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Fractional Visco-elasticity in One-Dimensional Models for Cardiovascular Flows

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One-dimensional models play a key role in multi-scale modeling of cardiovascular flows. Being able to accurately capture arterial wave propagation in large networks with low cost makes them appealing as a tool for stand-alone simulations or as physiological boundary conditions in coupled 3D-1D simulations. Here we study the effect of different arterial wall mechanics models on 1D and coupled 3D-1D blood flow simulations. We consider elastic, linear visco-elastic, and, for the first time, fractional-order visco-elastic models, integrated in a spectral-element 1D flow solver. Results are presented for 1D simulations in a patient specific network of 50 cranial arteries and for a 3D patient specific cerebral network with 10 outlets coupled to 1D fractal domains that mimic the structure of vessels in the meso-vascular range (radii 1mm – 50microns). Our conclusions quantify the effect of different wall models on the computed flow characteristics and the sensitivity on the input parameters.

Keywords: Blood Flow; 1D Models; Fractional Visco-elasticity; Geometrical Multi-scale Modeling