

Ventilation Heterogeneity Indices Computed from Hyperpolarized ^3He MRI Captures Differences between Asthmatic and Non-Asthmatic Lungs

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Introduction

Characteristics of asthmatic bronchoconstriction include reversibility and heterogeneity. These can be indirectly observed through the resulting ventilation distribution. Hyperpolarized (HP) ^3He MRI is a tool that has been increasingly used for looking at lungs, both healthy and with various respiratory diseases. This project examines the feasibility of quantifying ventilation heterogeneity resulting from bronchoconstriction in asthmatics using HP ^3He MRI.

Approach

HP ^3He MR static ventilation images were acquired before Methacholine challenge (pre-Mch), after Mch challenge (post-Mch), and after deep inspirations (post-DI) from asthmatic (n=13) and non-asthmatic (n=4) subjects. The resulting images are used to compute the fraction of each voxel occupied by fresh gas using a linear relationship between pixel intensity and HP ^3He gas volume, followed by the calculation of the standard deviation of the ventilation distributions (SDvent). The average local coefficient-of-variation (CoV) for each image set was also determined.

Results and Discussion

Figure 1 depicts the images and corresponding local CoV maps from a mid-coronal slice for a representative non-asthmatic subject.

For asthmatics, the average local CoV rose by 0.45 ($p < 0.002$) post-Mch. The subsequent 0.12 fall post-DI was not statistically significant ($p \geq 0.05$). For non-asthmatics, the average local CoV rose by 0.62 ($p < 0.02$) post-Mch, then fell by 0.44 ($p < 0.05$) post-DI.

For asthmatics, SDvent increased by 0.0795 ($p < 0.02$) post-Mch, then dropped 0.0474 ($p < 0.02$) post-DI. For non-

asthmatics, the post-Mch increase was 0.0506 ($p < 0.0001$), dropping by 0.0144 ($p < 0.0001$) post-DI.

Between the two subject populations, the difference in average local CoV and SDvent reduction post-DI was statistically significant ($p < 0.0001$).

The elevation of heterogeneity indices post-Mch indicates the presence of bronchoconstriction in both asthmatics and non-asthmatics. The subsequent reduction in the heterogeneity indices post-DI for non-asthmatics corroborate the current understanding that DI's are effective in reversing bronchoconstriction in non-asthmatics; in contrast, the lesser drop in heterogeneity indices post-DI for asthmatics support the belief that the mechanisms associated with DI's do not play as much role in asthmatics.

Conclusion

Average local CoV and SDvent from HP ^3He MRI are both emerging as effective indices of ventilation heterogeneity. This study also corroborates the current understanding that DI's reverse bronchoconstriction in non-asthmatics but to a lesser degree in asthmatics.

