# Influence of burn toxemia on correlations between heart rate and blood parameters depending on age

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## Abstract

The ongoing traditional intensive therapy turned out to be insufficiently effective in terms of correcting metabolic and functional disorders observed in the first 10 days of burn toxemia in the examined patients, which was expressed in the preservation of the increase in the mesor of the circadian rhythm of the HR detected on the first day. A negative correlation was found between erythrocytes, hemoglobin, and blood hematocrit with the mesor of the circadian rhythm of the HR in infancy, in senior school age and at the age of 19-40 years. Corrective antiarrhythmic drug therapy, aimed at maintaining a lower HR characteristic of the elderly, turned out to be effective. The absence of significant correlations between HR and white blood components indicates a fairly effective anti-inflammatory therapy in most of the studied patients.

Keywords: burn toxemia, blood, age, heart rate.

**Relevance.** It is known that acute burn toxemia lasts from 2-4 to 10-15 days. Diagnosed with toxic myocarditis - tachycardia, arrhythmia, deafness of heart sounds, expansion of the boundaries of the heart, decreased myocardial contractility and a drop in BP. There is toxic hepatitis, pneumonia, exudative pleurisy, atelectasis, bronchitis, pulmonary edema. Hemoconcentration is replaced by anemia - Ht, the number of erythrocytes decrease, hyperleukocytosis up to 30x $10^9$/l, a shift of the leukocyte formula to the left [1-4].

Due to the lack of information on the differentiated assessment of the severity of the condition, the peculiarities of the influence of changes in the homeostasis system depending on the

characteristics of the organism at different age periods, we considered it necessary to study the monitoring data of HR, traditional clinical and biochemical parameters of blood, to determine the relationship increasing the effectiveness of treatment, optimizing the prognosis.

**Purpose.** To study and assess the age-related characteristics of the effect of burn toxemia on the correlations of heart rate and blood parameters depending on age.

**Material and research methods.** The results of monitoring the heart rate (HR) of patients admitted to the Department of Cambustiology of the Republican Scientific Center of Emergency Medicine due to burn injury were studied. After recovery from shock, routine anti-inflammatory, antibacterial, infusion therapy, correction of protein and water-electrolyte balance disorders, early surgical, delayed necrectomy, additional parenteral nutrition, syndromic, symptomatic therapy were performed. Changes in the HR circadian rhythm were studied by hourly continuous recording of hemodynamic parameters in 107 patients with severe thermal burns in six age groups - group 1 - 31 patients aged 6 months - 3 years, group 2 - 25 patients aged 3.1-7 years, group 3 25 patients - 7.1-18 years old, 4 - 12 patients 19-40 years old, 5 - 7 patients 41-60 years old, group 6 - 7 patients 61-78 years old. The division into groups was dictated by the well-known characteristics of each age group, described in detail in the literature. Hemodynamic parameters in each pediatric group were differentiatedly studied in three subgroups, depending on the severity of the burn injury, taking into account the duration of intensive care in the ICU. Children were in the ICU from 4 to 10 days - 1 subgroup, 2 subgroup from 11 to 20 days, 3 subgroup from 21 to 50 days. Table 1.

Characteristics of patients admitted with thermal burns

| Subgroups | Groups | Age | Burn area of 2-3A degrees in% | 3 B degree | IF, units | In ICU, days |
|---|---|---|---|---|---|---|
| 1 | | 19.3±6.2 month | 32.7±9.8 | 0.1±0.03 | 33.4±10.1 | 6.8±1.8 |
| 2 | | 14.2±4.6 month. | 24.8±7.4 | 9±2.8 | 48.4±11.28 | 12.8±1.3 |
| 3 | Group 1 | 10.1±2.month. | 26.7±2.2 | 6±2.7 | 71.3±8.4 | 26.3±2.4 |
| 1 | | 4.7±0.8 | 37.3±14.7 | 3.1±4.4 | 42.5±15.7 | 8.1±1.3 |
| 2 | | 4.0±0.1 | 47.9±17.1 | 18.1±12.2 | 85.1±28.7 | 13.1±1.9 |
| 3 | Group 2 | 4.4±0.6 | 59.2±12.2 | 36.7±13.3 | 127.5±33.3 | 27.3±3.2 |
| 1 | Group 3 | 11.4±3.2 | 41±11 | 6.6±6 | 57±11 | 7.3±1.1 |
| 2 | | 15±2 | 55.1±14.4 | 4.8±3.5 | 86.3±15.7 | 12.7±1.1 |
| 3 | | 9.7±1.5 | 25.8±11.4 | 22.5±6.6 | 95.8±19.1 | 28.8±4.8 |
| | Group 4 | 27.3±5.6 | 59.4±13.5 | 21.3±13.3 | 119.4±38.4 | 22.4±14.6 |
| | Group 5 | 50.7±7.1 | 54.3±16.5 | 11.9±8.9 | 92.5±20.8 | 13.3±2.4 |
| | Group 6 | 71.3±7.0 | 40.8±5.8 | 21.7±6.7 | 86.7±12.8 | 18.8±9.5 |

