Erythrocyte-Erythrocyte aggregation dynamics as a bifurcation problem

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Red blood cells (RBCs) -erythrocytes- suspended in plasma tend to aggregate and form rouleaux. During aggregation the first stage consists in the formation of RBC doublets [1]. While aggregates are normally dissociated by moderate flow stresses, under some pathological conditions the aggregation becomes irreversible, which leads to high blood viscosity and vessel occlusion. Recently, D, Flormann et al [2] analyzed the doublet shape in the absence of applied flow in vitro and in silico. They observe that the contact surface of the doublet starts by flat then deformed (sigmoid) shape with the increase of adhesion energy. The passage from the flat to the deformed configuration correspond to a supercritical bifurcation.

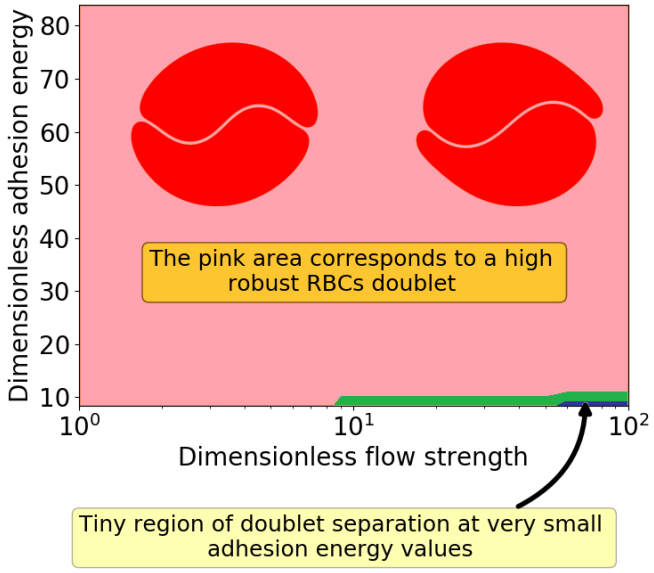

Figure 1. Phase diagrams showing a suppression of doublet separation in the parameter space of the dimensionless flow strength and the dimensionless adhesion energy. We clearly see shape adaptation as flow strength increases

We have analyzed [3], by means of the boundary integral method and the Helfrich model, the dynamics of RBCs doublets under shear flow and the impact on rheology. We present a rich phase diagram of RBCs doublets configurations. A close inspection at very low shear rate shows that the pitchfork bifurcation from flat to sigmoid in the absence of flow [2] becomes an imperfect bifurcation in the presence of flow. A remarkable feature found here is that when a single cell performs tumbling (by increasing cell internal viscosity) the doublet formed due to adhesion (even very weak) remains stable even under a very strong shear rate. It is seen in this regime that an increase of shear rate induces an adaptation of the doublet conformation allowing the aggregate to resist cell-cell detachment (Fig. 1). A link to pathological conditions (several common blood diseases) is highlighted.

Références

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