Flow of Red Blood Cells in Microchannel Networks: *in vitro* studies

Cidre, D.[1], Rodrigues, R.O.[1], Faustino, V.[1,2], Pinto, E.[1,2], Pinho, D.[2], Bento, D.[2], Fernandes, C. [1], Dias, R.[1,2], Lima, R.[1,2]

[1] ESTiG/IPB, Polytechnic Institute of Bragança, Bragança (Portugal)
[2] CEFT, Faculty of Engineering, University of Porto (Portugal)

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Introduction

Human blood is a multiphase biofluid primarily composed by the deformable red blood cells (RBCs) suspended in plasma, that exhibits unique flow characteristics on micro-scale level, due to their complex biochemical and their response to both shear and extensional flow, which influence the rheological properties and flow behaviour of blood [1,2].

The increasing interest by the microfluidic and biomedical communities has also played a key role in several recent developments of lab-on-chip devices for blood sampling, analysis and cell culturing, aimed in a near future, the development of blood diagnostic devices, as an alternative tool to the traditional diagnostic strategies.

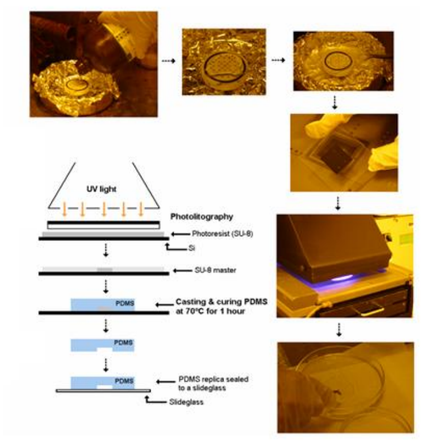
Blood flow in microvascular networks phenomena remains incompletely understood. Thus, it is important to investigate in detail the behaviour of RBCs flow occurring at a microchannel network, such as, with divergent and convergent bifurcations, which mimics the irregular vessel segments linked by numerous diverging and converging bifurcations.

Previously, we made *in vitro* studies in microchannels with a simple divergent and convergent bifurcation, that shown a pronounced cell-free layer (CFL) immediately downstream of the apex of the convergent bifurcation [1,4]. This interesting result led us to the present work, where by using a high-speed video microscopy system, we investigated the CFL in a microchannel network, in order to further understand the blood flow behaviour.

Materials and Methods

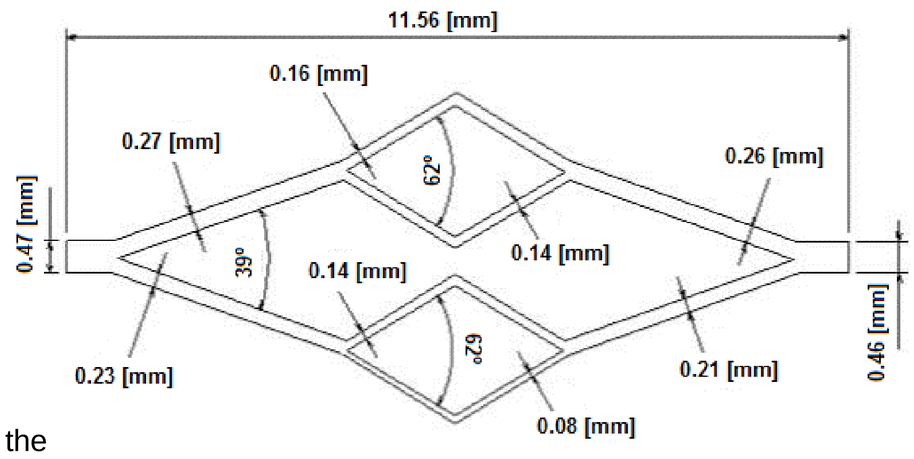
Experimental techniques

Microchannel fabrication

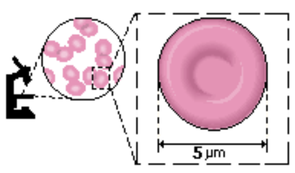


By using soft lithography the microchannels were made in polydimethylsiloxane (PDMS) due to their advantageous properties, including good optical transparency and biocompatibility, easily reversible sealing to glass, elasticity, replication of fine and complex geometries, and gas permeability which is suitable for culturing cells inside the microchannels.

