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Finite element modelling of coronary artery hemodynamics

The coronary arteries are responsible for supplying blood to the heart muscle and are a common site of arterial disease, which leads in its end stages to heart attack. Development of arterial disease in these arteries appears to be strongly influenced by biomechanical factors, including blood flow (hemodynamic) features. To better understand the disease process we therefore desire to model flow patterns in the coronary arteries. The modelling challenges in these arteries include very large deformations of the artery over the cardiac cycle, complex 3D geometries, and significant flow unsteadiness. Here we review some of the techniques used to overcome these challenges. In brief, coronary artery geometries are determined based on post-mortem casts and movies of beating hearts (cineangiograms). Flow modelling uses the Arbitrary Lagrangian-Eulerian (ALE) approach; mesh updating is based on a spring analogy model modified to preserve element quality during complex 3D motions. Flow unsteadiness is based on intra-operative measurements of blood flow wave forms in the affected arteries. An overview of our results will be given, demonstrating the primary effects of arterial geometry (particularly complex, compound curvature), with smaller effects due to flow pulsation and arterial motion.