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Membrane characteristics of blood erythrocyte levels in patients with bronchial asthma upon physical exertion

Key words: *bronchial asthma in adults, rheological properties of blood, biophysical parameters of erythrocyte membrane, morphofunctional parameters of erythrocytes, exertion.*

The results of epidemiological studies, unfortunately, show an increase in the incidence of bronchial asthma (BA). This disease affects people of middle age, among whom a greater or lesser daily physical activity is inevitable [1].

The results of global studies provide substantial arguments for including the pathology of membrane-receptor complex in the concept of asthma pathogenesis. It should be noted that pathogenic disorders are universal and comprises various cell populations [2, 4, 5, 6].

The role of erythrocytes in the pathogenesis of asthma has been actively studied for many years. It has been demonstrated that not only the role of erythron in gas exchange and blood rheology is important, but also a great pathogenetic importance lies in the state of erythrocyte membranes. Erythrocyte model is generally proven and widely used for studying of membrane-cell receptor characteristics, and not only in pulmonology. In essence, the lungs are the largest biological membrane of the body. The outer surface is represented by alveolar epithelium and surfactant, the inner surface of the membrane is lined with the endothelial cells of lung capillaries. Aero-hematic barrier of this membrane is ensured by the structural organization of membrane lipids. The cells of the alveolar epithelium and endothelium of lung capillaries, as well as the membrane of erythrocytes, are among the first ones to perceive information about changes in external conditions and the state of the internal environment of the body. Physical work, placing increased demands on the body and stimulating its adequate adaptation response (increased heart rate, cardiac output, respiratory rate and respiratory volume, the release of catecholamines, cortisol and other biologically active substances, the change in body temperature, pH of blood and mucus), actively changes not only the microenvironment of alveolocytes, endothelial cells and erythrocytes, but first and foremost, the state of their membranes [3, 7, 8, 9].

Thus, a key role in the perception of changes caused by physical exertion (PE) and the formation of adequate adaptive response to them belongs, in our opinion, to the cell membranes of erythrocytes, endothelial cells and cells of alveolar epithelium [10 – 13].

For patients with asthma, physical exertion is of particular importance, as a part of these patients respond to it by forming obstructive syndrome. The pathogenesis of this phenomenon is not fully understood. Literary sources offer different but not mutually exclusive hypotheses of the mechanisms of obstructive syndrome caused by physical exertion, in these patients. Data on participation of the membrane-receptor cell complex in the development of post-exertion obstruction in patients with BA are scarce in available literature [14 – 16].

Universal defect of perception and transmission of informational signal by a cell leads to pathological changes at different levels of functioning of bronchopulmonary system, which is of interest for research.

Thus, the **purpose** of this paper was to study the membrane-receptor characteristics of erythrocytes in patients with bronchial asthma upon performing physical activity.

Materials and methods

The research examined 75 patients with BA in remission phase, aged 28 to 68 (average age (41.2 ± 6.0 years)), including 31 men and 44 women. Medical history, clinical symptoms, indicators of respiratory function, reversibility of obstruction in the bronchodilator test were taken into account upon diagnosing. Patient selection according to the severity of BA was conducted in compliance with the criteria of the Order No. 128 of the Ministry of Health of Ukraine dated 19.03.2007 «On approval of clinical protocols of medical care in the specialty «Pulmonology» [17]. 10 healthy volunteers aged on average (45.0 ± 4.2 years) who had no clinically significant severe pathology, were examined as a method of control. All patients were on standard basic remission therapy which included the use of inhaled corticosteroids and β2 agonists of short action to reduce asthma symptoms.

During the observation, the patients were divided into 3 groups: 28 of them (37.3 ± 5.6) % were patients with light persistent course of the disease, 30 (40.0 ± 5.7) % patients with moderate course of the disease and 17 (22.7 ± 4.8) % patients with severe course of the disease. All patients were in remission..

The study evaluated the relative membrane charge (RMC) and relative gradient of membrane potential (RGMP) of erythrocytes (ER), the total number of erythrocytes* 10/l, Hb (g/l), the nature of liquid crystal lattice of blood serum, as well as the count of abnormal morphostructures of erythrocytes in the peripheral blood with determining of the degree of deformation of erythrocytes (DDE) was carried out, and also the level of blood saturation with determination of SaO2. Index was taken into account. The study of relative gradient of membrane potential of erythrocytes was conducted with the use of ionometer «OP-264/1» (Hungary). Determination of the relative charge of erythrocytes was conducted through mathematical calculations [19–20]. Sorption capacity of red blood cells (SYEE) was determined using the methylene blue dye. Unit of measurement was per cent (%). We determined the amount of methylene blue associated with the cells (Cb) and the amount of the dye remaining in solution (Cbs), which made it possible to calculate the distribution ratio of methylene blue between the cell and the environment (Q). The value of coefficient Q was determined by the formula: $Q = Cb/Cbs = (Vc/Ve)\ (Do\text{-}Dk)/Dk$, where Do and Dk are the values of optical density of the solution of methylene blue before and after incubation with erythrocytes. Assessment of erythrocyte deformation was carried out using the method of edge dehydration of biological fluids, and by electron microscope «NU 2» manufactured by VEB Carl Zeiss with photosystem MRS 60 [21]. The degree of erythrocyte deformation was determined according to the following scale: 0 – no deformation; 1 – 10-29 % of deformed erythrocytes; 2 – 30-69 % of deformed erythrocytes; 3 – 70 % or more of deformed erythrocytes [22].

