MOTION OF RED BLOOD CELLS AND CELL FREE LAYER DISTRIBUTION IN A STENOSED MICROCHANNEL

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Introduction

In microcirculation, the red blood cell (RBC) size comparing with the vessel diameter is not small enough, and the blood flow is strongly affected by individual RBCs behavior. Thus, it is important to understand the individual RBCs behavior when analyzing the blood flow in microcirculation. To observe inside the blood flow, we used a confocal-micro-PTV system[Lima et al 2006, 2007].

In our previous studies, we investigated the RBCs behavior in a straight channel with various Hct [Lima 2007]. In this study, we investigated RBCs behavior in a micro channel with stenosis and the cell free layer around the stenosis.

Methods

The confocal micro-PTV system used in this study consists of : inverted microscope (IX71; Olympus, Japan), confocal scanning system (CSU22;Yokogawa, Japan), high speed camera (Phantom v7.1;Vision Research, USA), DPSS laser (Laser Quantum, UK), syringe pump (KD Scientific, Holliston, USA), thermo plate (Tokai Hit, Japan),Objective Lens (Olympus, Japan (magnification: 20times, N.A.: 0.75, W.D.: 0.17mm)). We used a PDMS microchannel with rectangular cross section which has 50 μm width and 50 μm height. The stenosis has 30 μm width and 35 μm height.

We used 3 kinds of working fluids to compare: (a) pure water with 1% fluorescent particles (FluoSpheres carboxylte 1.0 μm orange, Sigma, UK), (b) labeled RBCs by a fluorescent dye (C-7000, Molecular Probes, USA) in DEX40 with 10% hematocrit Hct and (c) with 20 % Hct. By using our confocal system, we tracked fluorescent particles and labeled blood cells. The blood was taken from a 23 years old male and used a temperature of 37ºC to have a similar environment to the human body.

Results

From the result of fluid (a), the trajectories of tracer particles are symmetric before and after the stenosis which meets Stokes flow. From the result of fluid (b) and (c), however the trajectories are not symmetric. By comparing (b) with (c), the ΔY of (b) is larger than that of (c). The ΔY is given by :

$$\Delta Y = Y_{after} - Y_{before} \qquad (1)$$

where Y_{after} and Y_{before} is defined in Fig.1

Fig. 2 shows the correlation between Y_{before} and ΔY of 10% and 20% Hct. (fluids (b) and (c))

Discussion

The results show that the RBCs trajectories are asymmetric before and after the stenosis even under the Stokes flow and ΔY is larger with 10% Hct than with 20% Hct. One of the reason for this phenomenon is the RBCs can not have enough space to move freely that as the Hct increases.

Conclusion

In this study we investigated the RBCs behavior through the stenosis and the cell free layer. We observed that as the Hct increases the cell free layer after the stenosis tends to decrease, for Htcs bigger than 10%. In the future we are planning to quantify in more detail the RBCs radial displacement before and after stenosis according to Hct, stenosis geometry and so on.

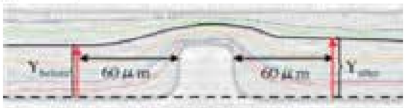

Fig. 1: Definition of Y_{after} and Y_{before}. The lines are trajectories of RBCs in 10% Hct by confocal-micro-PTV system.

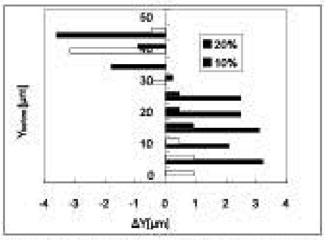

Fig. 2: Correlation between Y_{before} and ΔY.

References

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