Technische Universität Braunschweig

MUSEN

Arterial tissue mechanics: Imaging and related modeling and simulation

Lecture of

Prof. Dr. Gerhard A. Holzapfel

Institut of Biomechanics
Graz University of Technology, Austria

9. November 2017, 16.45 Uhr

Okerhochhaus, Pockelsstraße 3,
Seminarraum EG

Imaging and related modeling and simulation are used to better understand the relationship between the hierarchical tissue structure, the tissue function, and the biomechanical response of the tissue, which is typically characterized by strain energy, stress and strain. The tissue structure alters with diseases such as an aneurysm, and the tissue function changes, e.g., due to aging. Imaging, patient-specific modeling and simulation may aid medical diagnosis, help to improve treatment plans for cardiovascular diseases and better identify the potential patient risk before treatment takes place. Most approaches to the modeling of cardiovascular tissues, however, are still in the development stage.

In this lecture we analyze the changes of collagen structures in images obtained from cardiovascular tissues in health and disease using high-resolution optical microscopy. Continuum mechanics is then used to describe the microstructure of collagen fibers, in particular the spatial variation of the fibers, and to derive constitutive equations based upon imaging and mechanical data. Related finite-element simulations are presented that highlight the need to incorporate the structural differences of tissues [1,2]. Finally, by following the recently developed phase-field approach we model fracture of aortic tissues by considering an energy-based anisotropic failure criterion which captures the evolution of the crack phase-field [3]. The solution is obtained by an operator-splitting algorithm composed of a mechanical predictor step and a crack evolution step; a history field governed by the failure criterion is successively updated. We demonstrate the crack phase-field model by simulating fracture tests performed on specimens obtained from a human thoracic aorta.