Title: Measuring Specific Ventilation using Four-Dimensional Magnetic Resonance Imaging: A Novel Physiological Biomarker of Asthma

Trainee Name: Dante Capaldi

Supervisor(s): Dr. Grace Parraga

Structured Abstract:

Introduction: Specific ventilation (SV) is defined as a dimensionless quantity of inhaled gas ventilation that occurs during tidal breathing and is calculated as tidal volume divided by functional residual capacity [1]. 1H MRI was previously proposed to regionally quantify SV, using inhaled O2 as a contrast agent [2]. Our objective was to develop a novel and rapid way to measure whole lung and regional SV using free-breathing 1H MRI without exogenous contrast agents and over a short tidal breathing scan using conventional equipment. We also aimed to directly compare 1H MRI SV with hyperpolarized inhaled noble gas MRI ventilation and ventilation percent (VP).

Methods: We evaluated 10 asthmatics (50±12yrs) and two healthy volunteers (27±6yrs) who provided written informed consent to MRI, spirometry and whole body plethysmography. Pulmonary hyperpolarized noble gas MRI [3] and dynamic 2D multi-slice, whole lung coverage, free tidal-breathing 1H MRI using a bSSFP sequence [4] were acquired on a 3T system (GEHC). Free-breathing 1H MRI was retrospectively gated to generate tidal inspiration/expiration lung volumes that were co-registered using optical flow deformable registration [5]. 4DMRI SV maps were generated on a voxel-by-voxel basis using the co-registered volumes to generate local SV distribution maps. MRI ventilation percent (VP=ventilation volume normalized to thoracic cavity volume) and whole lung mean 4DMRI specific ventilation were determined and compared using Pearson correlation coefficients (r).

Results: 4DMRI SV and 3He MRI for an asthmatic showed visual qualitative agreement in all asthmatics. For all subjects, there was a significant relationship for MRI specific ventilation and inhaled noble gas MRI ventilation percent (r=.67, p=.02), FEV1/FVC (r=.74, p=.007) and plethysmography SV (r=.77, p=.003).

Discussion: In asthmatics, 4DMRI ventilation defects were spatially related with hyperpolarized inhaled noble gas MRI ventilation defects; 4DMRI SV also strongly correlated with experimentally measured SV and inhaled gas MRI ventilation percent. Free-breathing 4DMRI was exploited to generate specific ventilation maps that strongly correlated with experimentally acquired specific ventilation and inhaled noble gas MRI ventilation percent.

References: [1] Lewis, S. M., et al. 1978. [2] Sa, R. C. et al. 2010. [3] Kirby, M. et al. 2012. [4] Capaldi, D. P. et al. 2015. [5] Lucas, B. D. & Kanade, T. 1981.