Department of Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

Fall 2023 Seminar Series

MRI Based Computational Modeling for Patient Specific Fluid Dynamics

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Comprehensive characterization and quantification of blood flow is essential for understanding the function of the cardiovascular system under normal and diseased conditions. This provides important information not only for the diagnosis and treatment planning of different cardiovascular diseases but also for the design of cardiovascular devices. However, the anatomical complexity and multidirectional nature of physiological and pathological hemodynamics makes non-invasive characterization and quantification of blood flow difficult and challenging. Doppler ultrasound, a standard imaging technique, is limited to providing information on large vessels and calculating instantaneous average flow within the cardiac cycle. Magnetic resonance imaging (MRI) is increasingly being used for fluid dynamics analyses of cardiovascular diseases. Four-dimensional (4D) flow MRI obtains velocity measurements in three dimensions throughout the entire cardiac cycle. Several attempts have been made to non-invasively characterize the blood flow dynamics of different cardiovascular diseases using the combination of medical imaging and computational fluid dynamics modeling (CFD). Idealized geometries, as well as patient-specific anatomies, have been used for computational simulations, which have improved the understanding of the fluid dynamics phenomena in different vascular territories. While CFD modeling can provide powerful insights and the potential for simulating different physiological and pathological conditions in the cardiovascular system, it is currently not reliable for use in clinical care. Based on different studies, additional work is needed to verify the accuracy of current CFD approaches or identify and address current shortcomings. The overall purpose of this research is to develop, implement and validate non-invasive flow analysis methodologies to assess cardiovascular flow dynamics, using a combination of 4D flow MRI, particle image velocimetry, numerical simulations and patient-specific physical models. In this seminar, multidisciplinary work will be presented first, where different cardiovascular pathologies have been studied using in vivo, in vitro and computational models. Second, some advances will be presented, and a future outlook into the valuable contribution of engineering in medical imaging and diagnostic technology will be provided.

ABOUT the SPEAKER

Alejandro Roldán-Alzate is an Assistant Professor in the Departments of Radiology and Mechanical Engineering at the University of Wisconsin–Madison. He is the director of the Cardiovascular Fluid Dynamics Laboratory, which has the main interest in coupling engineering tools with medical imaging to non-invasively characterize the hemodynamics in different physiological and pathological conditions. Recently, Dr. Roldán-Alzate's laboratory has focused on non-invasive assessment of bladder biomechanics and Urodynamics.

Monday, October 23 at Noon
1003 Engineering Centers (Tong Auditorium)