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INSIGHTS INTO CYTOPLASMIC RHEOLOGY GAINED FROM MODELING CELLULAR BLEBBING

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Blebbing occurs when the cytoskeleton detaches from the cell membrane, resulting in the pressure-driven flow of cytosol towards the area of detachment and local expansion of the cell membrane [1]. Recent experiments involving blebbing cells have led to conflicting hypotheses regarding the timescale of intracellular pressure propagation. The interpretation of one set of experiments supports a poroelastic cytoplasmic model which leads to slow pressure equilibration when compared to the timescale of bleb expansion [2]. A different study concludes that pressure equilibrates faster than the timescale of bleb expansion [3]. To address this, a dynamic computational model of the cell was developed that includes mechanics of and the interactions between the intracellular fluid, the actin cortex, the cell membrane, and the cytoskeleton. The model results show that a single phase viscous fluid model of the cytoplasm is insufficient to explain experimentally observed bleb expansion times. Results also quantify the relative importance of cytoskeletal elasticity and drag in bleb expansion dynamics. This study also shows that recent multi-bleb experimental results can be explained by the combination of cytoskeletal poroelasticity with cortical actin dynamics.

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