All the tests were performed before and after the cardiorespiratory exercise test. In order to perform dosed physical exercise we used veloergometers EP/2 (Erich Jaeger, Germany) and Ergoselect 1000 LP Basic with auto power dissipation regardless of the speed of pedaling. Forecasting of power load, maximum oxygen consumption, minute pulmonary ventilation and heart rate was performed by the method of extrapolation, taking into account the age, gender and anthropometric parameters of the subjects. The maximum level of the accomplished physical exertion was estimated as the limit of functional capacities of the body. The study of ventilation lung function was conducted among all patients in the process of cardiorespiratory testing, i.e. before testing and immediately after its completion.. Spirometric indices were expressed as percentages of appropriate values and the degree of obstructive disorders was assessed before and after the physical exertion (PE). Besides, the index of FEV1 reduction per centas a result of PE was calculated by the formula ((absolute FEV 1 before PE) – (absolute FEV1 after PE))×100 %/absolute FEV 1 before PE. FEV1 reduction within 15 % and more was considered as a deviance from a norm, that is, it was a sign of post-exertion airway obstruction. On completion of the protocol, the patient was given an aerosol bronchodilator salbutamol at a dose of 400 mg, if necessary [23 – 25]. Statistical analysis of the obtained data was performed using licensed software products that are included in the software package Microsoft Office Professional 2000, on a personal computer IBM Celeron program Excel [26, 27]. The work was carried out at the expense of the public funds.

Results and Discussion

Indicators of external respiration in patients with bronchial asthma with mild, moderate and severe course of the disease before the cardiorespiratory exercise testing are presented in Table 1. The obtained data show that in patients with a mild course of the disease have spirogram speed indicators in remission within normal limits. In patients with a moderate course of the disease, FEV1 reduction is observed compared to control, impaired patency of distal bronchial tract: MEF 25 %, MEF 50 %, MEF 75 %. In a severe course of the disease, the respiratory failure is consequently, the severest. In patients with severe degree of BA, an expressed impaired patency of the distal airways is observed, which creates conditions for the development of chronic hypoxia in the body. The overall diffusion capacity of the lungs does not differ between the BA patients with a mild course of the disease and healthy individuals, but already in patients with a moderate course, and especially in those with a severe course of the disease, even without a significant reduction in spirogram speed indicators, the value of the membrane component of diffusion capacity of the lungs is reduced, which cannot be explained only by a decrease in gas exchange surface area.

The results of spirometry immediately after the cardiorespiratory exertion testing are presented in Table 2. It is obvious that besides impaired bronchial patency, changes in pulmonary residual volume are observed: functional residual lung capacity increases as well as the so-called closing volume, which reflects the process of the bronchi collapse before the level of maximum exhalation is achieved. Bronchial tonus in response to hyperventilation may vary in practically healthy people as well. However, the extent of these changes never comes to obstructive disorders and the FEV1 decrease never exceeds 10 %.

It is found that BA is the cause of oxygen regime change with chronic hypoxia development that triggers

Table 1

Indicators of lung volumes, capacities, bronchial obstruction in BA patients with a mild, moderate and severe course of the disease (M ± m)

