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Large-eddy Simulation of Heat and Water Vapor Transfer in CT-Based Human Airway Models[1] DAN WU, Department of Mechanical and Industrial Engineering, The University of Iowa, MERRYN TAWHAI, Auckland Bioengineering Institute, The University of Auckland, ERIC HOFFMAN, Medicine and Radiology, The University of Iowa, CHING-LONG LIN, Department of Mechanical and Industrial Engineering, The University of Iowa — We propose a novel imaging-based thermodynamic model to study local heat and mass transfers in the human airways. Both 3D and 1D CFD models are developed and validated. Large-eddy simulation (LES) is adopted to solve 3D incompressible Navier-Stokes equations with Boussinesq approximation along with temperature and water vapor transport equations and energy-flux based wall boundary condition. The 1D model provides initial and boundary conditions to the 3D model. The computed tomography (CT) lung images of three healthy subjects with sinusoidal waveforms and minute ventilations of 6, 15 and 30 L/min are considered. Between 1D and 3D models and between subjects, the average temperature and water vapor distributions are similar, but their regional distributions are significantly different. In particular, unlike the 1D model, the heat and water vapor transfers in the 3D model are elevated at the bifurcations during inspiration. Moreover, the correlations of Nusselt number (Nu) and Sherwood number (Sh) with local Reynolds number and airway diameter are proposed. In conclusion, use of the subject-specific lung model is essential for accurate prediction of local thermal impacts on airway epithelium.

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