Cell volume regulation is a fundamental property of all mammalian cells. Numerous signaling pathways are known to be activated by cell swelling and to contribute to cell volume homeostasis. Cellular biomechanics and membrane tension have long been proposed to couple cell swelling to signaling pathways; however, the impact of swelling on these parameters has yet to be fully elucidated. In this study, we utilize atomic force microscopy (AFM) under isotonic and hypotonic conditions to measure the mechanical properties of human aortic endothelial membranes. From AFM force/displacement curves, we obtain estimates of membrane elastic modulus, which reflects the stiffness of the sub-membrane cytoskeleton complex and the force required for membrane tether formation, reflecting membrane tension and membrane cytoskeleton attachment. We find that hypotonic swelling results in significant stiffening of the membrane region of endothelial cells, without a corresponding change in membrane tension or membrane-cytoskeleton attachment. Furthermore, depolymerization of F-actin in the cytoskeleton, which as expected results in a dramatic decrease in the cellular elastic modulus of both the membrane and the deeper cytoskeleton, indicating a collapse of the cytoskeleton scaffold, does not abrogate swelling-induced stiffening of the membrane, instead this stiffening is enhanced. We propose that the hypotonically induced membrane stiffening should be attributed to an increase in hydrostatic pressure that results from an influx of solutes and water into the cells. Most importantly, our results suggest that increased hydrostatic pressure, rather than changes in membrane tension, could be responsible for activating volume sensitive mechanisms in hypotonically swollen cells.

Recent Publications


Biography
Manuela A A Ayee is a Postdoctoral research fellow in the Department of Pulmonary and Critical Care Medicine at the University of Illinois at Chicago. Her current research focuses on investigating the modulation of cellular biomechanics by oxidized lipids and sterols under hypercholesterolemic conditions. She obtained her PhD in Chemical Engineering with a specialization in Computational Biomolecular Modeling and Interfacial Phenomena. Her broad research goals include combining computational and experimental techniques to reveal the role of small molecules in pathogenesis and elucidating the molecular mechanisms underlying their effects on membrane biomechanics and their subsequent modulation of cell biophysical properties. She will begin as a Professor of Chemical Engineering and Chemistry at Dordt College, Iowa in 2018.