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Surface Tension of Blood

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Summary
The surface tension of blood assessed in a group of 71 healthy subjects (24 men and 47 women) by the drop method at a temperature of 22 °C was $55.89 \cdot 10^{-3}$ N.m^{-1}, S.D. = $3.57 \cdot 10^{-3}$ N.m^{-1}. It did not correlate with age or sex of the examined subjects nor with any of the following variables: red cell sedimentation rate, blood haemoglobin levels, number of erythrocytes, total serum cholesterol, total serum triacylglycerols, creatinine blood levels, ALT and AST activity. The surface tension of blood and other body fluids can play an important part not only in the genesis and development of decompression sickness but also in other processes in the organism.

Key words
Surface tension of blood – Decompression sickness

Introduction

It seems that the impact of surface tension of body fluids on the course of various physiological processes is not fully appreciated yet. Its importance is mentioned most frequently in conjunction with the function of surfactant inside the alveolar sacs. This substance reduces the surface tension in the alveolar sacs and thus prevents their collapse and, moreover it is involved in the mechanics of respiration (Kimmel *et al.* 1995). It is known that the surface tension in the alveolar sacs is influenced by a number of factors, e.g. maturity of the pulmonary tissue, pathological processes in the lungs, inhalation of smoke etc. (Nieman *et al.* 1994, 1995, Subramaniam *et al.* 1995). It is remarkable that the function of gills also depends to a significant extent on the surface tension of the environment in which the aquatic animals live (Ribelles *et al.* 1995). Furthermore, it was reported that also the development and healing of gastric ulcers is influenced by the surface tension of the gastric mucosa and substances which form the gastric contents (Hills 1991). In a weightless state, the surface tension of blood plays a part in the formation of blood clots and affects the character of bleeding from the skin (McCuaig *et al.* 1992, Campbell *et al.* 1993). The surface tension of blood and other body fluids is very important in the development of decompression sickness of subjects under hyperbaric conditions (Gault *et al.* 1995, Hrnčíř 1993). The formation of gas bubbles which are the basic cause of this disease is greatly influenced by the surface tension of the environment (Hrnčíř 1996). Therefore, drugs which influence the surface tension of the blood, also alter the disposition for the development of decompression sickness (Hjelde *et al.* 1994).

In available textbooks of physiology or haematology the surface tension of the blood is usually not mentioned (nor that of other body fluids or tissues). We did not find any data in the literature whether the surface tension of the blood depends on age, sex, various biochemical and haematological indicators, on the health status etc. Nevertheless, this information could be useful when assessing the ability of a subject for work under hyperbaric conditions, in the treatment of decompression sickness or in the diagnosis of other diseases. This is why we decided to assess the surface tension of human blood and to find out to what extent it depends on some physiological and biochemical indicators.

Methods

In 71 healthy subjects examined within the framework of regular preventive examinations (24 men aged 18 to 62 years, 54.1±11.3 (SD) years, 47 women

aged 20 to 64 years, 42.7±11.3 (SD) years), the surface tension of the blood was assessed at a temperature of 22 °C by the drop method (Havránek 1967). Distilled water was used as a reference liquid with a known surface tension. In all the examined subjects, the following haematological and biochemical values were also assessed: red cell sedimentation rate (ESR), haemoglobin level (Hgb), number of erythrocytes (Ery), number of leucocytes (Leu), total serum proteins (TP), total serum cholesterol (Chol), triacyglycerol levels (Triac), creatinine (Creat) and the activity of alanine aminotransferase (ALT) and of aspartate aminotransferase (AST).

Student's t-test and methods of correlation analysis were used for statistical evaluation (Kubánková and Hendl 1986).

Results

The surface tension of the blood in the examined group (n=71) was $55.89\pm3.57 \cdot 10^{-3}$ (SD) $N.m^{-1}$, in men (n=24) $55.65\pm4.35 \cdot 10^{-3}$ (SD) $N.m^{-1}$ and in women (n=47) $56.02\pm3.09 \cdot 10^{-3}$ (SD) $N.m^{-1}$. The differences between men and women were not statistically significant.

Neither in men nor in women a correlation was found between the surface tension of the blood and age and the surface tension of blood did not correlate with any of the assessed haematological and biochemical variables (ESR, Hgb, Ery, Leu, TP, Chol, Triac, Creat, ALT, AST).

Discussion

The surface tension of patients' blood is not assessed in common medical practice as it is assumed to be of minor importance. In the literature, we were able to find only one paper which gives absolute values of the surface tension of blood (Hjelde *et al.* 1994). The reported value is somewhat higher than that found by us. It must be, however, mentioned that the authors assessed the surface tension of blood in a significantly smaller group of patients (n=29) than we did and that they did not report the temperature at which the estimations were made. (It is known that the surface tension of liquids depends on the temperature, e.g. the surface tension of water changes with a temperature change of 10 °C by cca 2.3 %.) It is obvious that blood has a substantially lower surface tension than water (the surface tension of distilled water at 22 °C is $72.45 \cdot 10^{-3}$ $N.m^{-1}$). This is probably due to the fact that blood contains substances with a detergent action. We were unable to find more exact data on the nature of these substances in the available literature and the role they could play. We are contemplating the importance of bile acids and their derivatives or possibly other substances (e.g. drugs) which are present in the blood stream in very small amounts and are not assessed as a rule. It is of interest that there are differences in the surface tension of blood between different animal species and that the administration of some drugs reduces the surface tension of blood by as much as 15 % (Hjelde *et al.* 1994).

Our data has not provided evidence that surface tension of the blood in humans correlates in any way with age and sex (or any basic haematological and biochemical values). From this ensues the conclusion that the somewhat greater tendency of women and elderly subjects to develop decompression sickness must be explained by the action of other factors (Hrnčíř 1993). Despite this, physical mechanisms are sureely involved. It has been confirmed experimentally that lower surface tension of the blood is a predisposing factor for the formation of gas bubbles during decompression and that this facilitates the development of decompression sickness (Hjelde *et al.* 1994, Hrnčíř 1993, Hrnčíř 1996). Because there are certain interindividual differences in surface tension values, its assessment could be a factor which should be considered when evaluating the ability of subjects to stay and work in a hyperbaric environment.

In our opinion, more important than knowledge of the absolute values of surface tension of the blood (and possibly other body fluids) are the findings concerning the causes of their changes and possible ways of influencing these changes. We therefore assume that it would be expedient to proceed with investigations of these problems further.

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Reprint Requests

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