DETERMINING PERMEABILITY AND DIFFUSIVITY PROPERTIES OF THE RAT AORTIC MEDIA

Andrew Comerford[1]*, Yean Chooi[2], Peter D. Weinberg[2] and Spencer J. Sherwin[1]

[1] Department of Aeronautics, Imperial College London, South Kensington Campus, SW7 2Az, London, UK, a.comerford@imperial.ac.uk

[2] Department of Bioengineering, Imperial College London, South Kensington Campus, SW7 2AZ, London, UK

Key Words: *Atherosclerosis, Permeability, Mass transfer, Spectral/hp element method*

Atherosclerosis is a patchy disease involving a complex build up of lipid, inflammatory cells and fibrous proteins in the intima and inner media of the arterial wall. The precise mechanisms involved in the disease are still disputed but include accumulation of lipid carrying molecules such as low density lipoprotein (LDL).

LDL may accumulate in the inner wall at sites of predilection not because it enters the wall more rapidly, but because, once it has entered the intima, it leaves more slowly across the media and into the adventitia. The media consists of cells, water, and structural molecules creating a tortuous path for transport that may result in accumulation in specific regions.

We are developing a coupled model of water and LDL transport within the arterial wall using the spectral/hp element framework Nektar++. The model incorporates both the local cellular structure and a realistic representation of the wall layers based on confocal images of the rat aortic bifurcation. These images are obtained by immersing excised aortic bifurcations in a solution of fluorescent protein tracer and imaging with a confocal microscope. Utilising a novel strategy we transform the microstructure from specific regions of interest confocal images directly to the computational mesh in which impermeable objects are treated fictitiously in the numerical scheme. On this mesh we solve Brinkman's equation for the water transport and the advection-diffusion equation for LDL transport to determine the full permeability and diffusivity tensor of different medial regions.

The numerical simulations of medial tissue highlighted that the heterogeneity of the medial structure is important for the transport properties of water and LDL. In particular, the calculated permeability and diffusivity tensors exhibited some anisotropy as well as regional variation between the inner and outer media. A major factor in this variation is the alignment and density of smooth muscle cells in the media, particularly adjacent to the adventitial layer.

The above models offer new insight into local wall transport properties and a potential route to an explanation for accumulation of LDL in the intima due to trapping of proteins in the media (Funded by European Commission Marie Curie Integration Fellowship and the British Heart Foundation).