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Letter to the Editors-in-Chief

PRINCIPAL FACTORS DERANGING BLOOD RHEOLOGICAL PROPERTIES IN MICROVESSELS

George Mchedlishvili
Microcirculation Research Center, I.Beritashvili Institute of Physiology,
Gotua Street 14, Tbilisi 380060, Republic of Georgia

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Since the time immemorial the blood was considered as homogeneous fluid, and the general regularities of the fluid mechanics were applied for studying the circulation. The blood viscometry as well as various model experiments with artificial tubes were widely used for investigating the rheological properties of blood, with lack of appropriate analysis of the blood flow in living microvessels. This always seemed to me insufficient for a better understanding of blood rheological properties, and disturbances, in the microcirculation.

I started to investigate the physiological and pathological phenomena of the microcirculation in the late 1940s. The extensive studies ultimately led me to the conclusion that the principal factor determining the normal blood flow in microvessels is the specific structure of blood flow in their lumina (Microcirc. Endothelium Lymphatics 7: 3-49, 1991). The structure implies in this case the manner of arrangement of the blood cells in specific patterns of organization. The structure is determined primarily by the behaviour of erythrocytes, since their number is almost 10,000 times as great as of the leukocytes, while the thrombocytes are, in addition, much smaller in size.

Proceeding from the postulate about significance of the dynamic blood flow structure as the major factor maintaining the normal rheological properties of blood in microvessels, it became possible to specify the principal types of the derangements in the structure which lead to disturbances of the blood rheological properties under various pathological conditions (see the figure). Thus, three main factors were identified that might disturb the blood flow structure and the blood rheological properties in microvessels. They are: enhanced intravascular erythrocyte aggregation, increased blood plasma viscosity, and lowered red blood cell deformability in the narrowest microvessels.

(1) **The enhanced intravascular erythrocyte aggregation** is certainly the most significant factor deranging the normal blood rheological properties in the microvessels, since it is incompatible with all the characteristics

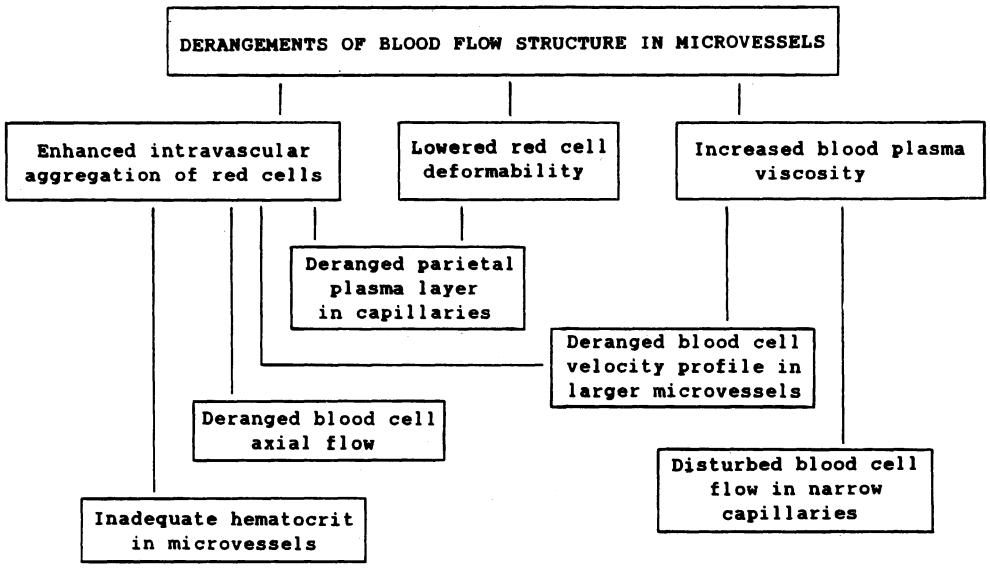

FIGURE
Basic factors disturbing the blood rheological properties in microvessels.

of the normal blood flow structure in their lumina: (a) Hematocrit would inevitably become inadequate in any microvessels as soon as the red cells stick to each other in the parent branches and this would inevitably derange the blood flow structure in respective microvessels. (b) The normal width of the axial blood cell core, being due to the dynamic forces that account for the shift of blood cells towards the vessel axes, would never be in evidence if the individual blood cells were aggregated. (c) The specific blood flow structure is incompatible also with intravascular erythrocyte aggregation in narrow capillaries where the cells are considerably deformed and squeeze in one file along their lumina. (d) It is self-evident that as soon as the individual red cells stick together forming aggregates in larger microvessels the normal velocity profile would be disturbed.

(2) **Derangement of the erythrocyte membrane deformability** disturbs the blood rheological properties only in the narrowest microvessels, e.g., in the cerebral capillaries, where the erythrocytes have to be stretched along the capillary axes. In case of lowering of the membrane deformability the parietal plasma layer becomes thinner, and this would especially disturb the blood fluidity if the blood plasma viscosity is heightened.

(3) **The enhanced viscosity of blood plasma** might disturb two characteristics of the blood flow structure in microvessels: the normal blood flow velocity profile in larger microvessels and the parietal plasma layer in narrow capillaries.

The knowledge of the basic factors responsible for disturbances of the blood flow structure in microvessels is essential for the correct choice of adequate techniques, which should be possibly direct and quantitative, for clinical investigations of the rheological properties of blood in patients.