Indicators	Group I	Group II	Group III
	BA patients with a mild persistent course	BA patients with a moderate course of the disease	BA patients with a severe course of the disease
	n = 28	n = 30	n = 17
R tot, %	105,9 ± 14,2	135,5 ± 18,2	201,3 ± 13,5[2, 3]
IC, %	110,8 ± 5,4	92,6 ± 4,4[1]	90,1 ± 4,1
VC_{MAX}, %	101,2 ± 5,9	95,2 ± 4,9	83,1 ± 5,4
ERV, %	104,3 ± 8,5	102,5 ± 5,5	72,1 ± 6,2[2, 3]
RV, %	94,6 ± 8,7	89,2 ± 6,7	140,1 ± 7,2[2, 3]
ITGV, %	95,6 ± 7,2	98,7 ± 5,2	112,3 ± 5,1[2]
TLC, %	100,6 ± 9,2	108,3 ± 7,2	109,2 ± 6,1
FEV_1, %	92,6 ± 6,5	65,3 ± 5,6[1]	55,2 ± 6,2[2]
FVC, %	91,2 ± 2,4	79,3 ± 1,4[1]	72,9 ± 2,0[2]
FVC, абс.	2,8 ± 1,3	2,5 ± 1,1	3,1 ± 1,2
FEV_6, л	2,78 ± 1,3	2,49 ± 0,1	2,6 ± 0,2
FEV_1 / VC_{MAX}, %	87,5 ± 4,9	85,6 ± 3,8	67,6 ± 4,8[2, 3]
FEV_1 / $FEV_{6,}$ %	83,5 ± 6,9	69,5 ± 5,8	56,1 ± 6,8[2]
MEF_{75}, %	71,3 ± 5,0	51,9 ± 3,9[1]	36,2 ± 7,1[2, 3]
MEF_{50}, %	62,6 ± 5,9	42,4 ± 4,7[1]	24,2 ± 6,2[2, 3]
MEF_{25}, %	52,6 ± 2,0	29,3 ± 1,2[1]	21,0 ± 1,2[2]
PEF, %	82,3 ± 4,6	69,8 ± 2,5[1]	54,2 ± 2,6[2, 3]
DLCO	88,4 ± 5,1	73,6 ± 4,1[1]	61,4 ± 4,2[2, 3]
KCO	86,2 ± 7,0	69,2 ± 5,6[1]	65,2 ± 4,2[2]
VA	102,4 ± 5,7	96,4 ± 3,2	89,4 ± 2,1[2]
V_{IN}	112,3 ± 6,7	97,3 ± 5,2[1]	96,4 ± 5,2[2]
FRC	105,3 ± 5,4	96,2 ± 3,2	83,4 ± 2,6[2]

Notes: [1] statistically significant difference between the performance of I and II groups (p <0.05); [2] statistically significant difference between the performance of I and III groups (p <0.05); [3] statistically significant difference between the performance of II and III groups (p <0.05).

morphological changes in the erythrocyte itself, reducing the rate of transition of one haemoglobin structure to another and its sensitivity to oxygen. And thus, if patients with a mild course of the disease do not have significant changes in the percentage of abnormally deformed erythrocytes of peripheral blood compared with healthy individuals, then BA patients with a moderate course of the disease have significant changes in the morphology of erythrocytes,

Table 2

Indicators of lung volumes, capacities, bronchial obstruction in BA patients with a mild, moderate and severe course of the disease (M ± m)

Indicators	Group I	Group II	Group III
	BA patients with a mild persistent course	BA patients with a moderate course of the disease	BA patients with a severe course of the disease
	After a cardiorespiratory exertion testing (within 20 minutes).		
	n = 28	n = 30	n = 17
IC, %	105,6 ± 4,9	91,7 ± 4,3[1]	89,4 ± 4,3
VC_{MAX}, %	100,2 ± 5,6	92,4 ± 4,6	81,4 ± 5,2
ERV, %	109,7 ± 8,6	112,4 ± 5,8	82,5 ± 6,6[2, 3]
RV, %	96,1 ± 8,9	98,3 ± 6,9	155,1 ± 7,5[2, 3]
ITGV, %	96,6 ± 7,4	91,3 ± 5,1	118,4 ± 5,3[2]
TLC, %	101,8 ± 9,8	111,2 ± 7,5	111,6 ± 6,5
FEV_1, %	90,6 ± 6,2	59,1 ± 5,6[1]	49,5 ± 5,9[2]
FVC, %	93,2 ± 2,5	88,3 ± 1,6[1]	71,6 ± 2,1[2]
FVC, абс.	3,2 ± 1,3	2,9 ± 1,2	2,1 ± 1,1
FEV_6, л	3,02 ± 1,3	2,87 ± 0,2	2,5 ± 0,2
FEV_1 / VC_{MAX}, %	85,2 ± 4,5	80,2 ± 3,5	71,3 ± 4,4[2, 3]
FEV_1 / $FEV_{6,}$ %	82,5 ± 6,6	69,5 ± 5,2	57,1 ± 6,7[2]
MEF_{75}, %	70,1 ± 4,6	49,3 ± 3,2[1]	28,3 ± 6,5[2, 3]
MEF_{50}, %	55,6 ± 5,1	41,3 ± 4,5[1]	21,5 ± 5,5[2, 3]
MEF_{25}, %	49,7 ± 1,9	23,4 ± 1,3[1]	20,0 ± 1,1[2]
PEF, %	77,3 ± 4,2	65,7 ± 2,4[1]	58,2 ± 2,7[2, 3]
DLCO	90,4 ± 5,2	71,8 ± 4,3[1]	65,8 ± 4,3[2, 3]
KCO	87,2 ± 7,0	72,2 ± 5,7[1]	68,2 ± 4,2[2]
VA	103,4 ± 5,6	98,3 ± 3,5	87,4 ± 2,1[2]
V_{IN}	115,5 ± 6,8	99,4 ± 5,3[1]	97,8 ± 5,1[2]
FRC	106,8 ± 5,5	98,3 ± 3,1	85,8 ± 2,8[2]

Notes: [1] statistically significant difference of indices between group I and group II (p <0.05); [2] statistically significant difference of indices between group I and group III (p <0.05); [3] statistically significant difference of indices between group II and group III (p <0.05).

