Comparison of Airway Diameter Measurements from an Anthropomorphic Airway Tree Model Imaged Using Hyperpolarized ^{3}He MRI and Multidetector CT

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Introduction

Identifying the airways involved in asthmatic bronchoconstriction is vital to understanding this disease and developing appropriate treatments. While measurement of airway diameters can be achieved using high resolution computerized tomography (HRCT), exposing an asthmatic to repeated doses of ionizing radiation for the purpose of tracking disease development is undesirable. A rigorous model-based algorithm for measuring diameters from airway features in Hyperpolarized (HP) ^{3}He MR images was recently developed. Although its ability has been demonstrated using tubes of known diameters, its fidelity when applied to anatomical features has yet to be demonstrated.

Methodology

An anthropomorphic airway tree model was constructed using segmentation data from in vivo CT scanning of a normal human subject scanned in the supine body posture. The segmented data was presented to a rapid prototyping device which produced a hollow model of the airway tree. This airway tree model was scanned using both HP ^{3}He MRI and Multidetector-row CT (MDCT). Static projection HP ^{3}He MR images were acquired using a Signa 1.5T MRI scanner upon introducing a 1:1 mixture of HP ^{3}He to N_2 into the model, with 46 cm FOV, 256×128 matrix, Fast GRE pulse sequence, and 14° flip angle. Diameters of airway segments were measured using a model-based algorithm written in MATLAB. MDCT scans parameters were: 120 mAs, 100 kV, 1.2 mm slice thickness with 0.6 mm slice spacing. Airways corresponding to those measured using HP ^{3}He MRI were also quantified from the CT images using custom software developed at the University of Iowa [3]. Software automatically segments the airway tree, identifies the airway centerline and branch points, labels airway segments and provides quantitative measures including local airway diameters based upon re-slicing the images perpendicular to the local airway long axis.

Results and Discussion

Figure 1 presents a negative static projection HP ^{3}He MR image of the anthropomorphic lung phantom, with the measured airways labeled. Figure 2 plots the major and minor diameters of the airways as obtained through MDCT (D_maj, D_min) and the diameters quantified using HP ^{3}He MRI (D_HPHe). The range of D_HPHe is consistently within the bounds set by D_maj and D_min, except for a 2% error for the trachea (G0), and less than 10% error for the airways G3-LRL, G4-RRLL, and G4-RRLR.

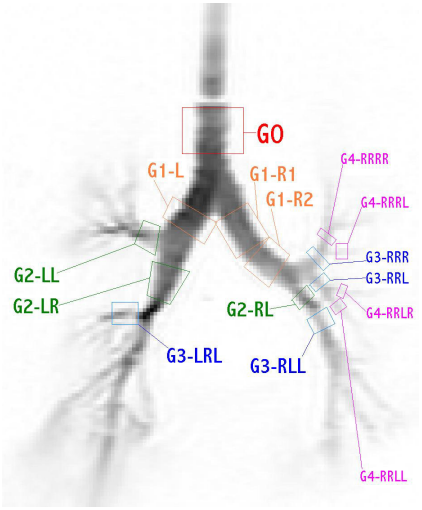

Figure 1. HP ^{3}He MR Image of Airway Tree Phantom and Locations of Diameter Measurements

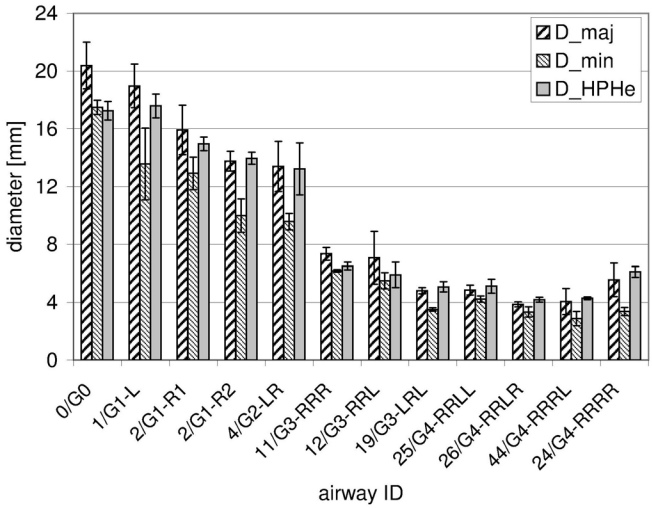

Figure 2. Comparison of Diameter Measurements Obtained Using CT and HP ^{3}He MRI

Conclusion

The robust model-based approach of measuring airway diameters from HP ^{3}He MRI shows that it can reliably produce airway diameter measurements comparable to those obtained using CT. This supports the use of HP ^{3}He MRI as a tool in the diagnosis, quantification, and treatment of bronchoconstriction in asthmatics.

References

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