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Three-Dimensional Airway Reopening – Finite-Reynolds-Number Effects

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Motivated by the physiological problem of airway reopening, we study the steady propagation of an air finger into a buckled elastic tube, containing an incompressible, Newtonian fluid. The fluid mechanics is governed by the Navier–Stokes equations, and the solid mechanics by Kirchhoff–Love thin-shell theory. The resulting three-dimensional, fluid-structure-interaction problem is solved numerically by a fully-coupled, finite-element method. The main aim of the study is to determine the propagation speed of the air finger as a function of the applied pressure. A characteristic two-branch behaviour in the propagation velocity-pressure curve is similar to earlier two-dimensional models. Furthermore, we find that fluid inertia has a significant effect, even at the low values of the Reynolds number that occur in the airways of the lung.

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