Table 3

Biophysical parameters of blood in patients with bronchial asthma of varying courses of the disease (compared to the healthy individuals group) (M ± m)

Indicators	Healthy donors (n = 15)	Group I	Group II	Group III
		BA patients with a mild persistent course (n = 28)	BA patients with a moderate course of the disease (n = 30)	BA patients with a severe course of the disease (n = 17)
RGMP (r. u.)	0,013 ± 0,001	0,029 ± 0,019	0,258 ± 0,022[1, 3]	0,325 ± 0,021[2, 3]
RMC (R. U.)	0,31 ± 0,005	0,302 ± 0,004	0,085 ± 0,008[1, 3]	0,045 ± 0,007[2, 3]
Degree of deformation of erythrocyte membranes	1,3 ± 0,1	1,4 ± 0,0	2,2 ± 0,0[1, 3]	3,2 ± 0,2[2, 3]
Degree of hypoxic anisotropy (points)	0,1 ± 0,0	0,1 ± 0,0	1,6 ± 0,0[1, 3]	2,3 ± 0,2[2, 3]
Sorption capacity of erythrocytes (%)	31,0 ± 4,6	42,4 ± 6,3	79,3 ± 12,4[1, 2, 3]	81,6 ± 12,8[2, 3]
Methylene blue distribution coefficient between the cell and the environment (Q) (r. u.)	0,73 ± 0,02	0,75 ± 0,06	1,31 ± 0,09[1, 2, 3]	1,28 ± 0,07[2, 3]

Notes: [1] statistically significant difference between groups I and II (p <0.05); [2] statistically significant difference between groups II and III (p <0.05); [3] statistically significant difference from the group of healthy individuals (p <0.05).

Table 4

Biophysical parameters of blood in patients with bronchial asthma of varying courses of the disease after exposure to physical exertion (compared to the healthy group) (M ± m)

Indicators	Healthy donors (n = 15)	Group I	Group II	Group III
		Patients with asthma with light persistent course (n = 28)	Patients with asthma how to moderate (n = 30)	Patients with severe asthma course (n = 17)
RGMP (r. u.)	0,010 ± 0,001	0,032 ± 0,018	0,272 ± 0,025[1, 3]	0,331 ± ,021[2, 3, 4]
RMC (r. u.)	0,33 ± 0,005	0,298 ± 0,004	0,075 ± 0,006[1, 3]	0,039 ± 0,006[2, 3, 4]
Degree of deformation of erythrocyte membranes	1,5 ± 0,1	1,5 ± 0,0	2,4 ± 0,0[1, 3]	3,3 ± 0,2[2, 3]
Degree of hypoxic anisotropy (points)	0,1 ± 0,0	0,5 ± 0,0	1,5 ± 0,0[1, 3]	2,5 ± 0,2[2, 3]
Sorption capacity of erythrocytes (%)	31,5 ± 4,2	44,6 ± 6,5	79,5 ± 12,2[1, 2, 3]	82,5 ± 12,9[1, 3]
Methylene blue distribution coefficient between the cell and the environment (Q) (r. u.)	0,72 ± 0,02	0,85 ± 0,08	1,30 ± 0,09[1, 2, 3]	1,35 ± 0,09[2, 3]

Notes: [1] statistically significant difference between groups I and II (p <0.05); [2] statistically significant difference between groups II and III (p <0.05); [3] статисstatistically significant difference from the group of healthy individuals (p <0.05); [4] statistically significant difference, from prior to physical exertion (p <0.05).

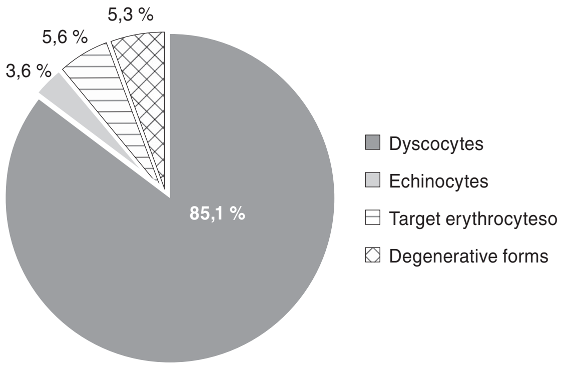

Fig. 1. **Morphological structure of erythrocytes in patients with BA of group I prior to cardiorespiratory load**