As shown in tab. 1, the main factors affecting the severity of the condition of children with thermal burns of infancy were age (the younger the child, the more severe the condition), the area of damage to the skin surface of grade 3B, and the IF index.

The average age of children with severe burns in the age group from 3.1 to 7 years (group 2) ranged from 3.9 to 5 years (tab. 1). The area of the 2-3A degree burn in subgroup 1 was $37.3 \pm 14.7\%$, in subgroup 2 - $47.9 \pm 17.1\%$, in subgroup 3 - $59.2 \pm 12.2\%$. A statistically significant difference was found in the area of grade 3B burns in subgroups 1 and 3, which in the most severe subgroup of children exceeded grade 3B burns than in group 1 by 11 times ($p < 0.05$) and was 6 times greater than in subgroup 2. In accordance with the severity of the condition, the duration of intensive therapy in ICU conditions in subgroup 2 was more than in the first by 62% ($p < 0.05$), in subgroup 3 more than three times longer ($p < 0.05$) than in the first. The main determinants of the duration of inpatient treatment in groups 1, 2 and 3 were such indicators as the size of the burn area of grade 3B, the Frank index, and the duration of intensive care in the ICU. Thus, age, IF index, and the area of grade 3B thermal damage served as objective indicators of the severity of thermal burns and made it possible to predict the duration of intensive care in the ICU and inpatient treatment of pediatric patients.

As can be seen from Table 1, the age groups of adult patients were significantly different and the mean values were $27.3 \pm 5.6$ years in group 1, $50.7 \pm 7.1$ years in the second, and $71.3 \pm 7.0$ years old in the third. The total area and area of deep skin lesions did not differ significantly. The highest index of IF was revealed in group 1, which determined the longest duration of intensive therapy in ICU conditions in group 4.

**Results and discussion.**

The mesor of the circadian rhythm HR on the first day in children under 3 years old in subgroup 1 did not differ from the norm, however, in subgroup 3, a significant increase in heart rate was found by 12% ($p < 0.05$) on day 1 and by 12% ($p < 0.05$) for 2 days. In the older group of school age in the 3rd subgroup, an increase in the mesor of the circadian rhythm HR in 1 - 8 days by an average of 8% ($p < 0.05$) was revealed. In the adult groups of those burnt on the first day, a tendency to an increase in heart rate relative to the age norm was revealed. Higher indicators of the mesor of the circadian rhythm HR were found in group 4 on days 2-6 compared to indicators in group 5 by 19%, 16%, 9%, 7%, 6% ($p < 0.05$, respectively). Also, HR indicators lower than group 4 were noted in patients of group 6 on days 1 - 8 by 14%, 12%, 12%, 20%, 14%, 12%, 17%, 18%, respectively, which characterized the effectiveness of corrective medication therapy aimed at maintaining a lower HR characteristic of older age.

