flowing along microvessels. Theoretical models for single-file motion of RBCs have yielded predictions of apparent viscosity that agree well with experimental results in glass tubes with diameters up to about 8 μm. However, development of realistic models for multiple-file RBC motion in tubes with diameters in the range 10–100 μm, including effects of cell-to-cell and cell-to wall interactions, has been an elusive goal. In this diameter range, the width of cell-free or cell-depleted layers near the walls strongly influences the apparent viscosity, but the mechanics of radial migration of RBCs in narrow tubes are not well understood. Here, a theoretical method is used to simulate the motion and deformation of RBCs in microvessels. Each RBC is represented as a set of interconnected viscoelastic elements in two dimensions. The motion and deformation of the cell in a microvessel and the motion of the surrounding plasma is computed using a finite-element numerical method. In simulations of RBC motion in capillary-sized channels, initially circular cell shapes rapidly approach shapes typical of those seen experimentally in capillaries, convex in front and convex at the rear. An isolated RBC entering an 8-μm capillary close to the wall is predicted to migrate in the radial direction as it traverses the capillary, achieving a position near the center-line after traveling a distance of about 60 μm. Cell trajectories agree closely with those observed in microvessels of the rat mesentery. This method can be used to simulate the motion of multiple interacting RBCs. Supported by NIH grant HL034555.

6543 We, 08:45-09:00 (P29)

Confocal micro-PIV measurements of blood flow in microchannels

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The detail measurements of velocity profiles of blood flow in microchannels are fundamental for a better understanding on the biomechanics of the microcirculation. It is therefore very important to obtain measurements with high accuracy and spatial resolution of the influence of the blood cells on the plasma flow behaviour. This paper presents and compares measurements of in vitro blood with different hematocrits within a square microchannel obtained by a confocal particle image velocimetry (PIV) system. This emerging technology by combining the conventional PIV system with a spinning confocal microscope has the ability to obtain not only high spatial resolution images but also three-dimensional (3D) optical sectioning velocity measurements. Velocity measurements of plasma seeded with 1 μm diameter fluorescent particles were performed at different locations along the depth of 100 μm square microchannel at a constant flow rate (0.15 μl/min) and Reynolds number (Re) of 0.025. By using our confocal micro-PIV system, it was possible to obtain time-series of instantaneous velocity profiles with high spatial resolution of 28.24 18.83 μm at time intervals of 5 ms between two images. The ensemble-averaged velocity results of blood flow with different hematocrits (up to 25%) have shown velocity profiles very close to a parabolic shape. However, by analysing the temporal variance of the instantaneous velocity profiles of different hematocrits, we have observed a substantial increase of the instantaneous velocity fluctuations by increasing the hematocrit within the plasma flow. Besides, some possible effects from the measurements accuracy and flow rate instabilities from the syringe pump, this observation also suggests that there is a direct correlation between the level of hematocrit and the temporal instantaneous velocity fluctuations.

7227 We, 09:00-09:15 (P29)

Red blood cell dynamics, deformation and separation in microfluidic devices

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Recent developments in microfluidics allow a wide range of possibilities for studying cellular-scale hydrodynamics. Here we use microfluidic technology to address the signifcance of cells deformation and hydrodynamic interaction, either in microchannels mimicking capillaries or bigger channels mimicking an arteriole. In the first type of channels, we propose a new high-speed microfluidic approach for measuring dynamical pressure-drop variations along a microchannel at the scale of individual flowing cells. The technique allowed us to monitor and compare the motion of healthy and drug-modified cells but also to record the pressure-drop variations associated to single hemolysis events. In the second type of channels, we show that rapid variations of the geometry (constriction) coupled to the deformability of the cells can dramatically modify their spatial distribution in the channel. We propose a microfluidic application of this "focusing" effect for separation of the red blood cells from their suspending plasma.