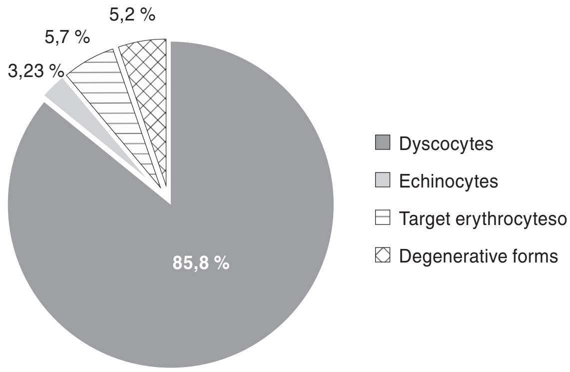

Fig. 4. **Morphological structure of erythrocytes in BA patients of Group I prior to cardiorespiratory load.**

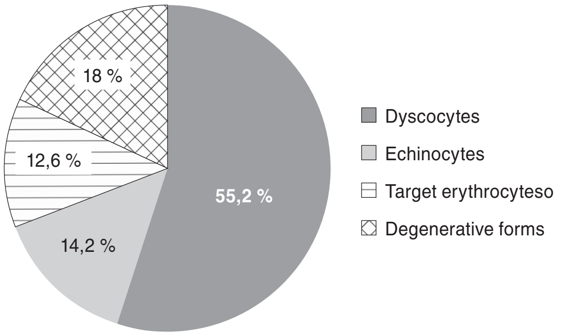

Fig. 2. **Morphological structure of erythrocytes in patients with BA of group II prior to cardiorespiratory load**

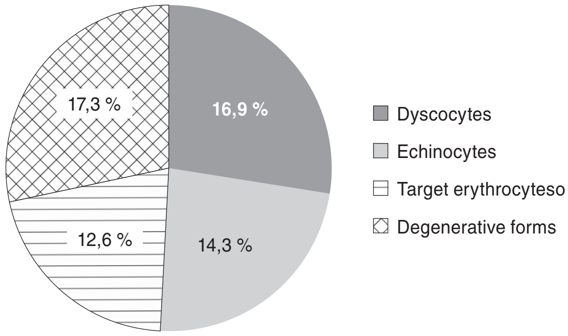

Fig. 5. **Morphological structure of erythrocytes in BA patients of Group II prior to cardiorespiratory load.**

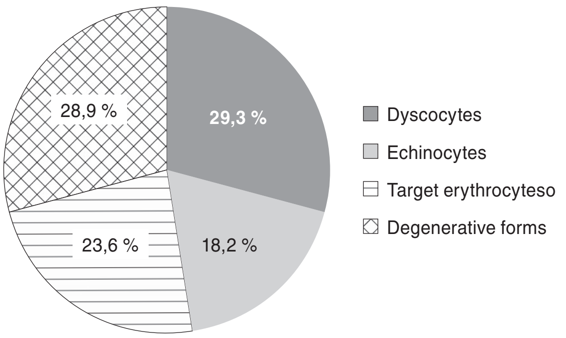

Fig. 3. **Morphological structure of erythrocytes in patients with BA of group III prior to cardiorespiratory load.**

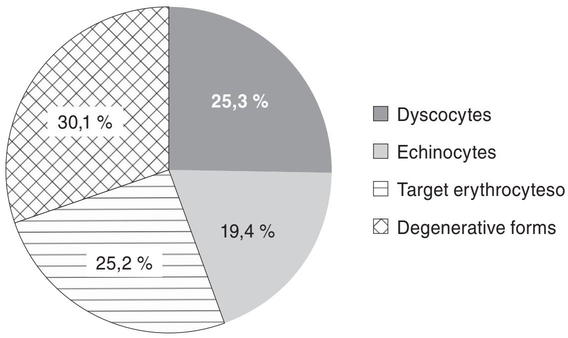

Fig. 6. **Morphological structure of erythrocytes in patients of Group III prior to cardiorespiratory load.**

