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Local aggregation characteristics of microscale blood flows

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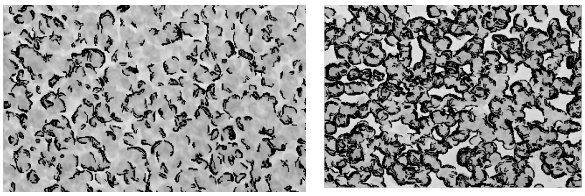
Erythrocyte aggregation (EA) is an important aspect of microvascular flows affecting the flow field and viscosity of blood. Microscale blood flows have been studied extensively in recent years using computational and microfluidic based approaches. However, the relationship between the local structural characteristics of blood and the velocity field has not been quantified. We report simultaneous measurements of the local velocity, aggregation and haematocrit distributions of human erythrocytes flowing in straight and bifurcating microchannels. Experiments were performed using human blood collected from healthy donors following an approved protocol. RBCs were separated, washed and suspended in PBS at a haematocrit of 25% whereas Dextran 2000 at 5mg/ml was added to induce RBC aggregation. The RBC suspensions were perfused through a straight (250 x 50 um) and a T-junction bifurcating PDMS microchannel (100 x 40 um) using a pressure -controlled regulator. The microchannels were placed on an inverted microscope and imaged using brightfield illumination. Acquired images were processed to obtain time-averaged velocity (using PIV algorithms and RBCs as tracers) and haematocrit distributions as described in Sherwood et al. (2012; 2014).

Local aggregation characteristics were firstly determined in the straight microchannel using statistical and edge-detection image processing techniques described in (Kaliviotis et al, 2015) while velocity profiles were obtained using PIV algorithms. Aggregation intensity was found to strongly correlate with velocity distributions. To investigate this further, the edge detection method was subsequently applied to the imaged RBC flows in the bifurcating microchannel and the size and distribution of aggregates through the flow domain were determined for various flow ratios between parent and daughter branch. The results demonstrate the combined effect of haematocrit and velocity distributions on local aggregation characteristics and the potential of various measures of aggregation in characterising the structural properties of blood.



(a) (b)

Figure 1. Edge detection applied to RBC microchannel flow images at a) high shear-b) low shear rates

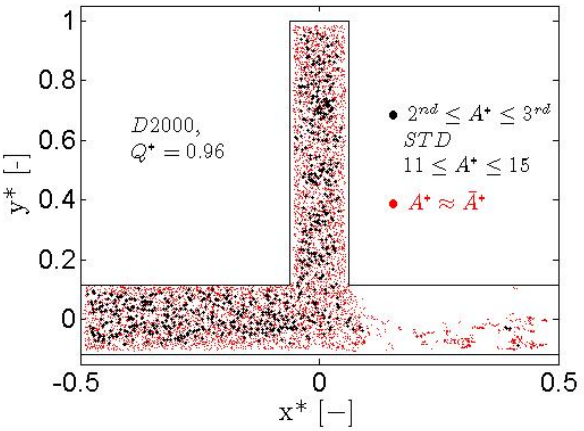


Figure 2. Distribution of aggregates with size A* between the 2nd and 3rd standard deviation for a flow ratios Q*= 0.96 in the left outlet branch of bifurcating microchannel. Aggregates of mean size (Ā*) are also shown for comparison. A*=1 corresponds to 1 RBC.

Kaliviotis et al., 2015. Quantifying local characteristics of velocity, aggregation and hematocrit of human erythrocytes in a microchannel flow. *Clinical Hemorheology and Microcirculation* DOI: 10.3233/CH-151980

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