Table 2

HR dynamics during toxemia, depending on age

| days | Group 1 | | | Group 2 | | | Group 3 | | | Group 4 | Group 5 | Group 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Subgroup 1 | Subgroup 2 | Subgroup 3 | Subgroup 1 | Subgroup 2 | Subgroup 3 | Subgroup 1 | Subgroup 2 | Subgrou p 3 | | | |
| 1 | 133±7.3 | 142±19.9 | 149±6.3* | 133±7.6 | 129±5 | 135±4 | 106±3 | 94±3 | 115±3* | 102±3 | 99±6.6 | 87±4≈ |
| 2 | 130±7.8 | 140±9.9 | 152±10.6* | 129±7.9 | 123±2 | 126±2 | 107±2 | 114±5 | 122±3* | 103±1 | 86±1.8≈ | 90±2≈ |
| 3 | 136±5.0 | 137±6.2 | 130±12.9 | 124±10.8 | 118±1 | 127±2 | 107±2 | 111±4 | 123±3* | 101.1±0.8 | 86.6±1.9≈ | 88.6±1≈ |
| 4 | 139.3±5 | 138.8±5 | 139.7±12 | 126.6±6 | 122±3 | 129±2 | 110±2 | 116±3 | 121±2* | 107.1±1.6 | 97.8±2≈ | 87.3±2≈ |
| 5 | 138.8±4 | 137.6±3 | 136.7±10 | 126.3±6 | 124±2 | 129±2 | 111±2 | 116±3 | 127±2* | 106.1±1.5 | 98.7±2.3≈ | 91.8±3≈ |
| 6 | 139.8±3 | 139.5±5 | 137.3±6 | 131.4±5 | 122±2 | 131±2 | 112±2 | 109±2 | 128±3* | 106±1.4 | 100.1±2≈ | 92.7±2≈ |
| 7 | 140.7±4 | 138.9±7 | 137.3±6 | 130.2±5 | 127±4 | 130±2 | 117±2 | 110±2 | 128±2* | 111±2.3 | 97.3±1.9 | 92±2.5≈ |
| 8 | 139.6±2 | 138±6.9 | 141.8±5 | 132.3±9 | 126±3 | 133±2 | 117±4 | 110±3 | 130±2* | 111±2.1 | 96.8±3.6 | 91.5±1≈ |
| 9 | 139.2±2 | 135.8±5 | 135.8±6 | 131±5.5 | 128±3 | 131±2 | 130±5 | 120±4 | 121±3 | 112.3±2 | 95.7±2.1 | 96.5±3 |
| 10 | | 136.2±6 | 136.8±7 | | 130±2 | 133±2 | | 112±4 | 128±3 | 110±2 | 93±3 | 93.4±3 |

*-the difference is significant relative to the indicator in 1 subgroup

≈-the difference is significant relative to the indicator in group 4

As shown in fig. 1, the negative effect of anemia on heart function (an increase in the tendency to compensatory tachycardia due to hemic hypoxia) was found in subgroup 1 of group 1, 1, 2, 3 subgroups of group 3, in group 4 and a slight trend in group 6. The revealed negative correlation between the red part of the blood (erythrocytes, hemoglobins and hematocrit with the index of the mesor of the circadian rhythm HR), regardless of the severity of burn injury in infancy, in senior school age and at the age of 19-40 years, testified to the negative effect of burn toxic anemia on cardiac function, causing tachycardia, which was not only compensatory in nature, but characterized the unfavorable state of myocardial trophism, myocarditis in conditions of severe intoxication, impaired capillary perfusion in combination with inflammatory changes in the heart muscle.
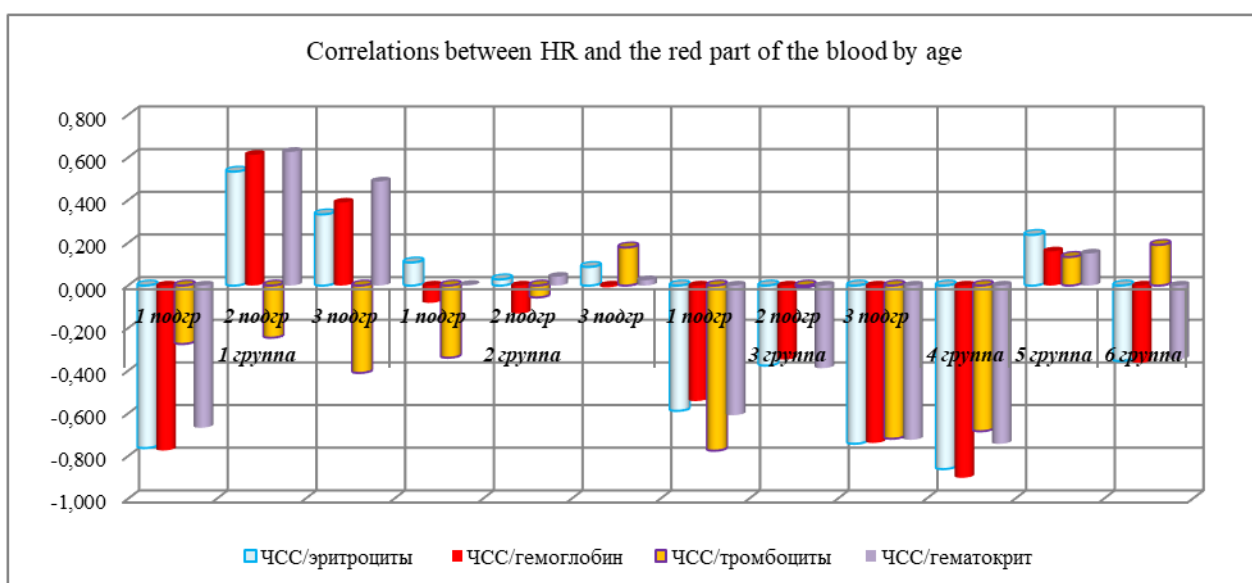