namely the tendency to low values of aggregation of erythrocytes, compared to healthy people. This is a consequence of microcytosis, as the smaller size of erythrocytes and their reduced aggregation are the adaptive mechanisms that create conditions to optimize the microcirculation. However, in patients with the severest course of the disease the level of aggregation of erythrocytes is increased, indicating significant damage to erythrocytes with formation of pathologically deformed morphoforms which are unable to maintain their functions in blood rheology. A more detailed examination has found that in BA patients with a mild course the morphological pattern of erythrocyte cycle is virtually indistinguishable from that of healthy individuals, namely normoforms (discocytes) – (85.1±1.7) %, echinocytes – (3.6±1 2) %, target cells – (5.6±0.5) %, the number of degenerative erythrocytes – (5.3±0.8) %. In patients with moderate asthma, the normoforms decrease to (55.2±1.2) % (in healthy individuals–94.2±2.0 %); number of deformed cells (echinocytes) increased to (14.2±0.4) %, (in healthy individuals –2.2±0.8) %); target cells – to (12.6±0.5) % (in healthy individuals – (3.1±0.6) %); number of degenerative erythrocytes increases to (18.0±1.3) % (in healthy individuals – (7.2±0.9) %). Upon severe BA, the percentage of normoforms is reduced to (29.3±1.8) %, echinocytes – to (18.2±1.1) %, target cells – to (23.6±0.6) %, degenerative forms – (28.9±2.1) % (see fig. 1, 2, 3). At the same time, no significant changes in the numbers of reticulocytes are observed in any of the groups. This indicates the presence of pathological changes in the erythrocytes of peripheral blood.

Biophysical characteristics of deformation capacity and osmotic resistance of erythrocytes confirm all the above. In a healthy individual, biophysical indicators of deformation properties of erythrocytes are a stable, unchanging value. Relative gradient of membrane potential of erythrocytes (RGMP) comprises, on average (0.011 ± 0.01) r. u., relative membrane charge (RMC) averages (0.29 ± 0.005) r. u., the degree of deformation of erythrocyte membranes is (1.1 ± 0.1) points. More detailed information is presented in Table 3.

A completely different pattern is observed in BA patients, and, as research has shown, it depends on the severity of the disease. In BA patients with mild course of the disease, RGMP and RMC indicators and the degree of hypoxic anisotropy are changed, but not significantly. In patients with moderate disease course, all the above characteristics are significantly different from both healthy group and the group of patients with mild course of the disease. The severest changes in the estimated parameters were observed in patients with severe course of the disease.

After the cardiorespiratory exertion testing, all the groups were re-examined. Physical exertion is a stimulus for increased activity of catecholamines, glucocorticoids and other biologically active substances. Its performance results in an increase in body temperature, blood pH decrease, change in the phase transition temperature of the lipid layer of the cell membrane, which leads to changes in membrane receptor function, structure and functional changes of cell membranes. After cardiorespiratory exertion testing, BA patients with varying degrees of severity manifested a different reaction of erythrocytes to load: the severer the course of the disease, the more expressed was the loss of charge on the membrane, the growth of gradient potential on it, the increase in permeability of erythrocyte membranes and sorption capacity of erythrocytes, deepening of hypoxic anisotropy of blood serum, the increase in the percentage of deformed cells. The results are presented in Table 4. Morphological pattern of erythrocyte part is also changed: the severer the course of the disease, the more expressed was the reaction of erythrocyte part to physical exertion.

In BA patients with a mild course of the disease, the percentage of normoforms (discocytes) if practically unchanged: from (85.1±1.7) % to (85.8±1.5) %, of echinocytes – from (3.6±1.2) % to (3.2±1.5) %, of target cells – from (5.6±0.5) % to (5.7±0.7) %, the number of degenerative erythrocytes – from (5.3±0. 8) % to (5.2±0.8). In patients with moderately severe asthma, a decrease of normoforms is observed from (55.2±1.2) % to (51.5±1.3) %; percentage of echinocytes – from (14.2±0.4) % to (16.9±±0.5) %, of target cells – from (12.6±±0.5) % to (14.3±±1.1) %; number of degenerative erythrocytes – from (18.0±±1.3) % to (17.3±±1.2) %. In severe asthma, a decrease of normoforms in response to load fell from (29.3±±1.8) % to (25.3±±1.1) %, of echinocytes – from (18.2±±1.1) % to (19 4±±1.2) %, of target cells – from (23.6±±0.6) % to (25.2±±0.5) %, of degenerative forms – from (28.9±±2.1) % to (30 1±±2.0) % (see. fig. 4, 5, 6).

This is confirmed by the reaction of erythrocyte membrane in response to load, which also depended on the severity of BA. The severer the course of the disease, and therefore initially reduced deformation capacity and osmotic resistance of erythrocytes, the more «traumatic» for it will be the exposure of the patient to the maximum permissible load, because these cells are unable to respond adequately to changing homeostasis influenced by increased requirements to oxygen transportation and rheological properties of blood, due to the work performed. More detailed information is presented in Table 4.

Conclusions

As a result of the conducted work the changes in biophysical parameters of erythrocytes in patients with bronchial asthma of varying courses of the disease under the influence of physical exertion were investigated and compared for the first time. As well as assessment of the osmotic deformation capacity and stability changes of these cells, the degree of their deformation and crystal optical characteristics of blood serum under the influence of exposure to the maximum permissible physical exertion, depending on the severity of asthma. It has been established that physical exertion leads to deterioration of the already altered deformation capacity and osmotic resistance of erythrocytes, deepening hypoxic anisotropy of blood serum, indicating exhaustion of compensatory mechanisms of the erythrocyte cycle of rheological properties of blood, depending on the severity of bronchial asthma. Given these findings, in the future it is necessary to improve the methods of treatment and rehabilitation of BA patients taking into account the results obtained.

