Modelling Haemodynamics in Small Vessels

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Abstract: Computational haemodynamics has been studied extensively for large to mid-sized vessels to research diseases such as aneurysms and atheroma. Different rheological models have been used to describe blood non-Newtonian effects of shear-thinning, viscoelasticity and thixotropy in a macro-scale, continuum model. This modelling can provide accurate results in relatively large vessels but is inappropriate for micro-sized vessels or near-wall regions where the constituents (such as the red blood cells and platelets) of the blood need to be modelled individually. Studies of physiological haemodynamics in micro-sized vessels has largely been performed using experimental techniques due to the difficulties in numerical modelling, however recently Lagrangian particle methods have been used to model complex multi-component and multi-physics problems.

In this work the moving particle semi-implicit (MPS) method [1] is used to model red blood cells (and other biological capsules) with a spring network as a first approximation of their membrane [2, 3]. Comparison with experimental data is used to choose appropriate parameters of the spring coefficients. The MPS method is chosen as the implicit formulation allows for larger time steps and a relatively accurate (local) incompressibility to be imposed.

Different scenarios of haemodynamics in micro-sized conduits will be studied in order to highlight the modelling methodology and rich insight that can be obtained from computational studies. Work on healthy and diseased states of micro-vessel circulation will be presented.

References

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