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Coarse-grained theory to predict red blood cell migration in pressure-driven flow at zero Reynolds number QIN M. QI, Stanford University, VIVEK NARSIMHAN, Massachusetts Institute of Technology, ERIC S.G. SHAQFEH, Stanford University — The pressure-driven flow of blood in a rectangular channel is studied via the development of a modified Boltzmann collision theory. It is well known that the deformability of red blood cells(RBC) creates a hydrodynamic lift away from the channel walls and most importantly, forms a cell-free or Fahraeus-Lindqvist layer at the wall. A theory is presented to predict the uneven concentration distribution of RBCs in the cross-stream direction. We demonstrate that cell migration is mainly due to the balance between the hydrodynamic lift from the wall and cell-cell binary collisions. Each of these components is determined independently via boundary element simulations. The lift velocity shows a scaling with wall displacement law similar to that from previous vesicle experiments. The collisional displacements vary nonlinearly with cross-stream positions a key input to the theory. Unlike the case of simple shear flow, a nonlocal shear rate correction is necessary to overcome the problem of zero lift and collision at the centerline. Finally a diffusional term is added to account for higher order collisions. The results indicate a decrease in cell-free layer thickness with increasing RBC volume fraction that is in good agreement with simulation of blood in 10-20% range of hematocrit.

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