HIERARCHICAL MODEL OF GAS EXCHANGE WITHIN THE ACINAR AIRWAYS OF THE HUMAN LUNG

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ABSTRACT

The acinar airways lie at the periphery of the human lung and are responsible for the transfer of oxygen from air to the blood during respiration. This transfer occurs by the diffusion-reaction of oxygen over the irregular surface of the alveolar membranes lining the acinar airways. We present an exactly solvable diffusion-reaction model on a hierarchically branched tree, allowing a quantitative prediction of both the pulmonary efficiency of the human lung and the oxygen current reaching the blood within the pulmonary arteries, over the entire system of acinar airways responsible for the gas exchange. Our model predicts that the oxygen current is insensitive to changes in the permeability of the alveolar membranes, over a wide range of permeabilities. Such fault tolerance has been observed in other treatments of the gas exchange in the human lung and is obtained here as a fully analytical result.