

Whole Lung Image Functional Modeling (IFM) using Hyperpolarized Helium MRI (Hyp ^3He MRI): Deep-Inspiration Response in Asthmatics

J. Kenyon, BS¹, S. Zhalehdoust, BS¹, J.B. Szender, MS¹, Y-S Tzeng, SM^{1,2}, L.M. Campana¹, G.R. Washko, MD², E. Israel, MD², M.S. Albert, PhD², K.R. Lutchten, PhD¹

¹Department of Biomedical Engineering, Boston University, Boston, MA

²Brigham and Women's Hospital, Boston, MA

We synthesized anatomically consistent airway tree models with Hyp ^3He MRI imaging data in order to quantify the airway structures responsible for ventilation and mechanical defects in asthmatics. We call this approach Image Functional Modeling (IFM). In healthy and asthmatic subjects, we measured lung resistance (R_L) and elastance (E_L) from 0.156 – 8 Hz and acquired static Hyp ^3He images at baseline, post-Methacholine (Mch), and again after a series of deep-inspirations (DIs). Image processing was used to convert the intensity Hyp ^3He MRI images to binary image masks (all-or-nothing ventilation) and to morph a 3D model of terminal lung units. The number and location of ventilated lung units lost due to induced constriction and then recruited following a DI were identified on a whole-lung scale. Heterogeneous closures of small airways in the model (< 2 mm) were necessary to match ventilation distribution post-Mch. Matching measured R_L and E_L required additional imposition of heterogeneous constriction throughout the remaining airway tree. On average, asthmatics needed a greater standard deviation of constriction both post-Mch and post-DI. Following a DI, the IFM showed that healthy subjects recovered more ventilated units than asthmatics and had a greater reduction in heterogeneity of airway constriction. In summary, IFM was used to show that airway provocation caused heterogeneous constriction and closures in both healthy and asthmatic subjects, but both were more alleviated via a DI in healthy subjects. These data indicate a structurally distinct airway system in asthmatics.

kenyonj@bu.edu