THE ROLE OF THE NON-LOCAL BENDING ENERGY IN THE RED BLOOD CELL RESPONSE TO MEMBRANE DEFORMATIONS

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Deformability of a circulating red blood cell (RBC) is determined by the internal viscosity of the cell, its surface to volume ratio and its membrane elastic properties. The latter are represented by the set of elastic moduli that measure the resistance of the cell membrane to deformation by surface expansion (dilation), shear, local bending and non-local bending, where the shear modulus is regulated both by skeletal and integral proteins and the expansivity modulus and the local and non-local bending moduli are mainly regulated by the lipid bilayer. We focus here on the membrane non-local bending energy contribution to the RBC deformability. The non-local bending energy is proportional to the square of the difference between ΔA and ΔA_o, where ΔA is the difference between the areas of the outer and inner neutral surfaces of the bilayer part of the RBC membrane, and ΔA_o is its equilibrium value. Analysis was based on deformation curves that were obtained by measuring the elongation of RBCs subjected to the shear flow in a transparent cone-plate rheoscope at various shear rates. Within a parametric model of non-axisymmetric ellipsoid we considered the elastic shear energy, the elastic local and non-local bending energies of the cell membrane and the work of viscous fluid. The contribution of the non-local bending energy was tested by chemically increasing the equilibrium area difference between the outer and inner neutral surfaces ΔA_o. For that purpose sodium salicilate was applied and decrease of RBC's deformability was observed. It is shown that in addition to its dependence on the shear energy of the skeleton, the deformation curve considerably depends also on the local and non-local bending energies of the lipid bilayer. Based on the analysis of the parametric model, the value of the non-local bending modulus of the RBC membrane was estimated.