An *in vitro* study of highly confined blood flows: From single bifurcations to 2D-networks

Adlan Merlo[1], Maxime Berg[1], Paul Duru[1] , Sylvie Lorthois[1]

[1]*Institut de Mécanique des Fluides de Toulouse (IMFT), Université de Toulouse, CNRS, INPT, UPS, Toulouse, France*
Corresponding author: adlan.merlo@imft.fr

Since the very first observations of microvascular networks in small animals by Jean-Marie Poiseuille in the XVIIIth century, the blood microcirculation has been extensively studied. One of the most striking feature highlighted by the French physicist is the highly heterogeneous distribution of the red blood cells (RBCs) throughout microvessel networks. Despite the intimate link between local RBC concentration (also called hematocrit) and surrounding tissue oxygenation, the coupling between microvascular architecture and hemodynamics is still poorly understood.

In vivo experiments provide data on spatio-temporal distribution of RBC concentration and velocities within a given microvascular network, but are limited to dilute regimes or highly confined flows, where the RBCs are arranged in single files and are therefore individually discernible [1]. Also, in such conditions, shape and diameters of the vessels cross-section is not precisely known. Along with physiological feedbacks, these uncertainties might be sources of errors. *In vitro* experiments can overcome such issues, inherent to the living [2]. Yet, providing reliable quantitative data at the scale of the blood microcirculation is challenging since the vessel diameters range from ~3 to ~10 µm, which is of the same order as the RBCs', or even smaller, and studies are often limited by the microfabrication process.

Our study aims at providing *in vitro* quantitative data on the distribution of the RBCs in geometries of increasing complexity: from diverging bifurcations to 2D-channel networks, with squared cross-section (WxW, W=5, 10, 20 µm). First, we have developed a calibration method that allows us to measure the hematocrit *in situ*, *i.e*. directly in the channel of interest, for a broad range of concentrations. Alongside with the hematocrit profiles, we are able to measure the RBC velocity profiles and thus deduce the RBC flow rate. By making simple assumptions on the suspending fluid, we deduce also the total blood flow rate. As a result, we have performed a parametric study of the phase separation (PS) effect, *i.e.* the non-proportional distribution of RBCs between the two daughter branches of a simple divergent bifurcation, and compared our results with the only *in vivo* empirically derived PS law [3]. Finally, we have designed 2D honeycomb networks and compared our experimental network perfusion with numerical simulations. For these networks, we show that the correlation between hematocrit and blood flow rate depends on the confinement of RBCs.

Acknowledgement: This work is supported by the ERC project BrainMicroFlow GA61510

References

[1] Desjardins et al., Neurobiol. Aging, **37**, 1947-1955 (2014)

[2] Roman et al., Biomicrofluidics, **10**, 034103 (2016)

[3] Pries et al., Microvascular Res., **38**, 81-101 (1989)