Changes of the Specific Conductivity of Erythrocyte Ghosts and Hemoglobin in Alcoholism

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One of the peculiarities of the surface membrane is its ability to bear a negative electrical charge responsible for such processes as contact interaction, adhesion, aggregation, formation of structures in the moving blood, and ionic permeabilities [2,8]. This charge changes throughout the course of vital activity of the cell (different degrees of its differentiation, decline of viability, and adsorption of a number of substances on the cell surface) [4,5] and reflects the biological state of the cell. Few data are available on the changes of erythrocyte electrical properties in alcoholism [11,13]. Yet such data are very valuable since they can provide information about the state of other cell membranes, including those of brain cells [12].

The aim of the present study was to investigate the specific conductivity (σ) of erythrocyte ghosts (EG) and hemoglobin (Hb) in patients with alcohol abuse for different times of withdrawal and to compare these parameters with the viscosity of suspensions of erythrocytes and their ghosts and with other blood indexes.

MATERIALS AND METHODS

Thirty-six alcoholic patients (mean age 37.4±1.44 years) under treatment in the narcologic department (alcoholic psychoses - delirium and hallucinosis - being observed in 5 patients, and signs of damage to the liver and pancreas in 5 patients) were examined over a period of time: the first examination was performed during the 1st week of withdrawal against the background of marked intoxication, and the second and the third examinations in the 2nd and 4th weeks against the background of detoxication therapy and administration of psychotropics (in the cases with psychoses). The alcohol abuse had a history of 13.9±1.3 years on average, for both the patients with and without alcoholic psychoses. However, within the entire group the patients exhibited differences with respect to the degree of genetic burden for alcoholism and

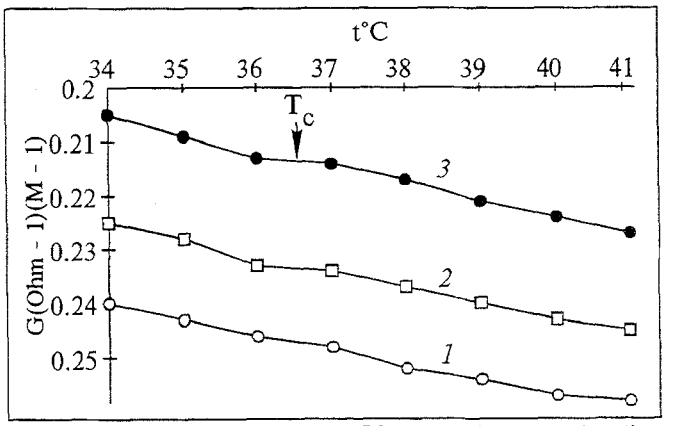

Fig. 1. Specific conductivity of EG suspensions as a function of temperature in alcoholic patients at different times of withdrawal. Here and in Fig. 2: *1*) 1st week of withdrawal; *2*) 2nd–3rd week of withdrawal; *3*) 3rd–4th week of withdrawal. Differences are reliable throughout the entire temperature interval. Tc is the phase transition.

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TABLE 1. Specific Conductivity of EG (in 1/Ohm×m) in Donors and Patients with Chronic Alcoholism ($X \pm m$)

Group	t°C								$(\sigma_2-\sigma_1)/\sigma_2$, %
	34	35	36	37	38	39	40	41	
Control	0.1920± ±0.0013	0.1962± ±0.0013	0.1996± ±0.0014	0.2016± ±0.0015	0.2056± ±0.0015	0.2090± ±0.0016	0.2128± ±0.0016	0.2165± ±0.0016	11.780±0.140
Alcoholic patients	0.2307± ±0.0016	0.2345± ±0.0017	0.2374± ±0.0016	0.2401± ±0.0017	0.2430± ±0.0017	0.2459± ±0.0017	0.2486± ±0.0017	0.2509± ±0.0016	7.890±0.210

Note. $(\sigma_2-\sigma_1)/\sigma_2 \times 100\%$ is the specific conductivity of EG (%). Over the entire interval of temperatures the reliability of differences between groups is $p<0.001$.

the type of alcohol-induced behavior. In studies of the specific conductivity of erythrocytes the group for comparison comprised donors (28 men, mean age 34.6±2.1 years) without alcohol abuse. The electrical properties of erythrocytes were assessed from the absolute values of the specific conductivity (σ) of EG and Hb at t=34°C, as well as from the changes of these indexes as a function of the temperature (T°C). The σ(T) dependence was plotted on the basis of measurements. The measurement technique was described by us previously [7]. The relative indexes: $(\sigma_2-\sigma_1)/\sigma_2 \times 100\%$, where σ_1 is the specific conductivity at t=34°C and σ_2 is the specific conductivity at t=41°C, and the temperature coefficient $\Delta\sigma/\Delta T$, were assessed. The viscosity of suspensions of erythrocytes and their ghosts was automatically measured using the method of capillary viscosimetry [3]. The relative indexes of viscosity were assessed by using similar formulas. The indexes of the whole blood: erythrocyte count, hematocrit, total Hb, mean corpuscular volume (MCV), and mean content and concentration of Hb in erythrocytes, were measured, and the color index was calculated by the standard formulas. The results were statistically processed on an IBM/PC/AT 286/287 with the aid of STATGRAPHICS software (version 3.0).

RESULTS

The erythrocyte count and total Hb proved to be low only in the patients with psychoses ($p<0.05$). A trend toward a decrease of the mean Hb content in erythrocytes was revealed (by 5.9%). The hematocrit was 7.5% higher than in the control. The MCV was also reliably higher (109.5±0.53 as against 92.8±0.62 μ^3 in the control).

