Modelling the Evolution of Vascular Disease: Cerebral Aneurysms

Cerebral aneurysms are disease of the brain vasculature. They appear as a sac-like out-pouching of a part of the arterial wall, inflated by the pressure of the blood that fills them. They are relatively common and affect up to 5% of the adult population. Most remain asymptomatic; however, there is a small but inherent risk of rupture. If rupture occurs there is a 30% to 50% chance of fatality. Consequently, if an aneurysm is detected, clinical intervention may be deemed appropriate. However, interventional procedures are not without risk to the patient. Given the relatively low risk of rupture it would be desirable to be able to identify those aneurysms most at risk of such an episode. This would assist clinical diagnostic procedures and avoid the potentially undesirable consequences of an unnecessary operation. It is envisaged that computational models of aneurysm evolution will ultimately be of help in achieving this aim.

Watton et al. [1] developed a mathematical model for the adaption of arterial tissue during the evolution of abdominal aortic aneurysm. This work introduced micro-structural growth and remodeling (G&R) variables into a realistic constitutive model of the arterial wall so that the evolving structure and composition of the tissue is simulated, i.e. elastin degradation and collagen G&R. This model has been adapted to consider ICA evolution, extended to explicitly link G&R to the local mechanical stimuli experienced by vascular cells and implemented into patient-specific cerebro-vascular geometries [2]. In this talk, the computational framework for modeling ICA evolution will be presented; model limitations and the direction for future research will be discussed.

[1] Watton PN, Hill NA, Heil M (2004). A mathematical model for the growth of the abdominal aortic aneurysm, *Biomechanics and Modeling in Mechanobiology,* 3: 98-113.
[2] Watton PN, Ventikos Y, Holzapfel GA (2010). Modelling Cerebral Aneurysm Evolution. Contributed book chapter in *Biomechanics and Mechanobiology of Aneurysms*.
(download from http://www.biomech.tugraz.at/publications#2011)

Dr Paul Watton

Institute of Biomedical Engineering
Department of Engineering Science
University of Oxford

Paul.Watton@eng.ox.ac.uk