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# CORRELATION BETWEEN SOME HEMORHEOLOGICAL INDICES AND PARAMETERS OF ERYTHROCYTE HEMOLYSIS IN PATIENTS WITH AUTOIMMUNE HEMOLYTIC ANEMIA

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*In patients with autoimmune hemolytic anemia a medium-correlation is found between some parameters of erythrocyte hemolysis (acid resistance, erythrocyte stromatolysis, hemolytic activity of blood serum) and hemorheological indices (deformability, aggregation of erythrocytes, blood viscosity).*

It is known that the action of extreme factors (blood loss, injuries, ultrasonication, hypoxia of hemic and hypoxic origin, etc.) can activate erythrodieresis (hemolysis) processes before enhancement of red blood regeneration starts [1, 2]. Simultaneously, ambiguous changes are found in some rheological parameters (deformability, aggregation of erythrocytes, etc.), and frequently in spite of natural hemodilution, in the case of anemia blood viscosity is found to increase, which is caused by changes in physiological properties of erythrocytes that occur in different erythrodieresis stages that follow mainly the channel-former mechanism and by an increase in the "rigidity" and aggregation of erythrocytes [3, 4]. In many pathological processes that are accompanied by anemia, in spite of clearly seen changes in red blood toward hemolysis and disturbances of rheological properties, no correlation between rheological properties of blood and erythrodieresis is found.

The goal of this work was to find possible correlations between some indices of erythrodieresis and blood rheology in the case of hematological pathology, in particular, in the case of autoimmune hemolytic anemia (AIHA). Blood (plasma) viscosity (BV, PV) was determined with a rotary viscometer, erythrocyte deformability (a rigidity index (RI)), by a filtration method (an IDA-1 device), and aggregation of erythrocytes (AE), by a the photometric method, including graphical records. Erythrocyte hemolysis was studied in terms of parameters of acid erythrograms [5] with their graphical records and calculation of the total-resistance index (TR); percentages of low-, medium-, and highly resistant erythrocytes (LR, MR, and HR, respectively) and erythrocyte stromatolysis indices were determined from the hemoglobin (Hb) yield. The humoral link of erythrodieresis was determined as a hemolytic activity of blood serum (HA), following the method developed by the present authors [6] in a test of incubation of homologous erythrocytes with studied and control sera with the HA calculated in activity units.

It is found that in comparison with normal donors, in AIHA patients a higher acid resistance of erythrocytes is observed; the total resistance index is 140–150% min higher with a lower number of LR erythrocyte forms and relative domination of MR and HR erythrocyte fractions (Table 1). Enhancement of erythrodieresis characterized by predominatly intracellular destruction of erythrocytes is supported by a rightward shift of erythrograms with a flatter hemolysis strip in HR erythrocyte forms (Fig. 1) that have substantially lower deformability, sometimes up to 12,000–17,000 arbitrary units (25 a.u. in the control). The changes in properties of erythrocytes were not accompanied by their intravascular stromatolysis, releasing free Hb. In some cases development of anemia (the hematocrit is 2.2 times lower), substantially higher (240–250 times) rigidity of erythrocytes, and changes in their resistance are caused by the action of humoral hemolytic factors on the erythrocyte membrane (the hemolytic activity of blood serum is 40–50% higher).

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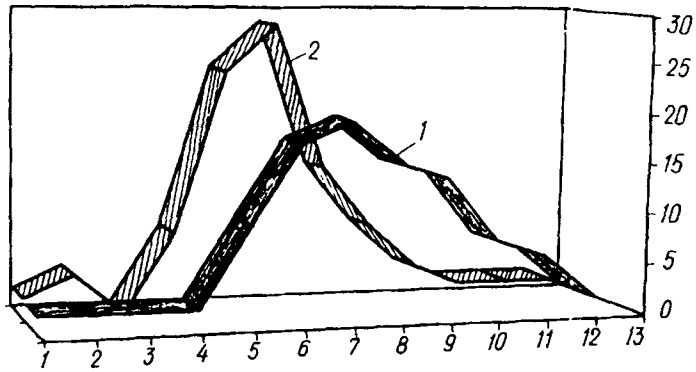


Fig. 1. Typical acid erythrograms of AIHA patients (1) and normal donors (2): abscissa is hemolysis duration $L$, min; ordinate is percentage of hemolyzed erythrocytes per unit time.

TABLE 1. Hemorheological Indices in Patients with Autoimmune Hemolytic Anemia ($M \pm m$; $n = 14$)

| Indices | Control | Patients | $P$ |
|---|---|---|---|
| Erythrocyte rigidity index, a.u. | 25.0 ± 5.10 | 6091 ± 1836 | < 0.001 |
| Blood viscosity, mPa·sec | 4.0 ± 0.18 | 2.44 ± 0.19 | < 0.001 |
| Plasma viscosity, mPa·sec | 1.38 ± 0.02 | 1.38 ± 0.04 | > 0.05 |
| Erythrocyte aggregation factor, a.u. | 0.9 ± 0.06 | 1.38 ± 0.42 | > 0.05 |
| Hematocrit, liter/liter | 0.43 ± 0.02 | 0.19 ± 0.02 | < 0.001 |

