KTH SOLID MECHANICS SEMINAR; Tuesday, March 18th, 13.15; KTH Solid Mechanics Seminar room

Nicholas Hill, “A Mathematical & Computational Model for the Propagation of the Pulmonary Pressure Pulse”

Dr. Nicholas Hill is Professor of Mathematics at the School of Mathematics & Statistics at the University of Glasgow, UK. He graduated from University of London and holds also a MSc in Theoretical Mechanics from the University of East Anglia. Dr. Hill worked as a postdoc at the University of Cambridge and the University of Colorado Boulder. Then he joined the Department of Applied Mathematics at the University of Leeds. Since 2001 he holds the Simson Chair of Mathematics at the University of Glasgow.

A novel multiscale mathematical and computational model of the pulmonary circulation is presented and used to analyse both arterial and venous pressure and flow. This work is a major advance over previous studies using structured trees to model vascular beds, e.g. Olufsen et al. (2012), which only considered the arterial circulation. For the first three generations of vessels within the pulmonary circulation, geometry is specified from patient-specific measurements obtained using magnetic resonance imaging (MRI). Blood flow and pressure in the larger arteries and veins are predicted using a nonlinear, cross-sectional-area-averaged system of equations for a Newtonian fluid in an elastic tube. Inflow into the main pulmonary artery is obtained from MRI measurements, while pressure entering the left atrium from the main pulmonary vein is kept constant at the normal mean value of 2 mmHg. Each terminal vessel in the network of `large' arteries is connected to its corresponding terminal vein via a network of vessels representing the vascular bed of smaller arteries and veins. We develop and implement an algorithm to calculate the admittance of each vascular bed, using bifurcating structured trees and recursion. The structured-tree models take into account the geometry and material properties of the `smaller' arteries and veins of radii > 50 microns. We study the effects on flow and pressure associated with three classes of pulmonary hypertension expressed via stiffening of larger and smaller vessels, and vascular rarefaction. The results of simulating these pathological conditions are in agreement with clinical observations, showing that the model has potential for assisting with diagnosis and treatment of circulatory diseases within the lung.

References

Olufsen, M.S., Hill, N.A., Vaughan, G.D.A., Sainsbury, C. & Johnson, M. (2012) Rarefaction and blood pressure in systemic and pulmonary arteries. J Fluid Mech 705:280-305.

Qureshi, M.U., Vaughan, G.D.A., Sainsbury, C., Johnson, M., Peskin, C.S., Olufsen, M.S. & Hill, N.A. (2014) Numerical simulation of blood flow and pressure drop in the pulmonary arterial and venous circulation, submitted to Biomechanics and Modeling in Mechanobiology.

.