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PLATELET AGGREGATION MODELING USING DPD METHOD AND PROBABILISTIC BINDING

***Nenad Filipovic[1,2], Milos Kojic[1,2] and Akira Tsuda[2]**

[1] University of Kragujevac
Jovana Cvijica b.b. 34000 Kragujevac, Serbia
fica@kg.ac.yu

[2] Harvard University
677 Huntington Av., 02115, Boston, USA
mkojic@hsph.harvard.edu

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ABSTRACT

Atherosclerosis is the hardening and narrowing of the arteries and is a disease that may start in childhood and progress over many years without producing any clinical symptoms. Platelet activation and aggregation play a major role in the onset of thrombosis in atherosclerotic arteries [1].

The objective of this study is to apply the Dissipative Particle Dynamics (DPD) method, to simulate platelet-mediated thrombosis. In a simplified model, where the presence of RBCs is neglected, blood is discretized into mesoscale particles representing plasma and platelets. Each platelet is modeled by one DPD particle. Besides the interaction repulsive, viscous and random forces among DPD particles, the attractive forces among activated platelets and with the wall, are included [2],[3]. We also simulated the fibrinogen binding process to receptors of activated platelets with a probabilistic model [4].

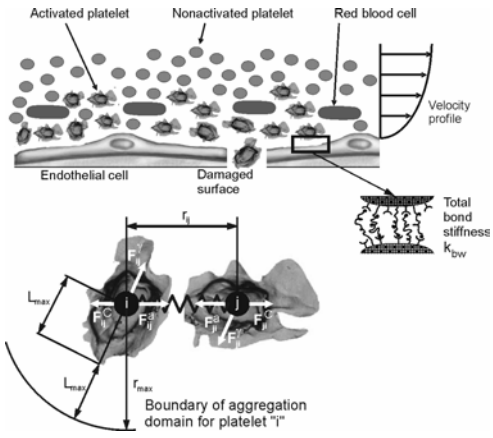

Fig. 1 Schematics of platelet aggregation and adhesion. Activated platelets in the vicinity of an injured wall epithelium and binding of platelets at the walls using springs. Interaction forces for two aggregated platelets [2],[3]. The domain of the interaction between platelets is denoted by r_{max}.

The basic equations of the DPD model of a fluid for a particle '*i*' can be written as

$$m_i \dot{\mathbf{v}}_i = \sum_j (\mathbf{f}_{ij}^C + \mathbf{f}_{ij}^D + \mathbf{f}_{ij}^R + \mathbf{f}_{ij}^a) + \mathbf{f}_i^{ext} \qquad (1)$$

where m_i is the particle mass; $\dot{\mathbf{v}}_i$ is particle acceleration as the time derivative of velocity; $\mathbf{f}_{ij}^C$, $\mathbf{f}_{ij}^D$, $\mathbf{f}_{ij}^R$ and $\mathbf{f}_{ij}^a$ are the conservative (repulsive), dissipative, random, and attractive interaction forces.

To test application of the DPD method and the assumption about the wall attractive force, platelet deposition in a perfusion chamber is modeled. The model corresponds to the experiment of Hubbell and McIntire (1986) [5].

The experimental results and the computed results for the adhered platelet distribution after 120[s] for the shear rate of 500[s^{-1}] is shown in Fig. 2.

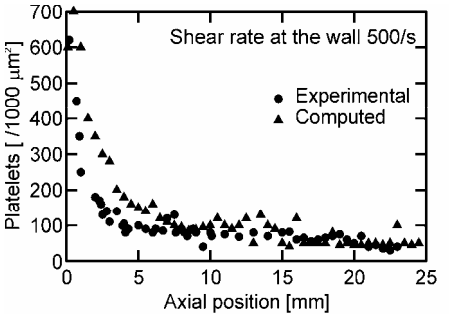

Fig. 2 Axial platelet deposition on collagen as predicted by computer solution using the DPD method [2],[3], and experimental results of Hubbell and McIntire (1986); after 120[s]; wall shear rate = 500[s^{-1}].

It can be seen from the above that the computed results match the results experimentally recorded by Hubbell and McIntire.

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