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Hydrodynamic forces on a wall-bound leukocyte in small vessels due to red cells AMIR H. G. ISFAHANI, JONATHAN B. FREUND, University of Illinois at Urbana-Champaign — As part of the inflammation response, white blood cells (leukocytes) bind to the vessel wall before they transmigrate across the endothelium. The interactions between the wall-adhered leukocyte and flowing red blood cells (erythrocytes) play a critical role in this process. We provide a quantitative investigation of the forces exerted on a wall-bound leukocyte using a simulation tool that is based on a fast $O(N \log N)$ boundary integral formulation. This permits simulations of red cells that are both realistically flexible and can approach to very close separation distances. The elastic membranes deform substantially but strongly resist surface dilatation. The no-slip condition is enforced both on the leukocyte and the round vessel walls. Vessel diameters from 10 to 20 microns are studied. At these scales the cellular-particulate nature of blood significantly affects the magnitude of the forces that the leukocyte experiences. For a tube hematocrit (cell volume fraction) of 25% and a spherical protrusion with a diameter 0.75 times that of the tube, the average forces are increased by about 40% and the local forces by more than 100% relative to those expected for a blood model homogenized by its effective viscosity. For a constant pressure gradient, the wall-bound leukocyte causes a blockage in the vessel. Different contact angles for the leukocyte as well as different mechanical properties for the erythrocytes are examined.

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