TABLE 2. Changes in Some Erythrocyte Hemolysis Indices in the Case of Autoimmune Hemolytic Anemia ($M \pm m$)

| Indices | $n$ | Control | Patients | $P$ |
|---|---|---|---|---|
| Acid resistance of erythrocytes (TR), % min | 14 | 629 ± 18.7 | 773 ± 59.8 | < 0.05 |
| Percentage of erythrocytes: | | | | |
| low-resistant | 14 | 15.1 ± 1,80 | 4.6 ± 0.80 | < 0.001 |
| medium-resistant | 14 | 69.9 ± 2.03 | 44.6 ± 5.50 | < 0.01 |
| highly resistant | 14 | 15.0 ± 2.63 | 50.8 ± 5.60 | < 0.001 |
| Hemolysis maximum, min | 14 | 5.4 ± 0.14 | 7.6 ± 0.92 | < 0.05 |
| Hemolysis duration, min | 14 | 11.2 ± 0.35 | 13.5 ± 0.97 | < 0.05 |
| Free Hb, mg/100 ml | 14 | 5.0 ± 0.50 | 5.9 ± 2.72 | > 0.05 |
| Hemolytic activity of serum, activity units | 13 | 5.5 ± 0.24 | 8.0 ± 2.45 | > 0.05 |

Analysis of hemorheological indices indicates a significant decrease in the blood viscosity with unchanged plasma viscosity in this group of patients. However, it is found that deformability of erythrocytes is substantially decreased and their aggregation tends toward enhancement (Table 2). Changes in AE of highly rigid and low-resistant erythrocytes observed in AIHA patients are presumably caused not only by a decrease in the electrokinetic potential of plasma origin (the "damage zone" is constituted by derivatives of protein of toxic hypoxia origin, medium molecules, etc.) but also by a decrease in the number of *de novo* erythrocytes in AIHA patients.

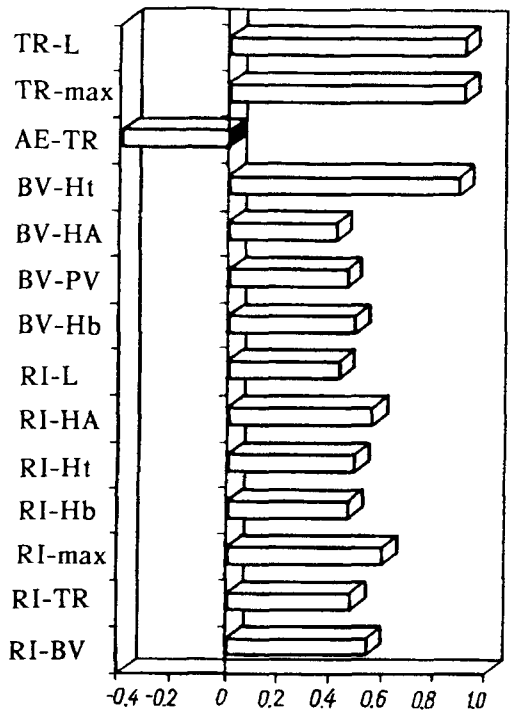


Fig. 2. Indices of correlation between parameters of hemorheology and erythrocyte hemolysis: abscissa is the correlation ratio; ordinate is hemorheological and hemolytic indices.

Results of studies of the correlation (a nonfunctional relation) between hemolysis and rheology suggest (Fig. 2) that the erythrocyte rigidity index directly (nonfunctionally) correlates (a medium correlation level) with an erythrocyte hemolysis index, namely, the integral total resistance, times of maximum hemolysis (max.; the correlation ratio (c.r.) is 0.61), or duration of hemolysis ($L$; c.r. = 0.43). In this case, with developing anemia and enhanced erythrocyte dieresis, one can see higher rigidity of erythrocyte fractions with highly acid resistance. It should be noted that the correlation between RI and hemolysis indices such as the amount of free Hb and hemolytic activity of blood serum is positive, i.e., the increase in humoral hemolitic factors of blood and free Hb is important for deformability of erythrocytes. Meanwhile, these humoral factors are independent of the TR index, and HA is not determined by the amount of free Hb. The last fact is verified in a number of studies; in particular, we [7] have shown that the increase in the HA depends on the renal function in pathological processes that are accompanied by an increase in perfusion pressure in renal microvessels (hypoxia). Consequently, the pathogenetic mechanisms of changes in dieresis and acid resistance are different, especially under pathogenesis, but these rheological and hemolytic tests correlate. The negative correlation ratio (−0.4) of aggregation and total resistance of erythrocytes with unchanged plasma viscosity suggests an effect of the number of erythrocytes on their ability to aggregate, and the higher the stability of erythrocytes, the lower the aggregation rate. Similar relations between primary changes in the aggregation parameters of erythrocytes and their acid resistance are also possible. The present data need additional characterization of functional properties of erythrocytes, especially in the case of hematological pathology of various nosological forms. A correlation is also found between blood viscosity and erythrocyte hemolysis indices such as the hemolytic activity of blood serum and the amount of free Hb (c.r. is 0.42 and 0.49, respectively), which, in turn, affect the blood microrheological index RI.

Determination of qualitative characteristics of rheological properties of blood and parameters of enhanced erythrocyte destruction will allow differentiated determination of primary links in disorders of the hematological status and a pathogenetically reasonable choice of instruments to control disturbances of the red-blood composition.

Thus, studies of hematological pathology, in particular, autoimmune hemolytic anemia, show a correlation between some erythrocyte hemolysis indices (total integral acid resistance and the other parameters of acid

erythrograms that closely correlate with TR, hemolytic activity of blood serum, and erythrocyte stomatolysis indices) and other hemorheological characteristics, namely, the erythrocyte rigidity index, blood viscisity (a positive correlation), and erythrocyte aggregation (a negative correlation). The regularities in anemia conditions found here can be useful in finding characteristics of red-blood regeneration, especially when it is necessary to differentiate between the intracorpuscular defects of erythrocytes and the effect of circulatory factors and to determine accordingly the tactics of reasonable regulation of disturbed erythrocyte homeostasis.

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