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Centre for BioSystems Science and Engineering

BSSE Seminar

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Spatial Patterns in Elastic Properties of Mitral Valves and Veins Reveal Understudied Heterogeneity in the Cardiovascular System

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ABSTRACT

Each tissue of the cardiovascular system exhibits a unique pattern of composition and material properties, which are matched to the tissue's mechanical environment and required function. The global objective of my research was to characterize such patterns in mitral valves and the central venous system with the goal of understanding how anatomical locations within each tissue differ and how they vary in their pathological responses. First, I employed a novel mechanical analysis method, optical coherence elastography, to assess the spatial pattern of elasticity along the surface of porcine mitral valve leaflets. This analysis revealed heterogeneity within and differences between the leaflets at a higher resolution than previously reported and broadened our understanding of mitral valve mechanics as they relate to the tissue's finely tuned composition. Next, I explored the mitral valve leaflets' differing responses to alterations in mechanical environment. Previously, the Grande-Allen lab at Rice University established that mimicking mitral regurgitation in a pseudo-physiological flow loop can lead to fibrotic remodeling and increased stiffness in cultured porcine mitral valves. I utilized this system to explore whether elimination of regurgitation would lead the leaflets to reverse remodel toward a healthy state. The finding of leaflet- and orientation-dependent remodeling revealed the complex interplay between valve composition, forces experienced by the valve, and responses to alterations in these forces. Finally, I shifted focus to exploring anatomical variation in the central venous system. Tensile testing was performed on healthy porcine veins and veins harvested from a porcine model of deep vein thrombosis (DVT). Detected location-specific differences in the thickness, stiffness, failure strength, and remodeling in response to DVT revealed previously understudied variation in venous system mechanics and pathological response. To further analyze the effects of DVT, I developed a pressurized digital image correlation system to examine the pressure-displacement relationship of veins. This system provides a platform to further investigate venous mechanics in their natural geometry. Together, my research reveals heterogeneity in the material properties and pathological remodeling of mitral valves and veins, thereby underscoring the need for the consideration of anatomical variation in the study and treatment of cardiovascular disease.

ABOUT THE SPEAKER:

Dr. Dragoslava Vekilov is a member of the Grande-Allen lab at Rice University in Houston, Texas. She recently graduated from Rice with her PhD in Bioengineering. Before that, she completed her BS in Biology at the University of Texas at Austin. During her doctoral studies, she was awarded the National Science Foundation Graduate Research Fellowship (NSF GRFP). Her research focus is on characterizing the spatial heterogeneity in cardiovascular tissue biomechanics. She utilizes a variety of mechanical analysis tools along with in vivo and in vitro model systems to analyze regional differences in physiological and pathophysiological tissue.