2023 Elsevier Distinguished Lecture

Lecture 15: Unraveling the Mechanics of Biological Soft Tissue Using Advanced Bioimaging Techniques

Dr. Anne Robertson

Distinguished Service Professor
William Kepler Whiteford Endowed Professor of Mechanical Engineering and Materials Science

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Also delivered via Zoom (Passcode: 898166)

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Biography: Dr. Anne Robertson is a Distinguished Service Professor and William Kepler Whiteford Endowed Professor of Mechanical Engineering and Materials Science at the University of Pittsburgh. The focus of Dr. Robertson's research is understanding the relationship between structure and mechanical function in biological soft tissues and using this knowledge to improve treatments of disease. She co-directs a multi-national program on cerebral aneurysms that is supported by the NIH and engages four clinical centers and three universities. She held a four-year term as a standing member of an NIH Study Section in the National Institute of Neurological Disorders and Stroke. She has held visiting faculty positions at institutions including the Bernoulli Center at the Swiss Federal Institute of Technology (EPFL), the Politecnico di Milano, University of Aachen, and Instituto Superior Tecnico, Lisbon. Dr. Robertson earned a B.S. at Cornell University and her M.S. and PhD degrees at U.C. Berkeley, all in Mechanical Engineering. She was a President's Postdoctoral Fellow in the Department of Chemical Engineering, also at U.C. Berkeley.

Abstract: Biological soft tissues such as artery, bladder and cornea are composite materials formed of cellular constituents along with acellular structural materials including collagen and elastin fibers. The organization and distribution of these constituents within each organ are critical for enabling its particular function, such as the remarkable capacity of the bladder to increase its volume over three-fold under small increases in pressure during filling. Forty years ago, Lanir published a seminal paper that recognized the importance of including this microstructure in material models for soft tissues. In particular, he introduced a structurally motivated constitutive model for collagenous soft tissues that included the distributions in both collagen fiber tortuosity and angle. However, there were no tools at that time for measuring these distributions and up until recently, most studies have continued to employ phenomenological models. This lecture is focused on recent work that leverages advances in bioimaging technology to obtain the data necessary to develop microstructural models of soft tissues. In particular, the advent of multiphoton microscopy has enabled direct imaging of elastin and collagen fibers in soft tissues without fixation or destructive tissue sectioning. Our group has leveraged these technologies to develop mechanical testing systems to simultaneously image collagen and elastin fiber organization during mechanical experiments. We have used these systems to directly measure the parameters in Lanir's structural models while also exploring how the composite organization in soft tissue drives their mechanical function. Applications of these approaches to understanding the high compliance of the bladder wall, rupture of cerebral aneurysms, as well as growth and remodeling in blood vessels will be discussed.

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