Fig.1

The revealed correlations indicate that the ongoing traditional intensive therapy was not effective enough in terms of correcting metabolic and functional disorders observed in the first 10 days of burn toxemia in the examined patients.
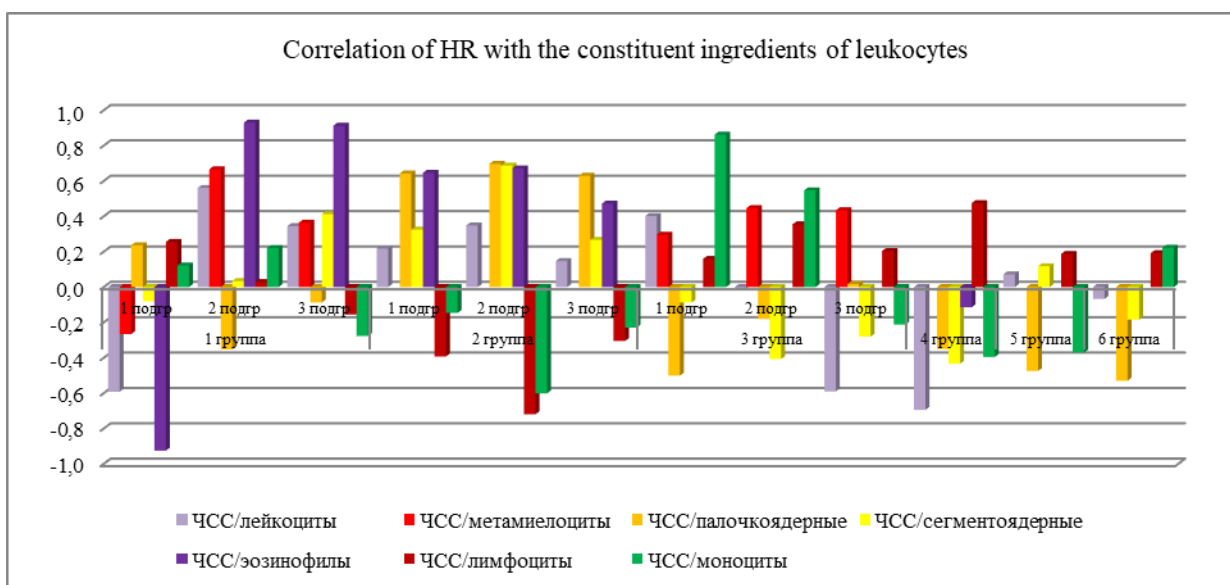


Fig.2

The absence of significant correlations between HR and white blood components indicates a fairly effective anti-inflammatory therapy (fig. 2) in most of the studied patients. However, a strong negative correlation between HR and eosinophils was revealed in children of subgroup 1 of group 1 and a direct correlation in 2,3 subgroups of group 1, moderate in all children of group 2, which can be understood as an age-related feature of the participation of cellular immunity and a more active participation of eosinophils in the systemic inflammatory response in children of early and preschool age in compensatory reactions during toxemia of burn injury. The direct correlation between HR and the number of monocytes in peripheral blood in children of the 1st subgroup of the 3rd group characterizes the insufficient effectiveness of anti-inflammatory correction, which was manifested by the tendency to increase the heart rate in response to the inflammatory response (growth of monocytes).

