TEORETICAL ANALYSIS OF HYDRODYNAMIC ACTIVATION OF BLOOD COAGULATION IN STENOSED VESSELS

Rukhlenko A.S.[1], Dudchenko O.A.[1], Guria G.Th.[1, 2]

[1]Moscow Institute of Physics and Technology (State University), 141700, 9, Institutskii per., Dolgoprudny, Moscow Region, Russia, Phone 007-495-408-5700
[2]National Center for Hematology, 125167, 4a, Novy Zikovsskiy pr., Moscow, Russia, Phone 007-495-612-2123

Blood coagulation disorders constitute the most common cause of death in developed countries. Therefore analyzing the processes that lead to coagulation and describing the characteristic scenarios by which clotting occurs are of great importance. At present the threshold-like activation of blood coagulation has been thoroughly studied only for low-Reynolds number flows (Re<1). In particular it has been shown that blood flow impedes the activation of blood coagulation [1-2]. On the contrary, a sharp drop of blood flow velocity may result in blood coagulation activation and a consequent vessel blockage. So far, theoretical analysis of thrombi formation under intensive blood flow conditions (Re~100) has been limited to blood coagulation scenarios in straight vessels [3].

In this paper we present the theoretical investigation of the early stages of blood coagulation processes in a stenosed vessel (e.g. vessel with an atherosclerotic plaque). Activation of thrombi formation was initiated by procoagulants infiltrating from the tissue surrounding the stenosed vessel. The increase of vessel wall permeability to initial procoagulants in response to the elevation of wall shear stress was taken into account.

The analysis was carried out under intensive blood flow conditions (Re~100). Typical scenarios were singled out and separately discussed. The conditions resulting in a particular scenario were given. Special attention was given to two important scenarios: the formation of massive solid thrombi and the formation of floating filament-like structures.

The influence of flow topology on blood coagulation processes was analyzed.

The dependence of blood coagulation threshold upon the size of the atherosclerotic plaque was explored. The results indicate that under intensive blood flow conditions (Re~100) the most thrombogenous plaques are the medium-sized (resulting in less than 50% of lumen area reduction).

References

1. *Chulichkov A.L., Nikolaev A.V., Lobanov A.I., Guria G.T.* Threshold activation of blood coagulation and thrombus growth under flow condition // Mathematical modeling, Vol. 12, No. 3, 2000, Pp. 76–95.
2. *Guzevatykh A.P., Lobanov A.I., Guria G.Th.* Threshold intervascular blood coagulation as a resut of stenosis development // Mathematical modeling, Vol. 12, No 4, 2000, Pp. 39–60.
3. *Guria, G.T., Herrero M.A., Zlobina K.E.* Ultrasound detection of externally induced microthrombi cloud formation: a theoretical study // Journal of Engineering Mathematics, Vol. 66, No. 1-3, 2010, Pp. 293–310.