Self-organization of the beating of myriads of microscopic cilia to transport mucus to the surface of our bronchi

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Abstract

We will discuss how active mucus-cilia hydrodynamic coupling drives self-organisation of human bronchial walls. The respiratory tract is protected by mucus, a complex fluid transported along the epithelial surface by the coordinated beating of millions of microscopic cilia. Its impairment is a strong marker of severe chronic respiratory diseases. The relationship between ciliary density and the spatial scale of mucus transport, as well as the mechanisms that drive ciliary-beat orientations during ciliogenesis are much debated. We experimentally show that mucus swirls and circular orientational order of the underlying ciliary beats emerge and grow during ciliogenesis, until a macroscopic mucus transport is achieved for physiological ciliary densities. We demonstrate that cilia/mucus hydrodynamic interactions govern the collective dynamics of ciliary-beat directions. We propose a two-dimensional model that predicts a phase diagram of mucus transport in accordance with the experiments.

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