A multiscale computational approach to the liver perfusion is proposed, which comprises different kinds of models relevant to a particular hierarchy of the blood circulation [3]. At the macroscopic scale, the liver receives blood from the two separated vascular system (trees), one belonging to the hepatic artery and other to the portal vein. These two vascular trees branch repeatedly, until they reach the microcirculation at the level of so-called hepatic units, typically considered as hexagonal lobules separated by thin vascular septum. The lobular structure can be approximated as a “locally” periodic array of honeycomb-like cells constituted by the sinusoidal porosity connecting the vertex and central veins which are the terminal branches of the two trees.

In the study we focus on the lobular level perfusion whereby flows in the vascular trees of the upper hierarchies are described by the multi-compartment Darcy flow model. We compare two homogenized models of the microcirculation relying on different assumptions. The first model is derived by the homogenization of the mesoscopic structure with the double-porosity medium represented by the Biot model with large contrasts in the permeability coefficients constituting the Darcy law. The resulting macroscopic model describes a two-compartment Darcy flow involving the pressure of the vertex and central vein systems. The newly developed so-called Biot-Darcy-Brinkman (BDB) model [1,2] arises from a two-stage homogenization of the fluid-structure interaction problem which requires geometric representations of the sinusoidal and the inter-lobular vasculatures. The BDB model involves two velocity fields and the pressure associated with the sinusoidal porosity. As the new ingredient, the effective medium coefficients depend on the macroscopic deformation, however, by virtue of the sensitivity-based expansion formulae [4] the local problems are not coupled to macroscopic problem. This leads to a weakly nonlinear problem which is solved using an efficient computational algorithm. Numerical examples are presented and computational issues are discussed.

REFERENCES