Mathematical modelling of cardiovascular and respiratory flow

In this talk, models of two fluid mechanical phenomena arising in physiology are considered: 1. blood flow in the coronary arteries and 2. liquid plug propagation in the upper airways.

1. By far the most common arterial disease is atherosclerosis, and in the coronary arteries alone it is the cause of one third of all deaths in Western society. Atherosclerotic plaques tend to develop in regions of low mean wall shear stress (WSS) and regions where the WSS changes direction in the course of the cardiac cycle.

The flow of an incompressible Newtonian fluid in a tube of time–dependent curvature is considered as a model for blood flow in the coronary arteries. The flow is driven by an oscillatory pressure gradient which has the same dimensionless frequency, α, as the curvature variations. At large values of α the flow consists of an inviscid core surrounded by a thin viscous Stokes boundary layer. Secondary motions in the Stokes layer "drag" the fluid in the core of the tube, thus generating secondary flows there. Numerically obtained results for the core flow are presented which compare favourably with existing asymptotic solutions.

2. The surface tension arising at the interface of the liquid lining and the air within the lung strongly influences pulmonary mechanical behaviour. The lung regulates its surface tension by producing surfactant and premature neonates may suffer from Respiratory Distress Syndrome, caused by a deficiency in pulmonary surfactant. A standard treatment is to deliver exogenous surfactant via direct liquid plug instillation into the trachea. The propagation of a surfactant laden liquid plug along a liquid–lined airway is modelled and its dependence on physiological parameters such as surface tension, airway lining thickness and surfactant properties is determined.