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A Computational Model of Deformable Cell Rolling in Shear Flow
CHARLES EGGLETON, Dept. of Mechanical Engineering, UMBC, SAMEER JADHAV, KOSTANTINOS KONSTANTOPOULOS, Dept. of Chemical and Biomolecular Engineering, Johns Hopkins University — Selectin-mediated rolling of polymorphonuclear leukocytes (PMNs) on activated endothelium is critical to their recruitment to sites of inflammation. The cell rolling velocity is influenced by bond interactions on the molecular scale that oppose hydrodynamic forces at the mesoscale. Recent studies have shown that PMN rolling velocity on selectin-coated surfaces in shear flow is significantly slower compared to that of microspheres bearing a similar density of selectin ligands. To investigate whether cell deformability is responsible for these differences, we developed a 3-D computational model which simulates rolling of a deformable cell on a selectin-coated surface under shear flow with a stochastic description of receptor-ligand bond interaction. We observed that rolling velocity increases with increasing membrane stiffness and this effect is larger at high shear rates. The average bond lifetime, number of receptor-ligand bonds and the cell-substrate contact area decreased with increasing membrane stiffness. This study shows that cellular properties along with the kinetics of selectin-ligand interactions affect leukocyte rolling on selectin-coated surfaces.

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