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Numerical modeling of compensation mechanisms for peripheral arterial stenoses

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Abstract

The goal of this paper is to develop a numerical model for physiological mechanisms that help to compensate reduced blood flow caused by a peripheral arterial stenosis. Thereby we restrict ourselves to the following compensation mechanisms: Metabolic regulation and arteriogenesis, i.e., growth of pre-existing collateral arteries. Our model is based on dimensionally reduced differential equations to simulate large time periods with low computational cost. As a test scenario, we consider a stenosis located in the right posterior tibial artery of a human. We study its impact on blood supply for different narrowing degrees by the help of numerical simulations. Moreover, the efficiency of the above compensation mechanisms is examined. Our results reveal that even a complete occlusion of this artery exhibiting a cross-section area of $0.442\,\mathrm{cm}^2$ can be compensated at rest, if metabolic regulation is combined with collateral arteries whose total cross-section area accounts for $8.14\,\%$ of the occluded artery.

Keywords: reduced model, peripheral stenosis, arteriogenesis, metabolic regulation

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