Mathematical Modeling of Thrombus Growth: Biochemical Network Reduction and Blood Slip Effects

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Abstract

Blood coagulation is an extremely complex biological process in which blood forms clots to prevent bleeding, following by their dissolution and the subsequent repair of the injured tissue. The process involves different interactions between the plasma, the vessel wall and platelets with a huge impact of the flowing blood on the thrombus growth regularization.

A mathematical model and some numerical results for thrombus development will be presented in this talk. The cascade of biochemical reactions interacting with the platelets, resulting in a fibrin-platelets clot production and the additional blood flow influence on thrombus development will be discussed.

Two main aspects will be considered. The first one is the mathematical model reduction in terms of biochemical reactions to simplify the model complexity, allowing to get results in agreement with experimental data. Therefore, the process will be initiated at the propagation phase, when the dominant part of thrombin and fibrin are produced. That requires an appropriate choice of the initial and boundary conditions to guarantee the prospective process development. A virtual equation to maintain the reliable prothrombinase production and additional platelets impact to the blood clot evolution is also included.

The second feature of the model is to include the slip velocity and the consequent supply of activated platelets, showing its importance on the whole blood coagulation process.

The model consists of a system of convection-reaction-diffusion equations, describing the cascade of biochemical reactions, coupled with a Newtonian or a non-Newtonian model for the blood. The main objective of this study is to build a blood coagulation model able to predict effects of specific perturbations in the hemostatic system that can't be obtained by laboratory tests, and assist in clinical diagnosis and therapies of blood coagulation diseases.

Keywords: Blood coagulation, mathematical modeling, numerical simulations, platelets, blood slip

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