Erythrocyte Deformability in a Hyperbolic Microchannel

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Abstract

Serious diseases such as diabetes and malaria are deeply related to microcirculation disorders caused by abnormal erythrocytes deformability [1]. Therefore, various studies on red blood cells (RBCs) deformation have been carried out but those studies rather focus on shear flow or extensional flow [2-6]. In this study, a relatively low aspect ratio (AR) hyperbolic microchannel was used in order to create an extensional flow combined with a shear flow, where AR=$\frac{h}{w}$, h means the depth and w means the width of the microchannel. The objective of the study is to investigate the degree of RBC deformation throughout the microchannel at the centerline ($y = 0$). The blood samples were RBCs diluted with the Hank's Balanced Salt Solution (HBSS) with the hematocrit (Hct) level set to be 2%. A polydimethylsiloxane (PDMS) microchannel, having a hyperbolic contraction region followed by an abrupt expansion shape, was fabricated by a soft-lithography technique. The dimensions of the microchannel: width of the inlet (w), length of contraction region (l), width of the exit of contraction (wc) and depth (h) were 400μm, 580μm, 20μm and

$14\mu m$, respectively. Hence, the AR was 0.035. The experimental equipment consisted of an inverted microscope (Diaphot 300, Nikon), a high-speed camera (FASTCAM SA3, Photron) connected to a computer and a $1mL$ syringe (TERUMO ® SYRING) controlled by a syringe pump (PHD ULTRA). The manufactured PDMS microchannel was placed on the stage of the microscope where the flow rate Q of the working fluids was kept constant at $0.5\mu L/min$. The flowing RBCs were recorded by a high speed camera at a frame rate of 7500 frames/s and analyzed. The DI was obtained by $DI=\frac{a-b}{a+b}$ where a refers to the major axis and b refers to the minor axis of the ellipse best fitted to RBCs. High DI values in the contraction region were observed. It is possible to say that the RBCs highly elongate with both extensional and shear dominated flows achieved by a hyperbolic microchannel with a relatively low aspect ratio AR.

Keywords: Erythrocytes, Red blood cell, Deformability, Deformation index, Extensional flow, Shear flow, Hyperbolic microchannel.

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