Direct strong correlation between HR and the level of glucose, total protein, albumin in the blood (fig. 3) in 1,2,3 subgroups of group 2, in 1 and 3 subgroups of group 3, subgroup 5, apparently, reflect an increase in the workload on of the heart in conditions of an increase in the concentration of the studied parameters, which may be characteristic of the loss of the water component of the blood volume. Confirmation of this assumption is the tendency to increase the heart rate with the growth of urea in children of groups 2 and 3. In group 6, the feedback of HR and total protein in the blood is associated with the negative effect of hypoproteinemia on cardiac function (fig. 3).
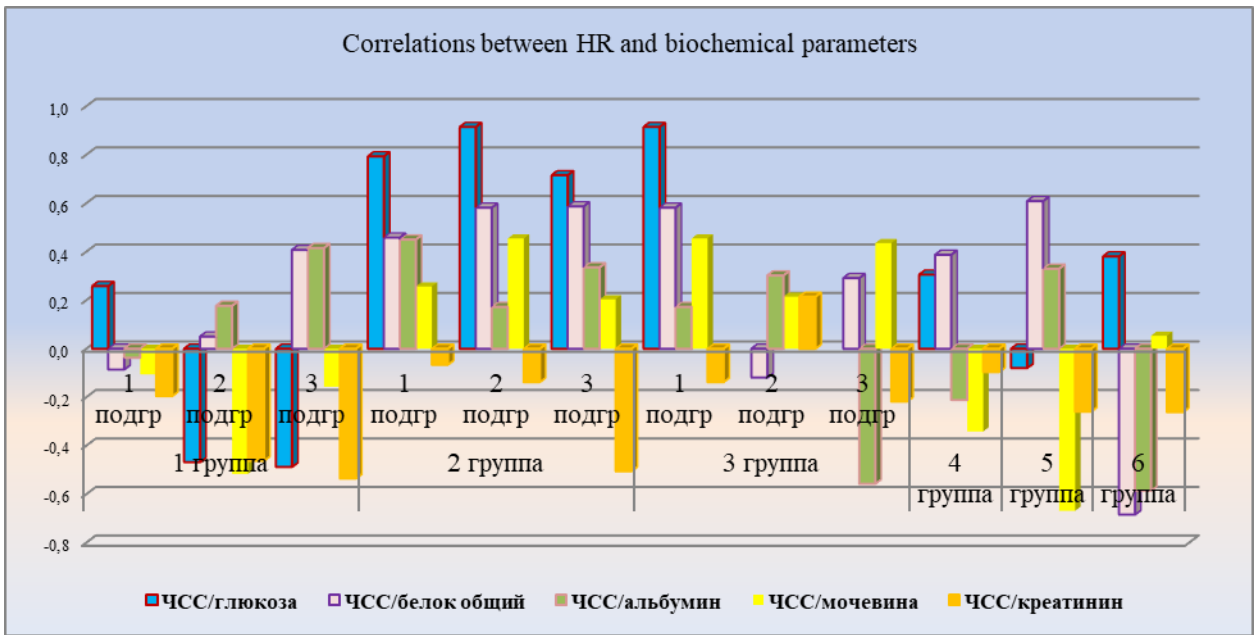
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Fig.3

