Reaction-Diffusion Waves of Blood Coagulation In quiescent plasma and in flow

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Abstract

One of the main characteristics of blood coagulation is the speed of clot growth. In the current work we consider a mathematical model of the coagulation cascade and study existence, stability and speed of propagation of the reaction-diffusion waves of blood coagulation [1]. We also develop a simplified one-equation model that reflects the main features of the thrombin wave propagation. For this equation we estimate the wave speed analytically. The resulting formulas provide a good approximation for the speed of wave propagation in a more complex model as well as for the experimental data.

Vessel occlusion is a perturbation of blood flow inside a blood vessel because of the fibrin clot formation. As a result, blood circulation in the vessel can be slowed down or even stopped. This can provoke the risk of cardiovascular events. In order to explore this phenomenon, we used a previously developed mathematical model of blood clotting to describe the concentrations of blood factors with a reaction-diffusion system of equations [2]. The Navier-Stokes equations were used to model blood flow, and we treated the clot as a porous medium. We identify the conditions of partial or complete occlusion in a small vessel depending on various physical and physiological parameters. In particular, we were interested in the conditions on blood flow and diameter of the wounded area. The existence of a critical flow velocity separating the regimes of partial and complete occlusion was demonstrated through the mathematical investigation of a simplified model of thrombin wave propagation in Poiseuille flow.We observed different regimes of vessel occlusion depending on the model parameters both for the numerical simulations and in the theoretical study. Then, we compared the rate of clot growth in flow obtained in the simulations with experimental data. Both of them showed the existence of different regimes of clot growth depending on the velocity of blood flow.

Keywords: blood coagulation, reaction-diffusion equations, blood flow, vessel occlusion.

References

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