Indian Institute of Science

Centre for BioSystems Science and Engineering

BioSystems Science and Engineering

Seminar

At 3:00 PM on 6th August, 2018 (Monday)

MRDG seminar hall, 1st Floor Biological Sciences Building

Failure Biomechanics of Ascending Thoracic Aorta

Dr. Spandan Maiti

Bioengineering Department, University of Pittsburgh

Abstract

Type A Aortic Dissection (TAAD) is a life-threatening condition involving delamination of aortic media layers. Current clinical guidelines recommend prophylactic surgical replacement of the ascending aorta at an aneurysm diameter >5.5cm to mitigate the risk of TAAD. However, large retrospective series and data from the international registry of acute aortic dissection (IRAD) has shown that as high as 62% of patients with TAAD have aortic diameters distinctly less than 5.5 cm, indicating the need of improved evidence-based risk prediction metrics. Construction of such metrics will require the knowledge of aortic wall tissue failure mechanisms under physiologic biaxial loading conditions. Our objective is to quantify the aortic tissue structure-property relationship to understand the pathophysiology of the ascending thoracic aorta. We have developed a multiscale model of the ATA wall tissue that incorporates its microstructural details. The model comprises of lamellar units (LU), the repeating structure of the aorta, which are in turn composed of an interlaminar space of non-fibrous matrix and collagen fibers surrounded by elastic lamellae. The details of the collagen fiber organization were obtained using multiphoton microscopy, and was directly incorporated in the computational model using embedded-fiber finite element method.

We will demonstrate that the complex stress-stretch relationship of aortic tissue can be reproduced from simple bilinear constitutive response for collagen fibers and a one-parameter neoHookean material model for non-fibrous matrix. Our modeling reveals the structural mechanisms operative at the pre-failure and failure regime of the tissue mechanics. Such modeling approach provides insight into how changes in collagen microarchitecture (due to aortic pathology such as aneurysm or dissection) affect the macroscopic tissue failure properties, and thus compromise biomechanical function of the aorta. The work presented herein is an important first step towards understanding the failure mechanics of the aortic dissection under physiologic loading conditions. A biomechanically-based paradigm using patient-specific metrics will likely improve our ability to predict aortic dissection risk, and thus better appropriate elective aortic intervention relative to the current clinical guidelines that are based on maximal orthogonal aortic dimensions.

About the Speaker

Spandan Maiti obtained his PhD from Aerospace Engineering Department at the University of Illinois at Urbana Champaign (UIUC). After a post-doctoral fellowship at the Beckman Institute, UIUC, he joined the faculty of Mechanical Engineering-Engineering Mechanics Department at the Michigan Technological University. He is at the Department of Bioengineering at the University of Pittsburgh from 2010, and currently is an Assistant Professor. His research interest is lies in the failure biomechanics of soft tissues. He has authored a number of journal papers in this area, and his work is supported by NSF and NIH.