that of SF_6 which impacts imaging protocol design and adds a dimension for optimization which is normally not available in an MRI study. In short, we can trade Pixel Bandwidth against NEX to optimize SNR for a given breathing pattern (short vs. long breath-holds). This also may be useful if average SAR becomes a major limitation

Clinical trials of lung airway disease treatments often require large numbers of subjects due to the limitations of global ventilation assessment or other clinical measures (e.g. number of exacerbations per year). This new imaging biomarker, PFx, for evaluation of regional ventilation may be an important step in decreasing the impact of these diseases.

References 1. Heron M, Nat Vital Stat Rep 57, 1-135, 2009. 2. Kauczor HU, Eur Respir J, 17, 1008-23, 2001. 3. Kuethe DO, Magn Reson Med, 39, 85-8, 1998. 4. Kuethe DO, Magn Reson Med, 48, 547-9, 2002. 5. Jacob RE, Magn Reson Med, 54, 577-85 2005.