Simulation of the Pulmonary Circulation – Comparison of Different Modelling Approaches

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Abstract. Pulmonary hypertension is a severe disease and can even lead to heart failure. Therefore it is important that the knowledge about pressure and flow waveforms in the pulmonary circulation is improved, which is the aim of mathematical models. Over the last decades different kinds of mathematical models were applied to simulate blood pressures and flows in the pulmonary circulation. In this work we are looking at three different approaches of mathematical models used in different studies in the past and are trying to compare them. The first model, we will look at is the Windkessel model, which is often related to an electrical circuit. The Windkessel model is a good approach, if one is interested in the variation of the pressure only over time and not in terms of location. Secondly, the Womersley solutions based on linearised Navier Stokes equations are taken into account. Compared to the Windkessel model, they take spatial distribution of pressure and flow in the vessels as well as reflections into account. Furthermore, we are also considering the one-dimensional nonlinearised Navier-Stokes equations. In this approach, a structured tree is often used as boundary condition to model the small arterioles, capillaries and even venules. Via this structured trees characteristics of the pulmonary circulation especially in the regions of the small vessels can be investigated. Each of this approaches has its pros and cons in terms of applying it to the pulmonary circulation. So depending on the detailedness of modelling and simulating the pulmonary circulation, different types of models should be considered.

Keywords: pulmonary circulation, Windkessel model, Womersley solutions, Navier-Stokes equations, modelling and simulation