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МЕМБРАННЫЕ ОСОБЕННОСТИ ЭРИТРОЦИТОВ КРОВИ У БОЛЬНЫХ БРОНХИАЛЬНОЙ АСТМОЙ ПРИ ФИЗИЧЕСКОЙ НАГРУЗКЕ

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Резюме

Цель работы: *исследование мембранно-рецепторных особенностей эритроцитов (ЭР) легких у больных бронхиальной астмой (БА) при выполнении физической нагрузки.*

Материалы и методы. *Были обследованы 75 пациентов с БА в фазе ремиссии заболевания в возрасте от 28 до 68 лет (средний возраст (41,2 ± 6,0) года), из них 31 мужчина и 44 женщины. При установлении диагноза учитывался анамнез, клинические симптомы, показатели функции внешнего дыхания, обратимость бронхообструкции в пробе с бронхолитиками. В процессе наблюдения больные были распределены в 3 группы: 28 (37,3 ± 5,6) % – пациенты с легким персистирующим течением БА, 30 (40,0 ± 5,7) % – с течением средней степени тяжести и 17 (22,7 ± 4,8) % – с тяжелым течением. Все пациенты были в стадии ремиссии заболевания.*

В процессе исследования оценивались относительный заряд мембраны и относительный градиентный мембранный потенциал ЭР, общее количество ЭР, содержание гемоглобина, характер жидкокристаллической решетки сыворотки крови; также проводился подсчет патологически измененных морфоструктур ЭР периферической крови с определением степени деформации ЭР, учитывался уровень сатурации крови с определением показателя SaO_2. Относительная степень деформации ЭР крови определялась согласно шкале: 0 – деформация отсутствует; 1 – деформировано 10–29 % ЭР; 2 – деформировано 30–69 % ЭР; 3 – деформировано 70 % и более ЭР.

Обследование проводилось до и после проведения кардиореспираторного нагрузочного теста. Статистическая обработка полученных данных выполнялась с помощью лицензионных программных продуктов, входящих в программный пакет Microsoft Office Professional 2000, на персональном компьютере ИБМ Celeron в Excel [11].

Результаты. *Полученные данные показывают, что у пациентов с легким течением заболевания скоростные показатели спирограммы в фазе ремиссии находятся в пределах нормы. У больных со средней степенью тяжести происходит снижение $ОФВ_1$ по сравнению с контролем, определяется недостаточность проходимости дистальных отделов бронхиальных путей: $MEF_{25\,\%}$, $MEF_{50\,\%}$, $MEF_{75\,\%}$. У больных с тяжелой степенью БА отмечается выраженное нарушение проходимости в дистальных отделах дыхательных путей, что создает условия для развития хронической гипоксии в организме. Различия в общей диффузионной способности легких у больных БА с легким течением и у здоровых не отмечались, однако у пациентов с БА со средней степенью тяжести и особенно с тяжелым течением, даже при отсутствии значительного снижения скоростных показателей спирограммы, значение мембранного компонента диффузионной способности легких снижено, что нельзя объяснить лишь уменьшением площади поверхности газообмена.*

Полученные данные показывают, что у пациентов с легким течением заболевания биофизические характеристики деформационной способности и осмотической устойчивости ЭР крови подтверждают все вышесказанное. У здорового человека биофизические показатели деформационных свойств ЭР крови стабильны.

Физическая нагрузка является стимулом для повышения активности катехоламинов, глюкокортикоидов и других биологически активных веществ. При ее выполнении происходит повышение температуры тела, уменьшение pH крови, изменение температуры фазового перехода липидного слоя клеточной мембраны, что приводит к изменению функции мембранных рецепторов, структурным и функциональным изменениям клеточных мембран. После кардиореспираторного нагрузочного тестирования у больных БА с различной степенью тяжести наблюдалась разная реакция ЭР на нагрузку: чем тяжелее течение заболевания, тем более выраженными были потеря заряда на мембране, нарастание на ней градиентного потенциала, увеличение проницаемости мембраны и сорбционной емкости ЭР, усугубление гипоксической анизотропии сыворотки крови, увеличение процента деформированных форм.

