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COMPLEX BLOOD BEHAVIORS IN COMPUTATIONAL HEMODYNAMICS

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MINI-SYMPOSIUM PROPOSAL

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Computational Fluid Dynamics (CFD) is now a well-established technique to get insight about hemodynamics in the cardio-vascular system and blood-wetted medical devices. Significant progress has been made during the last decade and the number of published papers in the domain has drastically increased. This rapid progress has been made possible thanks to the experience gained since the 80's in other research fields like aerodynamics, where CFD is being used as a key ingredient of any design and/or research effort. However, blood flows involve very specific properties that are not always present in other research fields and which have received little attention so far. Notably they deal with a very particular fluid, blood, which has several specific features:

- its rheology is extremely complex, including shear-thinning, thixotropic and two-phase flow effects [1,2]. Still, the Newtonian assumption is used in most of the studies with the justification that the apparent viscosity reaches a plateau for high strain rates. A few studies account for the shear-thinning behaviour of blood by making for example use of a Carreau-Yasuda type of model. The latter is definitely well suited to represent some non-Newtonian blood analogue fluids often used in in vitro experiments. Its suitability to model real blood is however more than questionable and more complete rheological models accounting for more complex effects are necessary to increase the accuracy of blood flow computations,

- blood is a bio-fluid which may be damaged (hemolysis) if submitted to strong stresses, heat or foreign materials and whose structure may change depending on its recent history. Abnormal blood clotting, called thrombosis, may lead to the obstruction of blood vessels, device failure or embolic stroke. Hemolysis [3] and thrombosis [4] are two manifestations of the living nature of blood. Their mathematical/numerical modelling is the subject of more and more intense research, but predictive models useable in practical computations are still lacking. One major difficulty in developing/validating such models is the large variability from sample to sample on top of the complexity of the physical phenomena themselves,

- Hemolysis and thrombosis are both impacted by the time of residence of blood cells [5], or at least the time of application of stress conditions. In terms of fluid mechanics, the characteristic time scales and local stresses strongly depend on the flow regime (laminar, transitional, turbulent); appropriate turbulence modelling strategies [6] as well as boundary conditions should be used in order to properly feed hemolysis/thrombosis models, although this is not the case in most of the current studies [7]. Robustness of the numerical results can also be questioned when dealing with transitional flows.

The objective of this mini-symposium is to offer to the biomechanical community the opportunity to share experiences/ideas regarding the ways of introducing more complex blood models in macroscopic scale computations. Contributions are expected and encouraged in the following areas: models for hemolysis and thrombosis, advanced rheological description of actual blood, accurate numerical methods for transitional flows including direct or large eddy simulations, multiscale computations. In addition, examples and methods for experimental and clinical validation of these novel computational models are expected with the objective to support credibility and acceptance.

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