Patient-specific modeling and analysis of dynamic behavior of individual sickle red blood cells under hypoxic conditions

XUEJIN LI, Brown University, E. DU, Florida Atlantic University, ZHEN LI, YU-HIANG TANG, LU LU, Brown University, MING DAO, Massachusetts Institute of Technology, GEORGE KARNIADAKIS, Brown University — Sickle cell anemia is an inherited blood disorder exhibiting heterogeneous morphology and abnormal dynamics under hypoxic conditions. We developed a time-dependent cell model that is able to simulate the dynamic processes of repeated sickling and unsickling of red blood cells (RBCs) under physiological conditions. By using the kinetic cell model with parameters derived from patient-specific data, we present a mesoscopic computational study of the dynamic behavior of individual sickle RBCs flowing in a microfluidic channel with multiple microgates. We investigate how individual sickle RBCs behave differently from healthy ones in channel flow, and analyze the alteration of cellular behavior and response to single-cell capillary obstruction induced by cell rheologic rigidification and morphological change due to cell sickling under hypoxic conditions. We also simulate the flow dynamics of sickle RBCs treated with hydroxyurea (HU) and quantify the relative enhancement of hemodynamic performance of HU.

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