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Mathematical modeling of local perfusion in large distensible microvascular networks

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Abstract

Microvessels -blood vessels with diameter less than 200 μm- form large intricate networks, functionally organized into arterioles, capillaries and venules. In these networks, the distribution of flow and pressure drop stems in a complex manner from single vessel behavior and mutual vessel interactions. In this paper we propose a mathematical and computational model to study the behavior of large networks of compliant microvessels. The network geometry is simplified for computational purposes. The arteriolar and venular trees are represented by graphs of straight cylinders, each one corresponding to a vessel. The two trees are connected through a capillary bed. The blood flow and pressure drop across each vessel are related via a simplified fluid-structure interaction (FSI) model, represented by a generalized Ohm's law featuring a conductivity parameter. The conductivity is a function of the vessel cross section area (shape and area), which, in turn, undergoes deformations due to luminal and external pressure loads. The membrane theory is used for the description of the deformation of vessel lumina, adapted to consider thick–walled arterioles and thin–walled venules. An original point of the present work is represented by the inclusion of a buckling model in