Michigan State University
Science at the Edge
Engineering Seminar

November 30, 2018
11:30 a.m., Room 1400 Biomedical and Physical Sciences Building
Refreshments served at 11:15 a.m.

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Effective Remodeling in the Walls of Human Cerebral Aneurysms

Abstract

Intracranial aneurysms (IA) are a pathology of cerebral blood vessels that manifest as an abnormal outpouching of the wall. While the incidence of rupture is low, spontaneous failure of the IA wall is responsible for approximately 80% of subarachnoid hemorrhagic strokes, a disease with high mortality and disability rates. Despite this dire situation, the identification of a tool to reliably assess IA rupture risk in the clinic remains elusive. Such a tool would enable patients with high risk aneurysms to be treated while avoiding unnecessary treatment in others.

While it is commonly accepted that abnormal blood flow within the aneurysm sac is an important factor in wall weakening, there remains a controversy over which aspects of the flow are critical in wall degradation. We conjecture that one of the reasons this controversy remains is the population of unruptured aneurysms are nearly always considered as a single cohort, although there is a great diversity even in the walls of unruptured IAs and in fact, at risk unruptured IAs are the target of risk assessment. In a prior work, we identified two sub-classes of unruptured aneurysms, one with low failure stress (0.63 MPa, 0.73 MPa) and a second group with failure stress from 1.2 MPa to 2.2 MPa. Therefore, rather than considering a binary scale of rupture/unruptured IAs, we introduce a continuum scale based on structural integrity metric that includes the factor of safety (FoS).

In this work, we address the fundamental question as to the physical mechanism by which high values of FoS are achieved in robust IAs and, our continuing efforts to understand the different physical mechanisms by which walls become vulnerable. Human cerebral aneurysm domes were harvested following surgical clipping in four medical centers drawn from the U.S. and Finland. Collagen fiber architecture and structure were analyzed using multiphoton microscopy (MPM) and electron microscopy. Mechanical testing through failure was performed with a custom uniaxial system. Histological assessment (classical and immunohistochemistry) was additionally used to understand variability between samples. High resolution micro-CT data from the harvested tissue in conjunction with patient specific 3D clinical imaging data were used to create 3D computational models of the aneurysm wall and surrounding vasculature for biomechanical (solid and fluid) analysis. We use newly developed tools to map human aneurysm tissue,

resected during surgical intervention back to the 3D reconstructed patient vasculature. This enables computational solid and fluid mechanics modeling to be used to assess the role of local intramural and hemodynamic stresses on IA wall biological and structural properties.

Bio

Anne M. Robertson is a William Kepler Whiteford Endowed Professorship of Mechanical Engineering and Materials Science and Professor of Bioengineering at the University of Pittsburgh. A central theme in her research is the relationship between soft tissue structure and mechanical function in health and disease for soft tissues such as cerebral arteries, cerebral aneurysms, tissue engineered blood vessels and the bladder wall. Dr. Robertson earned her PhD in Mechanical Engineering from the University of California Berkeley where she was also a President's Postdoctoral Fellow in the Department of Chemical Engineering. She directs a multi-institution program on cerebral aneurysms that is supported by the NIH. She is a standing member of the Neuroscience and Ophthalmic Imaging Technologies (NOIT) Study Section of the NIH. Dr. Robertson is founding Director of the Center for Faculty Excellence in the Swanson School of Engineering (SSoE) at Pitt, which takes the lead in developing and implementing programs to enhance the effectiveness of junior faculty in building outstanding academic careers.

For further information, please contact Prof. Alexandra Zevalkink, Department of Chemical Engineering and Materials Science at alexzev@egr.msu.edu.

Persons with disabilities have the right to request and receive reasonable accommodation. Please call the Department of Chemical Engineering and Materials Science at 355-5135 at least one day prior to the seminar; requests received after this date will be met when possible.