Throughout the entire interval of temperatures (34-41°C) the specific conductivity of EG suspensions and Hb solutions was reliably higher in alcoholic patients than in the control (Tables 1 and 2). An increase in their specific conductivity reflects a decrease in the hydrophilic properties of the membranes and Hb, which goes along with a drop of the ξ-potential and electrophoretic mobility, this leading to a reduction of erythrocyte coagulability.

The hydrophilic properties of the erythrocyte membrane in alcoholics are evidently reduced due to a decrease in the density of the surface charge, because the MCV increases by 17-18% for this pathology. Since the density of the surface charge is 60% determined by the membrane content of sialic and neuraminic acids (bound to membrane glycoproteins and glycolipids), redistribution of the latter occurs over the cell surface due to an increase of the erythrocyte surface. However, it cannot be ruled out that reduced hydrophilic properties of erythrocyte membranes are associated with a decreased absolute content of sialic and neuraminic acids in them [9,10].

Membrane proteins also make a certain contribution, since the hydrophilia of Hb as a representative of proteins is lowered. In this case the reduced hydrophilia is associated either with the content of aminodicarbonic acids or with conformational changes. The absence of T transformation in Hb during the acute phase and over the course of treatment attests to a change in the protein conformation.

Calculation of the relative values $(\sigma_2-\sigma_1)/\sigma_2 \times 100\%$ showed their reduction in patients with chronic alcoholism, which reflects a decrease of the temperature coefficient of specific conductivity ($\Delta\sigma/\Delta T$).

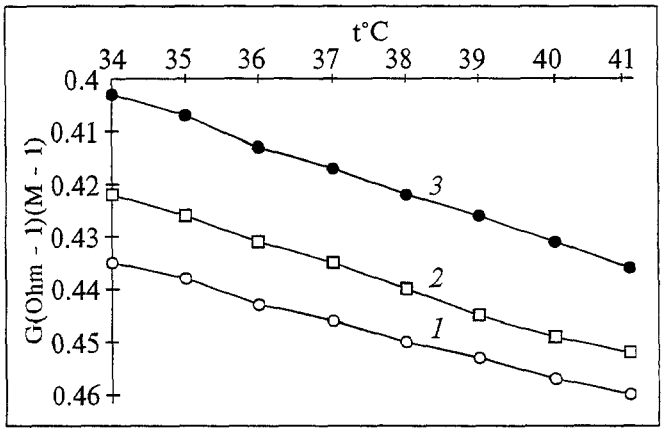

Fig. 2. Specific conductivity of Hb solutions as a function of temperature in alcoholic patients at different times of withdrawal.

TABLE 2. Specific Conductivity of Hb (in 1/Ohm×m) in Donors and Patients with Chronic Alcoholism ($X \pm m$)

Group	t°C								$(\sigma_2-\sigma_1)/\sigma_2$, %
	34	35	36	37	38	39	40	41	
Control	0.3944± ±0.0014	0.3997± ±0.0015	0.4048± ±0.0016	0.4081± ±0.0016	0.4132± ±0.0018	0.4180± ±0.0019	0.4229± ±0.0019	0.4273± ±0.0020	8.216±0.177
Alcoholic patients	0.4265± ±0.0014	0.4309± ±0.0015	0.4349± ±0.0014	0.4393± ±0.0015	0.4438± ±0.0014	0.4478± ±0.0014	0.4517± ±0.0013	0.4550± ±0.0013	6.345±0.168

Note. $(\sigma_2-\sigma_1)/\sigma_2 \times 100\%$ is the specific conductivity of Hb (%). Over the entire interval of temperatures the reliability of differences between groups is $p<0.001$.

Studies of the specific conductivity of EG suspensions and Hb solutions revealed the dynamics of these values over the course of treatment.

At early stages of withdrawal (Fig. 1, *1*) the specific conductivity was 20% higher than that by the end of treatment (Fig. 1, *3*) and 12% higher than that after 2 weeks of treatment (Fig. 1, *2*). It was characteristic for the temperature coefficient ($\Delta\sigma/\Delta T$) to increase somewhat (Fig. 1, *2*).

Of great interest in the case of EG is the dynamics of intensity of the anomalous σ zone near 37°C. At early stages of withdrawal the σ(T) dependence has a monotonous character or else two weak anomalous zones are observed at temperatures of 36 and 38°C (Fig. 1, *1*). After 2 weeks of withdrawal the σ(T) dependence changes its character; just one anomalous zone appears at 37°C, the intensity of which increases along with the prolongation of withdrawal (Fig. 1, *2* and *3*).

The presence of an anomalous zone in the σ(T) dependences for EG and Hb correlates with optic and rheologic data [3,6,7] and is interpreted as changes of ordering (anisotropy) of membrane proteins and phospholipids over a narrow range of temperatures. The regulatory role of the phase transition in the physiological range of temperatures is currently being studied. A relationship has been discovered between the phase transition and the activity of Na,K-ATPase and acetylcholinesterase or the rate of glucose utilization [6], this relationship between membrane structure and function manifesting itself not only in health but in pathology as well [1,3,6].

The direct correlation between the specific conductivity of EG and Hb and the stage of disease ($r=0.43$, $p<0.0042$ and $r=0.34$, $p<0.02$, respectively) and the inverse correlation between the temperature coefficient and the severity of disease ($r=-0.46$, $p<0.0019$) attest to the possibility of using these parameters for diagnosis and prognosis.

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