Computational Modeling of the Respiratory System

by Wolfgang A. Wall, Lena Wiechert, Andrew Comerford, Sophie Rausch and Robert Metzke
Chair for Computational Mechanics
Technical University of Munich, 85748 Garching, Germany

We show recent advances in developing a comprehensive computational model of the respiratory system based on different novel multi-field and multi-scale approaches.

The human lung is still only a very poorly understood system. For many reasons however it would be very beneficial to get deeper insights in various phenomena as e.g. dispersive aerosol transport or ventilator-induced lung injury (VILI). Our efforts that are described in this talk are heading towards a better understanding of ventilator-induced lung injury and the development of new protective ventilation strategies that are able to decrease the high mortality in this area. To reach this goal a detailed understanding of fluid and solid mechanical processes at different levels -- from the trachea down to the alveolar and even cellular level -- is necessary.

On the largest scale the model incorporates fluid-structure interaction effects in the first generations of the bronchial tree. Patient-specific geometries obtained from CT scans are enhanced via special boundary conditions and artificial extensions allowing information transfer to non-resolved areas and finally to the alveolar area where VILI occurs. In the respiratory zone a dynamic nested multi-scale approach was established. This is based on a detailed micromechanical model including complex constitutive models of alveolar tissue -- obtained from experiments on living lung slices -- and surfactant effects. At the lowest scale also force transmission in cells is tackled.