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How to Breathe in a Liquid-Filled Lung: Symmetry of Airway Reopening

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Many respiratory diseases cause the occlusion of pulmonary airways with viscous fluid. The subsequent airway reopening is assumed to occur by the propagation of an air finger into the liquid-filled airways. We investigate the behavior of the air finger as it reaches a single bifurcation and determine under what conditions the finger branches symmetrically. If the fluid pressure in both channels ahead of the branching finger are equal, the finger will preferentially reopen a single path through the branching network. If the ends of the channels are capped with compliant chambers, representing the lung elasticity, the pressure required to drive the air finger can be dominated either by viscous losses or by elastic forces. Below a critical velocity, elastic forces dominate and symmetric branching is predicted to occur. We augment our theoretical model with an experimental study in which the problem is investigated using microfluidic channels.

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