Significant were (fig. 4) the negative effect of plasma sodium growth on cardiac function in subgroup 1 of group 1 and in group 4, an increase in plasma potassium concentration in 2, 3 subgroups of group 2, 2 subgroup of group 3, as well as an increase in ALT in 6 group. The different directions of the influence of electrolytes on myocardial function can be explained by various changes in homeostasis during the period of burn toxemia, which created different conditions for heart function even under conditions of effective control of blood biochemical parameters, when in some cases the increase in heart rate was of a compensatory nature, in others it turned out a direct reaction to changes in the concentration of substances in the blood, synapses, increasing the sensitivity of adrenergic receptors, thirdly, the manifestation of early signs of acute heart failure (for example, with an increase in ALT) in elderly patients.
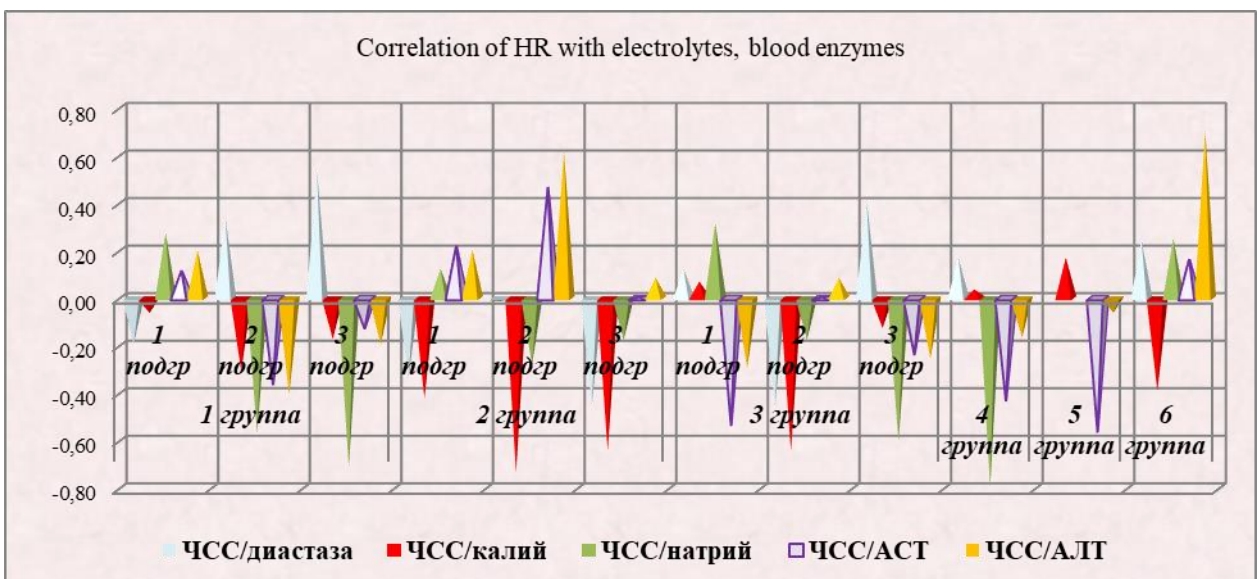
Fig.4

As shown in fig. 5, in children of the 1st subgroup of infancy, a direct relationship was found between the increase in PI on HR, and in the 2nd and 3rd subgroups (more severe burns), the opposite was found. The latter can be thought of as a positive effect of PI growth on heart function. Direct rather strong correlation between PI and HR is associated with the influence of water deficiency in subgroup 1 of group 1, limitation of infusion therapy due to the predominance of enteral administration, and better general condition of patients. With more severe burns of infants (subgroups 2,3), a tendency to decrease the protein-forming function of the liver (decrease in PI) contributed to the development of tachycardial syndrome in children.

