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Computational modeling of cilia dynamics in the human airways

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Mucus clearance in the human airways is regulated by carpets of motile cilia on the epithelial layer of the lungs. The forward and backward strokes of cilia facilitate the clearance of mucus in the airways. Primary ciliary dyskinesia (PCD) also known as immotile-cilia syndrome is a congenital disorder that refers to a set of human diseases caused by the abnormal structure and/or function of motile cilia. PCD usually leads to immotile or dis-coordinated movement of cilia that impede effective mucociliary clearance. Accumulation of mucus in the lung airways provide a viable environment for bacteria to grow and thrive, resulting in disease and reduced lung functioning. In this talk, we present a computational model that describes how the pressure gradient in the airways during inhalation and exhalation affect cilia dynamics in health subjects and also in subjects experiencing PCD. In the model, cilia are represented as elastic solids, peri-cilia liquid and mucus layers are represented as fluids with different densities and viscosities. Numerical simulation is carried out using the finite element method. Simulation results show that airway pressure gradient may influence cilia dynamics. Results also show that changes in ciliary structure/properties would impede the effectiveness of mucociliary transport.