ABSTRACT

Despite the phenomenal advancements in medical science and technology, hydrodynamics in physiological vessels remains to be poorly understood. A complete analytical treatment of the problem is extremely difficult, but the availability of sophisticated experimental systems and the support from the numerical simulations has pushed the limits of the current understanding of the subject. Coupled with microfluidics technology, *in-vitro* models for physiological vessels offer a good starting point to investigate the fundamental physics of the problem as well as to derive quantitative aspects for the design and development of many medical diagnostic devices.

Microfluidic channels fabricated using polydimethylsiloxane (PDMS) along with blood analogue fluids are potential candidates to study hydrodynamics in physiologically relevant deformable vessels. In the present work, starting with a simple rectangular microchannel with steady flow of a Newtonian fluid, realistic situation of blood flow in physiologically relevant biomimetic hydrogel microchannels has been systematically investigated. Detailed studies are carried out using pressure drop experiments, deformation analysis using image processing and flow visualization using micro-particle image velocimetry (micro-PIV) and micro-particle tracking velocimetry (micro-PTV). The prime focus of the thesis is to understand how the deformability of the wall affects the hydrodynamics of blood and its components flowing through a biomimetically engineered microchannel. Polydimethylsiloxane (PDMS) as well as gelatin are used as the base material for fabrication purposes. Newtonian fluid (DI water), non-Newtonian blood analog fluid (Xanthan gum solution) and the blood itself in the diluted form as working fluids are employed in the present study. Both steady and pulsatile flows are studied in detail. Relevant mathematical models are developed to estimate the deformation of the channel walls and the predictability of the model is demonstrated by comparing with the experimental results. The scope of the work extends from a biofluid dynamic study in deformable microchannel transporting complex fluids to design aspects of deformable microchannels for lab-on-a-chip applications.

Keywords: Microfluidics, Deformable microchannel, Lab-on-a-chip (LOC), Hydrogel, PDMS, Xanthan gum, Soft lithography, Non-Newtonian fluid, Blood, Red blood cells (RBCs), Blood rheology, Cellular deformation, Image processing.