6697 We, 09:15-09:30 (P29)

Observation of deformation of human red blood cell passing through a micro-channel array as a model of human blood capillary

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The present paper describes a new micro-channel array device capable of evaluating both behavior and dynamic characteristics of deformability of red blood cell (RBC), which has been developed by using a semiconductor fabrication technique. By using the fabricated micro channel having a 5 μm 5 μm square cross section of 100 μm in length to simulate capillaries, the temporal behavior and deformation of RBC was able to be observed more clearly than by using a conventional micro-channel. After the whole blood was centrifuged and erythrocytes were separated from plasma, erythrocytes were diluted with autologous plasma by a hematocrit of 10%. This suspension was made to flow through the micro channels and deformation of erythrocyte was observed over 3 days. The visualization result showed that three different kinds of deformation were observed, namely, asymmetrical shape, plane symmetrical shape and axisymmetrical shape. In the case of axisymmetrical deformation at a similar velocity in physiological flow, it was found that the RBC did not deform in the whole body but only locally in the backward sides of the cells. And it is found that although the front side of the erythrocyte bulged out at first, it became flatter as days passed by. The RBC was able to pass through the micro channel of about 3 μm both in height and width. The result of deformability measurement showed that the deformability of RBC had clearly decreased with day lapsed from blood drawing. This research was partially supported by Kansai University the Academic Frontier project of "Creation of the Realistic Model of Human Tissues/Organs using Nano / Sub-Micro Technology and their Development to Artificial Tissues/Organ".

4366 We, 09:30-09:45 (P29)

Dynamic deformation behavior of normal human red blood cells freely suspended in a sinusoidally oscillating quasi-Couette shear flow: Elastic stretching and viscoelastic recovering model

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For studying mechanical response of red blood cells (RBCs) inside the cardiovascular devices, dynamic deformation of RBCs under a fluctuating shear flow is of great interest. This study quantitatively evaluated RBCs' dynamic deformation and rheological behavior under a quasi-Couette flow with the peak shear stress from 50 to 270 Pa produced using a Cyclically Reversing Shear Flow Generator (CRSFG). The CRSFG consisted of a slider crank mechanism to produce a cyclical reciprocating motion of the upper plate of the parallel glass plates separated by 30 μm. The RBCs suspension (hematocrit; 0.5%, viscosity; 200 mPa-s, room temperature; 24.5°C) composed of the fresh human whole blood and 31 wt% Dextran phosphate buffered solution was injected in the space between the parallel glass plates. Under the reciprocating frequencies of 1, 2, 3, and 5 Hz, the time course images of RBCs' going through dynamic deformation were acquired using a high speed video camera with the shutter speed of 5000 fps. The displacement signal of the moving glass plate was also obtained using an eddy current type gap sensor with the sampling frequency of 20000 Hz. The maximum and minimum elongation levels of RBCs both linearly increased with the reversing frequency. During stretching phase, L/W (L, W: major and minor axis of the ellipsoidal RBC shape) increased linearly for a short while as a function of both time and shear stress. An interesting finding was that during the recovering phase, a time delay from the zero shear stress point to the minimum elongation level was observed for all the reversing frequency (about 8% of one cycle time). Even after the shear stress started to increase in the opposite direction, the L/W continued to decrease. The elastic stretching and viscoelastic recovering model can characterize the RBCs' deformation response under a quasi-Couette reversing shear flow.

4340 We, 11:00-11:30 (P32)

Flow of bioartificial capsules in microchannels

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Bioartificial capsules consisting of an internal liquid protected by a thin hyperelastic membrane are used in many applications (biomedical, cosmetic, pharmaceutical industries), where they are transported in small channels such as capillary vessels, cylindrical tubes or microfluidic channels. Such particles are quite fragile owing to the thinness of the membrane and it is important to verify that they will not break up unduly.

When flowing in a channel, a capsule may deform but the stress level in the membrane is difficult if not impossible to measure. We have thus designed a