Cerebral blood flow – red blood cell distribution in capillary networks

Background: capillary perfusion in the brain is characterized by a continuous flow of red blood cells (RBCs) and plasma. The distribution of RBCs within cerebral microcirculation has a crucial role in brain metabolism and oxygenation. Spatial heterogeneity and rapid fluctuations of RBC velocities occur within the capillary network in different conditions (e.g. regional cerebral activation). Instantaneous changes of local RBCs concentration have a strong impact on the local flow resistance with effects on the flow and pressure fields in the whole network. A better understanding of the cerebral blood flow is therefore fundamental for understanding the dynamics of many physiological and pathological processes in the brain.

Aim: Our research aims at investigating the distribution of RBCs at the capillary level i.e. focusing on the separation of cells and plasma at consecutive microvascular bifurcations. Different approaches are being explored for modelling cerebral blood flow: i) *in vitro* modelling, using microfluidics ii) *in vivo* measurements of RBCs velocities at capillary bifurcations (in collaboration with the Institute of Pharmacology and Toxicology, University of Zurich) and iii) *in silico* modelling (in collaboration with the Institute of Fluid Dynamics, ETH Zurich).

Tasks

The split of computational and experimental tasks will be defined according to the profile of the candidate.

Experimental tasks:

-Development of a microfluidic system for the study of RBCs' flow behavior in a microcirculation-mimicking network.

- Analysis of RBCs' velocities at capillary bifurcation, assessed *in vivo* using Two-photon microscopy.

Computational tasks

-Modelling the distribution of RBCs in a capillary network

-Validation of experimental data (see above)

-Modelling physiological and pathological conditions (e.g. stroke, RBCs' malformations etc.)

Requirements

Basic knowledge of fluid mechanics.

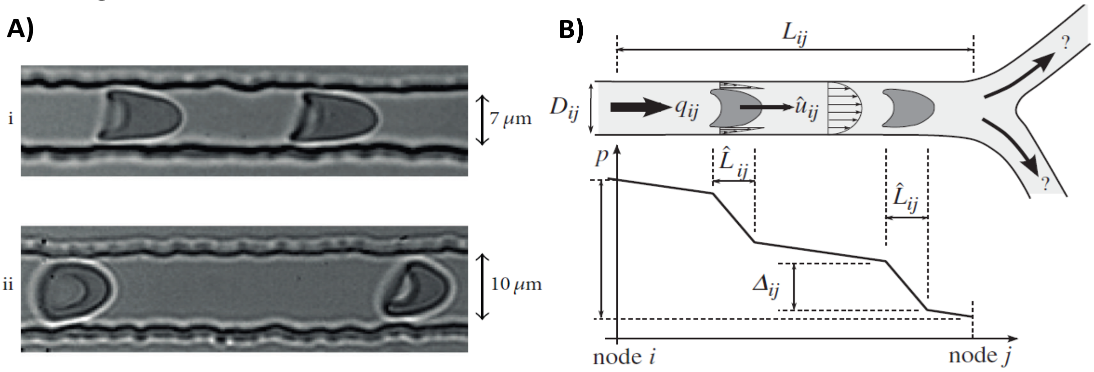

Figure: A) RBCs' deformation in microchannels [1] B) Pressure distribution in a capillary of diameter D_{ij} and length L_{ij} connecting the nodes i and j with a mass flow rate q_{ij} and two RBCs of length $\hat{L}ij$ with a velocity $\hat{u}ij$. Δ_{ij} is the additional pressure drop due to the RBCs [2].

Institutes involved in the project

-Cardiovascular Engineering, ARTORG Center, University of Bern, Bern (CH)

-Institute of Pharmacology and Toxicology, University of Zurich, Zurich (CH)

-Institute of Fluid Dynamics, ETH Zurich, Zurich (CH)

References

1. Cluitmans et al., Alterations in Red Blood Cell Deformability during Storage: A Microfluidic Approach. *Biomed Reseach International*, 2014:764268.
2. Obrist et al., Red blood cell distribution in simplified capillary networks. *Philos Trans A Math Phys Eng Sci.* 2010:2897-918.

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