Post-doctoral position at the Center for Biomedical and Healthcare Engineering, ARMINES/Mines Saint-Etienne – Laboratoire Sainbiose (UMR INSERM-U1059)

MULTISCALE MODELING OF HUMAN AORTIC ANEURYSM RUPTURE MECHANISMS

Keywords: Aortic aneurysm, aneurysm rupture, multiscale modeling, large-strain homogenization, strength

Academic context: This post-doc position is part of the interdisciplinary AArteMIS - Aneurysmal Arterial Mechanics: Into the Structure - project (2015-2020) awarded to Pierre Badel (www.emse.fr/~badel) under the European Research Council Starting Grant scheme (http://erc.europa.eu/starting-grants). His group at Centre Ingénierie et Santé (a research center of Mines Saint-Etienne) focuses on carrying out fundamental investigations in the domain of arterial mechanics, especially aneurysm rupture in collaboration with vascular surgeons of Saint-Etienne University Hospital. The AArteMIS project also involves the 3S-R lab of Grenoble University for advanced analysis of the microstructure of complex entangled materials.

Scientific context: The rupture of an Aortic Aneurysm (AA), which is often lethal, is a biomechanical phenomenon that occurs when the wall stress state exceeds the local strength of the tissue. Current understanding of arterial rupture mechanisms is poor, as the physics taking place at the microscopic scale in collagenous structures remains an open area of research. Understanding, modelling, and quantifying the micro-mechanisms which drive the mechanical response of such tissue and locally trigger rupture represents the most challenging and promising pathway towards predictive diagnosis and personalized care of AA.

Project summary: During the first 2.5 years of the Aartemis project, our group collected experimental data on aneurysm mechanics, combining confocal microscopic stacks of images and bulge-inflation mechanical data from the elastic regime of the mechanical response up to rupture. Different tests are currently developed to understand the microstructural origin of the arterial rupture. In parallel, a multiscale mechanical model, based on an extension of the Eshelby problem to large strains, has been developed, which takes information of the microstructure (fiber type, orientation, and fraction, stratified organization…) as inputs and predicts the non-linear, elastic macroscopic mechanical response as output. Regarding model development, the next step consists in incorporating the recent and up-coming results on the rupture mechanisms. This will be achieved by defining strength criterion of the constituents at the microscopic scale according to the experimental observations and to the state of the art, and upscale the microscopic response in order to predict the macroscopic strength of the tissue. Through innovative theoretical developments, the successful applicant will propose the bases for the first physically-founded model of the strength of aneurysms. He/she will also be in charge of validating the proposed model.

Student profile: background in theoretical mechanics. The ideal applicant also has experience in non-linear constitutive relations, theoretical mechanics, and possibly large strain mechanics, and motivation for work at the interface between disciplines. Fluency in English is required and French, or willingness to learn French, will be appreciated.

Administrative aspects: The employer is Armines, linked by state-approved agreements to Mines Saint-Etienne, one of the most prestigious engineering schools in France. This project is funded for 18 months, starting around Summer 2018 (net salary, including social security ~ 2 400 €/month).

If you are interested, send a curriculum vitae, a cover letter describing previous research experience and interests, the names and contact information of two references. Please, submit via email with “ERC AArteMIS PD2” on the subject line to Pierre BADEL, Professor (badel@emse.fr) and Claire MORIN, PhD (claire.morin@emse.fr).