Multiscale Simulation of Gas Flow in the Human Lung

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GOAL

The goal is to develop a comprehensive computational fluid dynamics (CFD) model for pulmonary flow that utilizes subject-specific airway geometries, spans spatial scales from the largest bronchial airways to alveolar sac, and employs a Computed Tomography (CT) data-driven, multistage approach to provide accurate predictions of regional ventilation and gas transport through the entire moving airway tree.

APPLICATIONS

- Drug delivery: improve pharmaceutical aerosol drug delivery.
- Biomedical imaging: advance Xenon or Helium CT/MRI.
- Life/health sciences: predict subject-specific regional ventilation for diagnosis of patterns related to pathologic changes in airway geometry and parenchyma.
- Cross-disciplinary research: Innovation.

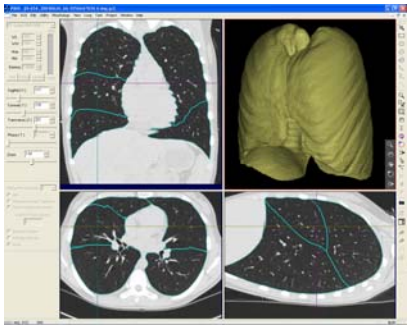
SOME FACTS

- Early exposure to environmental pollutants has chronic, adverse effects on lung development in the children from the age of 10 to 18 years (Gauderman et al. 2004).
- Lung hot spots concentrate carcinogens that produce or incite lung cancer (Heistracher & Oldham 2003). Safe limits for pollutant concentration could be underestimated.
- The Iowa Radon Lung Cancer 5-year Study suggests that cumulative residential radon exposure is a significant risk factor for lung cancer in women.

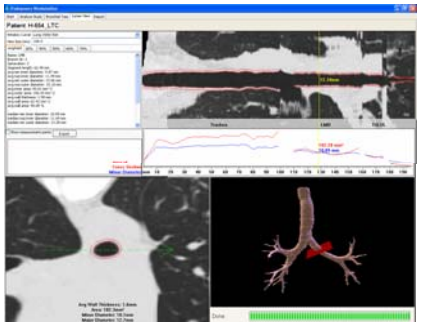
METHODOLOGIES

1. CT Image Data Analysis: PASS (Pulmonary Analysis Software Suite) developed by Dr. Hoffman.
2. Segmentation and Airway Tree Data: VIDA (Volumetric Image Display and Analysis) developed by Dr. Hoffman.
3. Geometric Modeling and Mesh Generation: 1D volume filling technique, alveolar geometric model, and automatic mesh generation developed by Dr. Tawhai.
4. Multiscale Simulation: High-performance parallel computational fluid dynamics and structural mechanics codes for multscale simulation developed by Dr. Lin.
5. Animal and Human CT Experiments: Siemens MDCT scanner in the Iowa Comprehensive Lung Imaging Center (I-Clic) directed by Dr. Hoffman will be used. The clinical applications of this study will be investigated by Dr. McLennan.

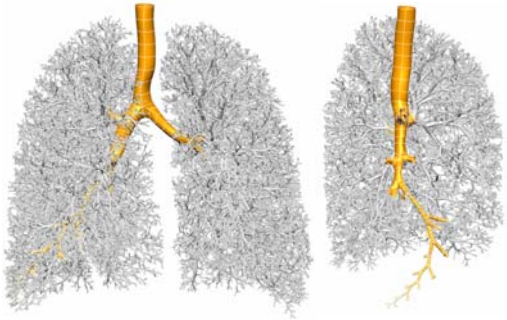
1. CT Image Data & Lung Functions



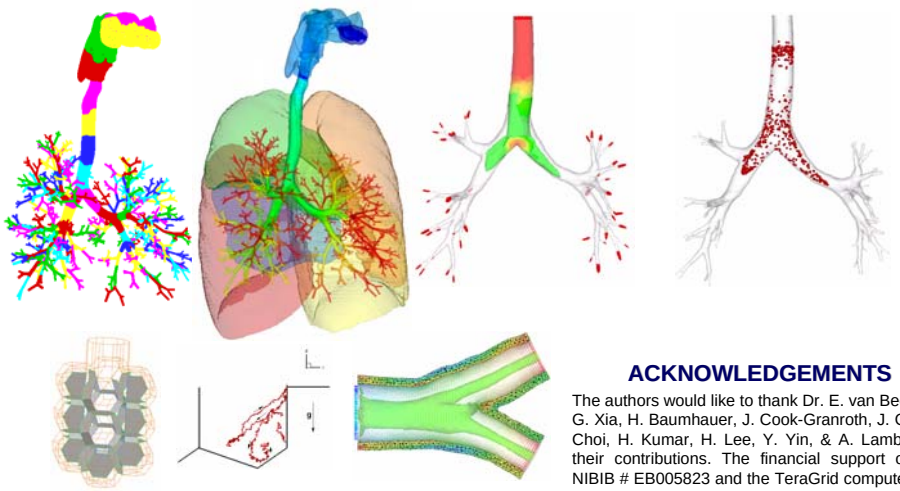
2. Segmentation & Airway Tree Data



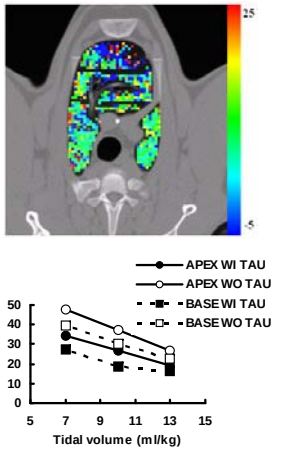
3. Geometric Modeling & Mesh Generation



4. Multiscale Simulation of Air Flow in Rigid and Flexible Walls



5. Animal and Human CT Experiments



(Chon et al., *Resp Physiol Neurobi* 148, 2005)

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