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Again About the Fåhraeus-Lindquist Effect

Katiukhin LN*

Sechenov Institute of Evolutionary Physiology and Biochemistry, Russian Academy of Sciences, (IEPhB RAS) 44 Thorez Avenue, Saint-Petersburg, 194223, Russian Federation.

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In 1929, Fåhraeus (1888-1968) have reported on a rheological effect in microwessels [1]. When blood was flowed from a large diameter tube into a capillary tube, the average hematocrit of the capillary blood was less than that of the blood in the larger tube. This phenomenon was called the the Fåhraeus-effect. The effect was interpreted as a feature of particulate flow, when the hematocrit in the capillary is a function of radial position of erythrocytes. An article was later published by Fåhraeus and Lindquist [2], which was demonstrated that if blood flows through glass capillary tubes of decreasing radius, a decrease in hematocrit was accompanied by a progressive decrease in apparent blood viscosity (the "Fåhraeus-Lindqvist effect"). (By the way the term "apparent" (or "effective") viscosity is widely used for the derived value of blood viscosity and reflects the viscosity of a Newtonian fluid that would yield the same flow under otherwise identical conditions, for clarity).

Some later works showed that mean velocity of the red blood cells in capillary tubes is higher than the mean bulk flow velocity [3,4]. The erythrocytes are moves away from the boundary toward the channel center, while the suspending plasma fluid is displaced to the cell free layer regions left by the migrating cells. It results in the formation of a cell-free layer next to the tube wall (skimming). Thus, in small tubes the plasma acts as a lubricant layer [5-9]. Subsequent studies have shown that apparent viscosity continues to decline at diameters that correspond to the arteriolar segments of the systemic vascular tree, where the majority of the total peripheral resistance resides and is actively regulated *in vivo*. The Fåhraeus-Lindqvist effect thus reduces microvascular resistance, thereby maintaining local tissue perfusion at a relatively lower blood pressure [10].

There are some works on the practice of theoretical modeling of the effects [11-13]. It is assumed that in the observed effects in microvessels aggregation properties of erytrocytes participate [5,14-17]. It is worth noting that shear rate in vessels of asuch diameters is much higher than the threshold for complete destruction of aggregates (50 C^{-1}) [18,19]. Given this circumstance, such participation is very hypothetical [20,21].

The effects considered are reduced to a parallel decrease in hematocrit and blood viscosity in microvessels. However, it is worth noting that the redistribution of erythrocytes in the bloodstream according to a widely admitted hypothesis does not change the ratio of the solid and liquid phases in the blood wessel. There is one paper, where has been shown that, contrary to a widely admitted hypothesis, the Fåhraeus-effect does not account for the Fåhraeus-Lindqvist effect [22]. The real reason for the change in hematocrit and plasma viscosity the blood flowing in small vessels, remains enigmatic. In our deep conviction, events in the microworld of the microwessels occur as follows. Given that the erythrocyte membrane is inextensible, the developing shear stress in small vessels causes a forced change in the shape of oxygen carriers with a decrease in their volume while maintaining the surface area. Due to these changes, under the influence of a pressure gradient the liquid phase moves from the red blood cell into the lumen of the capillary. The hematocrit and viscosity of the blood in the vessel are reduced accordingly. These transformations are reversible. When the red blood cell leaves the capillary, shear deformations decrease, the shape of the cell is restored and water with electrolytes returns inside the red blood cell [23].

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Corresponding author: Katiukhin LN, Sechenov Institute of Evolutionary Physiology and Biochemistry, Russian Academy of Sciences, (IEPhB RAS) 44 Thorez Avenue, Saint-Petersburg, 194223, Tel: 89112673192; E-mail: lion@iephb.ru

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