Plenary Lecture (Medal ISB), Tuesday, July 3,

13:00 - 14:00 room MLH-A+B

L2 Microvascular hemodynamics: System Properties

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Rheological properties of newtonian fluids are fixed material properties and don't change with shear rate or shear stress. However, it is well known, that blood being a complex fluid exhibits a deviation from that behavior with increasing apparent viscosity at decreasing shear rate. This results from a change in the interaction between the different components of the blood, water and small solutes, macromolecules and blood cells. Such a pseudoplastic behavior can still be seen as a material property of the blood, which is not the case for phenomena reported for the perfusion of blood through narrow bore glass tubes, microvessels or microvascular networks. In these conditions, the observed hemodynamic behavior is dictated by the interacting properties of the blood and the structures it is flowing through – i.e. the systems properties.

These properties deviate from those obtained with a newtonian homogenous fluid perfused through the same structures in several aspects which result from the interactions between the flowing components and the external structure. The presence of a confined space with a (cross- sectional) dimension comparable to that of blood cells causes increasing influence of the tube or vessel wall with the cells for decreasing diameter. This leads to an accumulation of cells in the axial flow regions and to a decrease of viscous cell to cell interactions. The former is the basis of the Fahraeus-Effect, the reduction of hematocrit in small tubes or vessels (volume fraction) relative to the hematocrit of the blood perfused to them (flow fraction). The Fahraeus-Effect together with the latter leads to the surprising and strong reduction of effective viscosity during flow in small tubes or vessels, the Fahraeus-Lindquist-Effect. In microvessels the vessel wall is not a rigid surface but rather a gel with complex mechanical and biological properties, the so called endothelial surface layer or glycocalyx which further modifies the hemodynamic properties of the system. The next level of interactions is seen at microvascular bifurcations where red cells and blood plasma usually exhibit unequal distribution to the daughter vessels (phase separation effect). In microvascular networks the different properties of arterio-veneous flow pathways consisting of the increasingly smaller vessels of the arterial trees, the capillaries and venules with increasing diameter in the veneious vessel trees and the successive microvascular bifurcations lead to additional effects on hematocrit and flow (Network-Fahraeus-Effect and Pathway-Effect).