INTRODUCTION

• Asthma is a chronic respiratory disease characterized by inflammation of the bronchial lining and constriction of airway smooth muscle (ASM).
• Identifying the regions of airway closure is critical for determining target sites for anti-inflammatory drugs.

One way to assess asthmatic lung structure is through a new imaging modality, Hyperpolarized (HP) 3He MRI.
• Traditional MRI utilizes the protons in water to capture various body tissue, but cannot image lungs well due to lack of water content.
• HP 3He MRI is able to image airspace through the inhalation of polarized noble gas.

HEALTHY

ASTHMATIC

ANATOMICALLY-BASED MODELING

This model is able to predict whole lung mechanics based on a generic airway tree with asymmetric bifurcations.
• Each airway is modeled as a function of diameter and thickness with an alveolar tissue element attached to each terminal airway.
• The properties of each airway are combined in serial and parallel fashion (see below) to get a total lung resistance and lung elastance as a function of frequency.

PROJECT GOAL

• Use HP 3He MRI to determine ventilation distribution for baseline and post-Methacholine (Mch) challenge conditions.
• Synthesize image with 3D model to identify non-ventilated regions in model.
• Compare measured lung mechanics and model-based simulations to assess the size and location of airways that can or cannot be constricted in an asthmatic lung.
• Establish how airways in asthmatics are distinct from healthy subjects via an analysis of deep inspirations.

PATIENT SPECIFIC DATA

LUNG MECHANICS

Figure 3. Plotted above are measured dynamic lung resistance and elastance versus frequency pre- and post-bronchial challenge in a healthy subject. In the post-Mch challenge, elevated resistance and elastance values are evident.

EXTRACTION OF VENTILATION FOR IFM ANALYSIS

The first step in MRI image analysis requires thresholding the baseline MRI image to isolate the healthy lung boundary. This results in an image-based mask for each slice.
• Each terminal branch slice is then morphed to the size and shape of its corresponding HP 3He MRI baseline image mask.
• Ventilated terminal branches for each slice are then identified and used to find the post-Mch condition ventilation.

IFM IMAGING RESULTS

SUMMARY / FUTURE WORK

• IFM identifies ventilation defects in terminal lung units occurring with broncho provocation.
• IFM identifies impact and re-opening of airway with deep inspiration.
• Future work will identify airway constriction necessary to match both IFM to the MRI images of Figure 4 and the mechanical data of Figure 3.

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