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Newtonian and non-Newtonian fluids in flexible straight vessels

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Diseases of the cardiovascular system, such as arteriosclerosis of the human arteries, represent one of the main causes of death in the western world [1]. To develop and establish new methods for a more precise diagnosis and patient-specific treatment routines, a detailed knowledge of the underlying phenomenon of the fluid-structure interaction (FSI) between the elastic blood vessels and the non-Newtonian blood flow is an essential prerequisite. Since this long-term goal of disease- and patient-specific vascular surgeries can be promoted by numerical simulation tools, benchmark experiments that analyze the interaction of vessel elasticity and unsteady wall-shear stress (WSS) distribution are essential to validate these simulations [2]. This means, the non-Newtonian behavior of the blood must be taken into account. According to van Wyk et al. [3], a Newtonian fluid can be used in large models of human arteries, if the range of shear rate is predominant at values where the blood viscosity can be assumed to be constant. However, in the vicinity of the wall, the transient WSS distribution is influenced by the the shear-rate dependent viscosity. Hence, the velocity field, the FSI, and the WSS must be determined with high temporal and spatial resolution. The scope of this experimental study is to compare the oscillatory flow of Newtonian and non-Newtonian blood analog fluids in straight elastic vessels, to determine the influence of the viscoelastic fluid properties on the vessel dilatation and WSS distribution using time resolved particle-image velocimetry. It is shown that the assumption of Newtonian fluids for larger arterial blood vessel models under transient flow conditions could lead to inaccurate results. Furthermore, a significant impact of the blood analog fluid on the amplitude of the WSS distribution was found.

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