

Numerical computation of cell motion in a branching flow

M. G. Blyth

University of East Anglia, Norwich.

Abstract

Motivated by a desire to model the transit of a red blood cell through a branch in a capillary network, we present a computational framework for examining the motion of an elastic fluid-filled capsule through a conduit with a side branch. Assuming a low Reynolds number, as is reasonable for capillary flow, the problem is modelled using the linear equations of Stokes flow. The mathematical formulation allows for an encapsulated fluid of generally different viscosity to that outside the capsule. This allows us to account for the viscosity contrast between the haemoglobin inside a blood cell and the surrounding plasma. The wall of the elastic capsule is treated as a thin elastic membrane capable of supporting elastic tensions and bending moments. The fluid flow and subsequent deformation of the elastic capsule is computed using the boundary element method. Both the problem formulation and the numerical method will be described in detail.

As a first step, our recent work has focused on the motion of a two-dimensional elastic capsule through a branching channel. Work on cell motion in straight channels has shown that, despite the two-dimensional approximation, deformed cell profiles nevertheless resemble those seen in experiments. Our results indicate that the path selection of a cell at a branch junction can depend crucially on cell deformability: cells with different elastic properties may follow different routes out of the junction in otherwise identical flow conditions. Work on the more realistic three-dimensional problem of a red blood cell moving through a branching tube, which is at an early stage, will also be discussed.