A direct strong correlation between PI and HR in group 5 is due to the negative effect of hypercoagulation on cardiac function, causing a tendency to tachycardia, with the resulting oxygen debt in the myocardium, a decrease in blood flow velocity, a tendency to hypercoagulation and thrombus formation. A tendency to tachycardia under conditions of hypercoagulation was also found in subgroup 2 of group 2, in subgroup 2 of group 3, and in groups 4 and 6 (fig. 5).
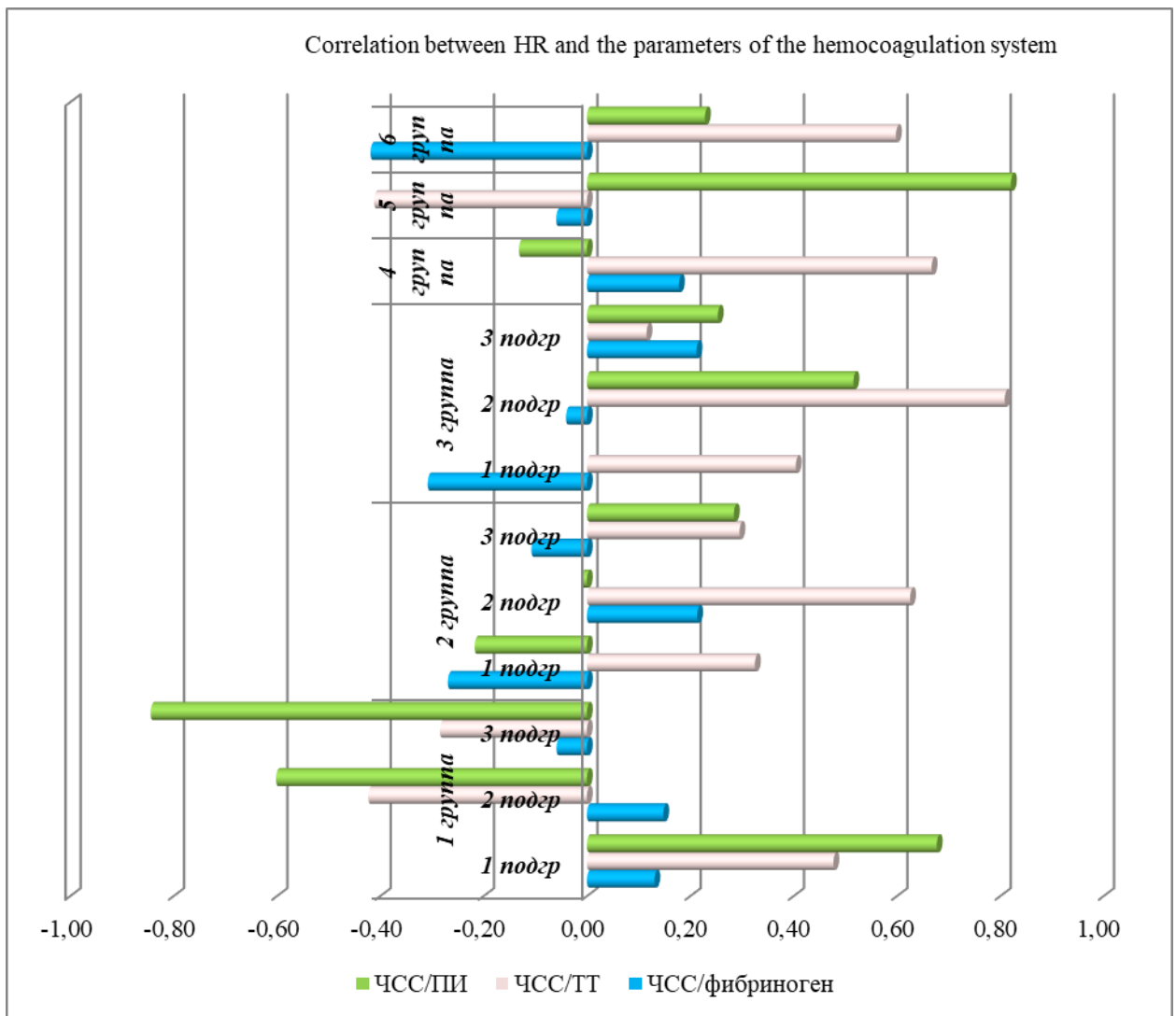
Correlation between HR and the parameters of the hemocoagulation system

Fig.5

**Conclusion.** The ongoing traditional intensive therapy turned out to be insufficiently effective in terms of correcting metabolic and functional disorders observed in the first 10 days of burn toxemia in the examined patients, which was expressed in the first 10 days of toxemia in the preservation of the HR circadian rhythm mesor increase detected on the first day. A negative correlation was found between erythrocytes, hemoglobins, and hematocrit with the HR mesor of the circadian rhythm regardless of the severity of burn injury in infancy, in senior school age and at the age of 19-40 years. Corrective antiarrhythmic drug therapy, aimed at maintaining the lower HR characteristic of older age, turned out to be effective. The absence of significant correlations between HR and white blood components indicates a fairly effective anti-inflammatory therapy in most of the studied patients.

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