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Mucus Rupture in A Collapsed airway: An Experimental Study[1]

YINGYING HU, SHIYAO BIAN, JAMES B. GROTBERG, Department of Biomedical Engineering, University of Michigan — Mucus plugs can completely obstruct an airway. Difficulty in mucus clearance results in lost gas exchange and inflammation. Non-Newtonian properties of mucus, yielding stress and shear-thinning, play significant roles in mucus clearance. We use aqueous carbopol 940 as a mucus stimulant to study clearance of a mucus plug with properties of yielding stress and shear-thinning in a bench-top experiment. A collapsed airway of the 12^{th} generation in a human lung is simulated in a two-dimensional PDMS channel. A stable pressure drop is set along the plug to drive rupture. A micro-PIV technique is used to acquire velocity fields during the rupture process. A yielding pressure drop (initiating plug yielding) is nearly independent of initial plug length. Plug rupture can occur by focused deformation along the centerline or by total plug propagation where the trailing film is thicker than the precursor film. Maximum velocity appears at the rupture moment, and increases at higher pressure drop or smaller plug length. The wall shear gradient can undergo a rapid reversal when rupture occurs, possibly an injurious event to underlying airway epithelial cells.

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