FLOW MEASUREMENT AND CONVECTIVE PARTICLE DISPERSION IN LUNG ACINI

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Abstract

The alveoli are the smallest units of the lung that participate in gas exchange. The ability of the alveoli to exchange gas is often compromised by the deposition of harmful inhaled particulate matter on the alveolar wall. At the same time, the alveoli can also be exploited as effective delivery sites for inhaled therapeutic aerosols for local and systemic ailments. Since, the transport and deposition of inhaled aerosol particles is influenced by convective airflow patterns, understanding alveolar fluid flow and mixing is a necessary first step towards predicting aerosol transport and deposition in the human acinar region.

In this study, airflow patterns have been measured using a simplified *in-vitro* alveolar model consisting of a single alveolus located on a bronchiole. The model comprises a transparent elastic $5/6^{\mathrm{th}}$ spherical cap (representing the alveolus) mounted over a circular hole on the side of a rigid circular tube (representing the bronchiole). The alveolus is capable of expanding and contracting. Realistic breathing conditions were achieved by exercising the model at physiologically relevant Reynolds and Womersley numbers. Particle image velocimetry was used to measure the resulting flow patterns.

Data were acquired for five cases obtained as combinations of the alveolar wall motion (rigid/oscillating) and the bronchiole flow (none/steady/oscillating). Detailed vector maps at discrete points within a given cycle revealed flow patterns, and transport and mixing of bronchiole fluid into the alveolar cavity. The time-dependent velocity vector fields were integrated over multiple cycles to estimate particle transport into the alveolar cavity and deposition on the alveolar wall. The key outcome of the study is that alveolar wall motion enhances mixing between bronchiole and alveolar fluid. The mixing is maximized when alveolar wall oscillates in tandem with the oscillation of the bronchiole fluid, which is the operating case in the human lung.

Future work will focus on measuring velocity fields for 1) asynchronous oscillation of the alveolar wall and the bronchiole flow, 2) extended range of physiologically relevant Reynolds and Womersley numbers.