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Nonlinear analysis of the influence of surfactant on the stability of a liquid bilayer inside a tube YUANYUAN SONG, DAVID HALPERN, University of Alabama, JAMES GROTBERG, University of Michigan — The lung's airways are coated internally with a liquid bilayer consisting of a serous layer immediately coating the airway wall and a more viscous mucus layer which is exposed to the gas core. A surface tension instability at the interfaces may lead to the formation of liquid plugs that block the passage of air. This is known as airway closure. Here we consider this thin liquid bilayer coating within a compliant tube in the presence of insoluble surfactant at the mucus-gas interface. Surfactant can reduce the surface tension and induce a stress gradient, both of which are stabilizing. Lubrication theory is used to derive a system of nonlinear evolution equations for the thickness of the layers, the location of the tube wall, and the surfactant concentration. The effects of various parameters, the thickness of the bilayer to the tube radius, the layer thicknesses ratio, the surface tension ratio, and the viscosity ratio between the two layers, and wall compliance parameters, are investigated numerically. For a single layer in a rigid tube, surfactant can increase the closure time by approximately a factor of five. However, for a bilayer, the presence of surfactant slows down the closure time by a significantly larger factor, twenty times or more dependent on system parameters.

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