Geometry and dimensions of the microchannel

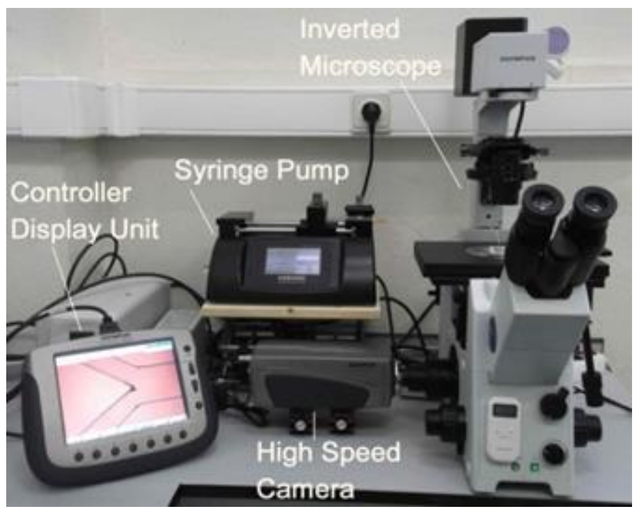


Experimental parameters



Ovine RBCs	≈ 5 µm
Flow rate	5 µl/min
Haematocrit level	10%
Capture frame rate	60 frames/s

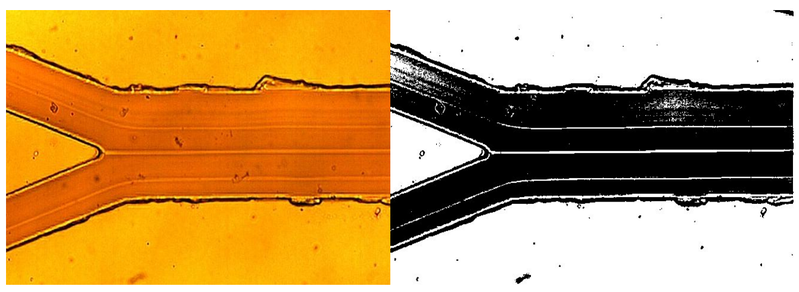
Experimental set-up



The high-speed video microscopy system consists of an inverted microscope (*IX71, Olympus*) combined with a high-speed camera (*i-SPEED LT, Olympus*), and a syringe pump (*PHD ULTRA*) with a 1 ml syringe (*TERUMO ® SYRING*).

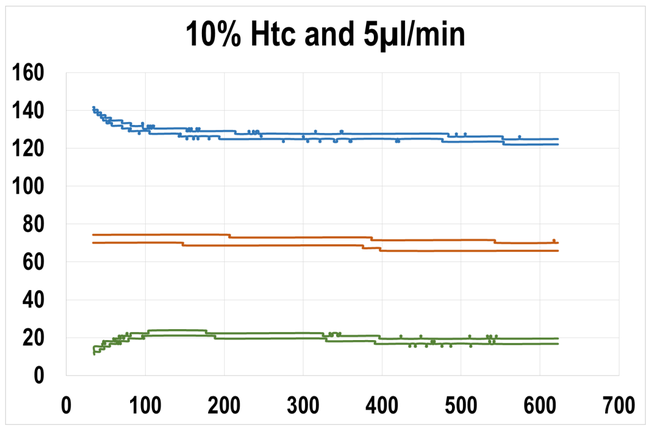
Results and Discussion

The recorded images were processed and analysed using an image processing program (Image J, 1.46r).



(a) (b)

A treatment of the image (a) was made to convert it into a binary image (b), showing the existence of a CFL around the apex of the three confluences and its propagation in a straight line in the region after it.



The graphical outcome of the treated images shows a higher CFL in the middle zone that was resulting from the final confluence, and two slightest CFLs resulting from the others upstream confluences.

Conclusion and Future work

At the last convergent bifurcation we report a total of three cell-free layers (CFLs) resulting from the complex microchannel network geometry, where the middle streamline formed around the apex is more pronounced than the ones formed upstream.

The early results appear to indicate that this variance in the CFLs derives from the differences in the confluences geometries that influence the RBCs velocities and trajectories profiles.

References

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