A Multiscale, Spatially–Distributed Model of Airway Hyper–Responsiveness.

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Rationale: Airway hyper–responsiveness (AHR), along with airway hyper–sensitivity, is a defining feature of asthma, and greater understanding of this emergent phenomenon may lead to better insight into and treatment of the condition. We seek a multiscale, spatially–distributed, mathematical model of the lung to help us understand the role of airway smooth muscle and parenchymal material in AHR.
Methods: Our model couples together the organ scale with the tissue scale in the lung in a multiscale approach to the problem. At the organ level, parenchymal tissue is modeled as a compressible Blatz–Ko material in three dimensions, with expansion and recoil of lung tissue due to tidal breathing. The governing equations of finite elasticity deformation are solved using a finite element method. An airway tree is embedded in this tissue, with airway smooth muscle behavior described by a modified Hai–Murphy cross–bridge model (Wang et al., Biophys. J. 94:2008). Each airway segment is initially assumed to be radially symmetric and longitudinally stiff, and thus the embedded airway tree is essentially 1D.
Results: Our spatially–distributed, multiscale model yields organ–level observations while incorporating tissue–level modeling detail. Preliminary results from the integrated model indicate potential use in the study of many phenomena associated with asthmatic AHR, including spatial distribution of ventilation defects, patchiness, and effects of deep inspirations.

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