MOBEMENT OF THE BLOOD AND CHANGES IN ITS ELECTRICAL CONDUCTIVITY

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Like other biological fluids, the blood of man and animals has a relatively high electrical conductivity by comparison with the remaining tissues of the body. For this reason the electrical conductivity of any area of the body and organ depends on the quantity of blood present in it. This relationship between the electrical conductivity of the tissues of the body and their blood content is at the basis of electrophlethysmography [3, 6 and others]. However, the electrical conductivity of the blood is not constant in physiological conditions, but depends on the rate of its movement; this introduces errors during investigation of the circulation of the blood by electrophlethysmographic methods.

Sigman, Kolin, Katz et al. [7] found that the electrical conductivity of circulating blood changes in relation to changes in the rate of the circulation: as the linear velocity of the blood flow rises from 0 to 40 cm/sec, the electrical conductivity of the blood increases by 5-10%. These workers suggested that this phenomenon was due to agglutination. Changes in the electrical conductivity of a column of blood in the aorta of a rabbit when the blood flow was suddenly arrested were observed by Weeks and Alexander [8]. A. A. Kedrov and A. I. Naumenko [1], from studies of the pulse variations in the cranial cavity by the method of electrophlethysmography, point out that the resistance of the blood is a function of its movement.

In this connection there is undoubted interest in the study of the relationship of changes in the electrical conductivity of the blood and its movement and the frequency of the alternating current used to measure it.

EXPERIMENTAL METHOD

Measurement of the electrical conductivity of the blood while moving was carried out by means of a special apparatus [3] producing alternating current of various frequencies between a range of 20 cps to 500 kcps. The blood to be tested passed at a determined velocity through glass tubes 8 mm in diameter and 600 mm long. In the lower part of the tubes were fused platinum electrodes in such a way that a line joining the centers of the electrodes formed a definite angle with the direction of movement of the blood. This arrangement of the electrodes enabled the relationship between the direction of an externally applied electric field and the change in electrical conductivity of the blood during movement to be investigated. In the experiment we used three types of tubes, in which the angle between the tube axis and the line joining the centers of the electrodes was 90°, 45° and 0°. Experiments were carried out on citrated and defibrinated blood from human subjects, dogs and cats. In the majority of cases an alternating current of frequency 300 kcps was used in the investigations.

To enable the results of the different experiments to be compared and analyzed, we used the relative change in the electrical conductivity of the blood, equal to the quotient obtained by dividing the change in electrical conductivity of the blood by the electrical conductivity of the blood at rest. Both measurements were taken in the same units (mhos). In this way we could make allowance for errors in individual experiments, since the effect of any factor applied equally to both the initial value of the conductivity and to the change in this value.

In all the experiments the relative conductivity of the blood was within limits of 0.005 to 0.008 mho, and its changes with movement amounted to 2 to 5% of the initial value.
EXPERIMENTAL RESULTS

The experiments showed that both citrated and defibrinated blood change their electrical conductivity on movement (Fig. 1), and citrated blood rather less so than defibrinated. The electrical conductivity is most sharply altered when the velocity of movement of the blood increases from 0 to 15 cm/sec. Increase in the velocity of movement of the blood above 20 cm/sec causes no appreciable change in the resistance.

Keeping the velocity of movement of the blood constant (12 m/sec), we altered the frequency of the current. During the change in frequency from 20 cps to 500 kcps, the curve of the resistance of the blood fell by 30-35%. The resistance of the blood was altered most when a constant current was passed through it (Fig. 2).

To ascertain the causes of the decrease in the resistance of the blood, 30 experiments were carried out with ionized colloidal solutions and blood components, and also with hemolysed blood. These experiments showed that a change in the resistance is observed only in the blood or component of the blood in which the red cells are present as integral structural elements. Neither blood plasma nor hemolysed blood changes its resistance on movement. In experiments with suspensions of red cells it was shown that their resistance decreases on movement according to the same law as that obeyed by whole blood, but in contrast to whole blood, the change in the resistance of the suspensions is rather smaller. The magnitude of the change in the resistance of a suspension of red cells depends on their concentration (Fig. 3).

It was found that the relative change in the electrical conductivity depends on changes in the surface of the red cells. From a comparison of the findings obtained in the experiment with whole blood and with the suspension of red cells, it may be seen that the latter changes its resistance less on movement.

It follows from the experiments with hemolysed blood that disturbance of the structure of the red cell deprives the blood of this property.

It may be concluded from the results obtained that the relative electrical conductivity of the blood is greatly influenced by its chemical composition as a system; exclusion of one factor from it results in a change in the entire system. This is confirmed by a comparison of the results obtained in experiments with citrated and defibrinated blood. In trying to understand this relationship it is important to realize that the blood plasma, although it does not change its electrical conductivity on movement, nevertheless has a considerable effect on the change of electrical conductivity of the whole system.