Выводы. *В результате проведенной работы впервые были исследованы и сравнены изменения биофизических показателей ЭР крови у больных БА с различной степенью тяжести заболевания под влиянием физической нагрузки. Впервые оценены изменения величин деформационной способности и осмотической устойчивости этих клеток, степени их деформации и кристаллооптических характеристик сыворотки крови под влиянием выполнения максимальной* *нагрузки в зависимости от степени тяжести БА. Установлено, что физическая нагрузка приводит к ухудшению уже измененных деформационной способности и осмотической устойчивости ЭР крови, усугубляет гипоксическую анизотропию сыворотки крови, что свидетельствует об истощении компенсаторных механизмов эритроцитарного звена реологической способности крови и зависит от степени тяжести БА. Учитывая полученные данные, в дальнейшем необходимо совершенствовать способы лечения и реабилитации больных БА с учетом полученных результатов.*

Ключевые слова: *бронхиальная астма у взрослых, реологические свойства крови, биофизические показатели эритроцитарной мембраны, морфофункциональные характеристики эритроцитов крови, физическая нагрузка.*

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MEMBRANE FEATURES ERYTHROCYTE LEVELS IN PATIENTS WITH BRONCHIAL ASTHMA DURING PHYSICAL EXERTION

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Abstract

Aim. *To study of membrane receptor features of erythrocytes (ER) the lungs of asthmatic patients during exercise.*

Materials and methods. *Were examined 75 patients with asthma in remission of the disease, from 28 to 68 years (mean age (41,2 ± 6,0) years), including 31 men and 44 women. Diagnosis is taken into account history, clinical symptoms, lung function, reversibility of bronchial obstruction in the sample with bronchodilators. After the observation, patients were divided into 3 groups: 28 (37,3 ± 5,6) % — patients with mild persistent course, 30 (40,0 ± 5,7) % — with moderate stroke and 17 (22,7 ± 4,8) % — with severe. All patients were in remission of the disease.*

The study evaluated the relative charge of the membrane and relative gradient membrane potential, ER and the total number of red blood cells, the nature of liquid crystal lattice of blood serum, also conducted counts of abnormal morphostructures ER in the peripheral blood to determine the degree of deformation of ER, consider the level of oxygen saturation of blood with certain indicators SaO_2. The degree of deformation of the red blood cells was determined according to the scale: 0 — no deformation; 1 — 10–29 % deformed red blood cells; 2 — strain 30–69 % of red blood cells; 3 — deformed 70 % or more of ER.

All the survey was conducted before and after cardiorespiratory exercise test. Statistical data processing was performed using the licensed software, included in the software package Microsoft Office Professional 2000 at the IBM personal computer in the Celeron Excel.

Results. *Was found. that patients with mild disease spirogram speed performance in remission is within normal limits. Patients with moderate severity of the disease, there is a decrease in FEV_1 compared to the control is determined by the lack of cross-sections of the distal bronchial passages: $MEF_{25\,\%}$, $MEF_{50\,\%}$, $MEF_{75\,\%}$. Patients with severe asthma the expressed violation of patency in the distal airways, which creates conditions for the development of chronic hypoxia in the body. No difference in overall lung diffusion capacity between asthmatic patients with mild disease and healthy, but even in patients with asthma with an average level gravity, and especially severe, even in the absence of a significant reduction in speed performance spirogram, the value of the membrane component of the diffusion capacity of the lungs is reduced that can not be explained only by a decrease in the surface area of gas exchange.*

The findings indicate, that patients with mild asthma biophysical characteristics of deformability and osmotic stability of red blood cells confirms all of the above. In a healthy person the biophysical parameters of deformation properties of red blood cells are stable.

Exercise is a stimulus to increase the activity of catecholamines, glucocorticoids and other biologically active substances. In its implementation is an increase in body temperature, a decrease in blood pH, change in the transition temperature of the lipid layer of the cell membrane, which leads to a change in the function of membrane receptors, structural and functional changes of the cell membranes. After cardiorespiratory exercise testing in patients with asthma with varying degrees of severity observed different reactions of ER to the load: the more difficult the case is, the more pronounced was the loss of the charge on the membrane, the growth on her gradient potential increase in membrane permeability and the sorption capacity of red blood cells, the deepening of hypoxic anisotropy serum the blood, increasing the percentage of deformed shapes.

Conclusions. *As a result of this work it was first studied and compared changes in biophysical parameters of red blood cells in patients with bronchial asthma with varying degrees of severity of the disease under the influence of physical activity. For the first time assessed values change deformability and osmotic stability of the cells, the degree of deformation and the crystal-optical characteristics of the serum under the influence of implementation of the maximum load, depending on the severity of asthma. It was found that physical activity leads to a deterioration already changed deformability and osmotic stability of red blood cells, enhances hypoxic anisotropy serum, indicating the exhaustion of compensatory mechanisms ER rheological link capacity of the blood, and it depends on the severity of asthma. Given the findings in the future, it is necessary to improve methods of treatment and rehabilitation of patients with asthma taking into account the results obtained.*

Key words: *bronchial asthma in adults, blood rheology, biophysical parameters of erythrocyte membranes, morphological and functional characteristics of red blood cells, exercise.*

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