# A porous medium approach to coronary blood perfusion

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Because of the large number of microvessels per unit volume, the analysis of blood perfusion through a regular network analysis is tedious and time-consuming. This reserach aims at formulating and verifying a porous medium theory of blood perfusion. The theory transforms the discrete network of microvessels into a continuum by means of a formal averaging procedure. During this transformation, the distinction between arterioles, capillaries and venules is preserved thanks to the introduction of an arteriovenous parameter. The complexity of the resulting continuum formulation is independent of the density of the network considered and can be viewed as an extension of the classical theory of flow through saturated porous media. An 8-node isoparametric brick finite element is developed on the basis of this formulation. The model is experimentally verified for low Reynolds steady state Newtonian flow through an branching network of about 500 rigid vessels (fig.). Both experiment and simulation include the case of collateral flow following stenosis and occlusion of one of the main feeding vessels. Although the comparison of model and experiment is not conclusive as far as the validity of the theory is concerned the results do show that the model has predictive power in the case of low Reynolds steady state flow of a Newtonian fluid in a rigid vascular tree. The same finite element model is used to simulate the coronary circulation. The model includes non-linear elastic vessel walls and is able to simulate blood perfusion in an axisymmetric continuum. The intramyocardial pressures computed with the ventricular model of the companion paper is used as extravascular pressures in the perfusion model. The model simulates systolic-diastolic coronary flow differences during the normal cardiac cycle and predicts collateral flow following occlusion of one of the arterial input vessels.

Fig.: Flow distribution in experiment (left) and model (right). Occlusion of the left input vessel induces a reduction of perfusion of the left side of the plate.