The Lattice Boltzmann Equation for Modelling Arterial Flows: Review and Application

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The lattice Boltzmann model (LBM) is a relatively new development in computational fluid dynamics. Here we review the technique with particular emphasis on its application to biological systems. Further, we consider its application to arterial flows and discuss its potential for simulating flow on length-scales where traditional numerical approaches can be troublesome. Finally we present results from a preliminary investigation which demonstrate the suitability of the LBM.

The study of blood flow has a number of important applications, especially when plaque deposits buildup on the blood vessel walls. In many cases *in vivo* experiments are extremely difficult and so numerical simulation and *in vitro* measurements become the main investigative tools. Traditionally numerical techniques such as the finite element method or the finite difference method have been applied to such problems. Here we consider the alternative approach of the LBM. The LBM has been widely applied in the field of fluid dynamics over recent years and has been found to be particularly well suited to flows with complex boundary conditions as well as multi-phase and suspended particle problems. It is therefore potentially a very useful tool for investigating physiological flows and since it is a maesoscopic model it may be especially useful for nano-scale problems where the application of traditional methods is not straightforward. Despite these advantages, and the increasing popularity of the LBM in other areas of fluid simulation, its application to blood flow problems is very limited.

Results are presented for oscillatory, zero-mean, channel flow which was selected to fully evaluate the LBM when applied to oscillatory flow and to act as a precursor to three-dimensional simulations in realistic geometries with typical flow patterns. The results are in excellent agreement with analytic solutions and clearly demonstrate the potential of the technique to full arterial flow simulations. Important parameters such as stress can be calculated from the simulation results. This is important since the buildup of plaque is thought to depend on the stresses and a large stress can be responsible for rupturing the plaque buildup which can have fatal consequences. Other aspects of the LBM which are required to build a realistic model, such as simulations in compliant tubes, are also considered.

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