EXPERIMENTAL METHODS FOR CLINICAL PRACTICE

Effect of Photohemotherapy with a Low-Energy Helium-Neon Laser on Blood Fluidity in Patients with Bronchial Asthma of Infectious-Allergic Origin

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It is shown that hemorheological disorders contribute to the pathogenesis of infectious-allergic asthma. Positive effects of laser therapy are associated with improved blood fluidity.

Key Words: *bronchial asthma; blood viscosity; phototherapy*

Although a great variety of preparations acting on all pathogenic components of asthma are available at the present time, drug therapy is often ineffective particularly when this respiratory disorder develops against the background of emphysema and diffuse pneumosclerosis accompanied by chronic respiratory insufficiency.

A decrease in blood fluidity occurring in asthma is quite often underestimated. Chronic obstructive lung diseases are characterized by polycythemia, high blood viscosity, and low erythrocyte elasticity [4,5]. A high erythrocyte count, as a consequence of adaptation to chronic oxygen deficiency, results in an increase in blood viscosity. This has a number of adverse effects on the circulatory system: blood flow, venous return, stroke and minute volume decrease, while systemic and pulmonary vascular resistance increases. Previously, it was shown that in chronic obstructive lung disease the elasticity (deformability) of erythrocytes is reduced [3]. This leads to obstruction of the capillary bed and metabolic disorders in organs and tissues. In the lungs, gas exchange is impaired and vascular resistance is increased. A combination of decreased erythrocyte elasticity and high hematocrit is particularly harmful for the organism. With normal erythrocytes, blood retains its fluidity even when the hematocrit is as high as 95%; however, if the erythrocyte rigidity increases, blood retains normal fluidity at hematocrit <60% [1].

The above observations were confirmed by experimental and clinical studies. An decrease in blood fluidity achieved in patients with cor pulmonale, chronic bronchitis, or emphysema by normovolemic hemodilution improved blood flow in pulmonary arteries and aorta, reduced blood pressure, decreased pulmonary and systemic vascular resistance, and increased oxygenation of arterial blood [6-8].

Thus, blood fluidity should be taken into consideration in chronic respiratory disorders and be corrected if necessary. None of the available drugs has any appreciable effect on blood fluidity. Positive effects were attained by cytopheresis and long-term oxygen therapy. Recently, it has been demonstrated that blood fluidity can be increased with a helium-neon laser radiation. The aim of the present study was to evaluate the effectiveness of laser photohemotherapy in patients with asthma.

MATERIALS AND METHODS

The study included 18 patients hospitalized after ineffective outpatient treatment. All of them suffered from complicated infectious-allergic asthma (Table 1).

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Laser therapy was started after 7-10 days of drug therapy including corticosteroids. It consisted of 4-6 blood irradiation procedures performed every other day. Blood (150-200 ml) was drawn from the cubital vein into sterile flask with heparin (5000 U). Reinfusion was started immediately after irradiation (1 mW/cm^2) which was carried out in a transparent plastic tube placed in an Isolda-ELOK apparatus. A low-energy helium-neon laser served as a source of radiation. Blood was reinfused within a 30-min period.

Blood viscosity was measured before blood exfusion and 5 min after reinfusion in a Low Shear-30 rotary viscosimeter, shear rate ranging from 1.285 sec^{-1} to 128.5 sec^{-1}.

Plasma viscosity was measured at a shear rate of 128.5 sec^{-1} at 37°C.

Hematocrit was determined in an Autocrit centrifuge. In addition, the effect of laser therapy on platelet aggregation was measured in an Elvi-840 aggregometer using the following platelet activators: ATP (2×10^{-5} M), epinephrine (5×10^{-6} M), ristomycin (1.5 mg/ml), and heparin (10 U).

RESULTS

Blood viscosity was increased in 16 out of 18 patients (89%), the increase being particularly high in 5 patients (Table 1). Alterations of blood viscosity were not related to sex and age of the patients, duration of asthma, and secondary disease. Hematocrit was normal only in 4 patients, while 14 patients had various degrees of polycythemia. Moderately elevated hematocrit cannot be regarded as a unique cause of the considerable increase in blood viscosity. Measurements of plasma viscosity showed abnormal values in 14 patients, the mean value in 18 patients being 1.51±0.04 cP (the normal range is 1.23-1.27 cP). Plasma viscosity was particularly high (1.60-1.72 cP) in asthmatic patients with ischemic heart disease. The absence of correlation between plasma and blood viscosities suggests that an increase in blood viscosity results from pathological aggregation and low elasticity of erythrocytes.

Immediately after reinfusion, the following changes were recorded: 1) reduction in blood viscosity by

TABLE 1. Alterations in Blood Viscosity (cP) and Hematocrit (HC) in Patients with Infectious-Allergic Asthma Complicated by Chronic Respiratory Insufficiency After Reinfusion of Autologous Blood Irradiated with Helium-Neon Laser

Patient No.	Degree of respiratory insufficiency	Associated disease	Age in years	Sex	Duration of asthma	Before irradiation			After irradiation		
						blood viscosity at indicated shear rates, sec^{-1}		HC, %	blood viscosity at indicated shear rates, sec^{-1}		HC, %
						1.285	128.5		1.285	128.5	
1	II	IHD	72	m	12	47.0	6.13	50	32.2	4.96	48
2	I	—	25	m	12	37.3	6.08	53	32.4	5.67	50
3	II	IHD	56	m	3	45.4	6.34	53	34.8	5.64	50
4	I	Chronic hepatitis	40	m	20	35.64	4.76	50	30.1	4.63*	50
5	II	IHD	73	m	20	29.2*	4.40*	48	23.5*	4.34*	48
6	II	IHD	69	m	15	38.0	5.45	50	31.3	4.62*	48
7	I	IHD	50	w	25	33.1	5.30	49	26.2*	4.81	47
8	II	Acute pneumonia	34	w	14	36.2	4.81	49	26.8*	4.22*	47
9	II	Hypertension	47	m	7	40.1	5.61	49	34.8	5.25	48
10	I	—	59	w	10	30.9	4.50	45*	27.4*	4.27*	44*
11	II	—	40	w	10	39.7	5.24	50	30.2	4.84	49
12	I	IHD	43	m	5	42.1	6.13	53	28.3*	5.01	49
13	II	—	40	m	12	42.0	5.01	51	20.3*	4.26*	47*
14	II	—	65	m	9	31.6	4.83	47*	27.5*	4.14*	45*
15	I	—	57	w	7	45.4	6.60	57	33.2	5.58	54
16	II	Hypertension	58	w	6	34.0	4.84	44*	23.5*	4.04*	43*
17	II	IHD	71	w	12	34.8	4.76	49	29.9	4.20*	47
18	II	—	41	w	30	21.8*	3.70*	41*	21.1*	3.36*	40*
Mean						36.90±1.51	5.25±0.18	49.33±0.86	28.52±1.03	4.66±0.15	47.44±0.73

Note. IHD = ischemic heart disease. *The value is within physiological range.

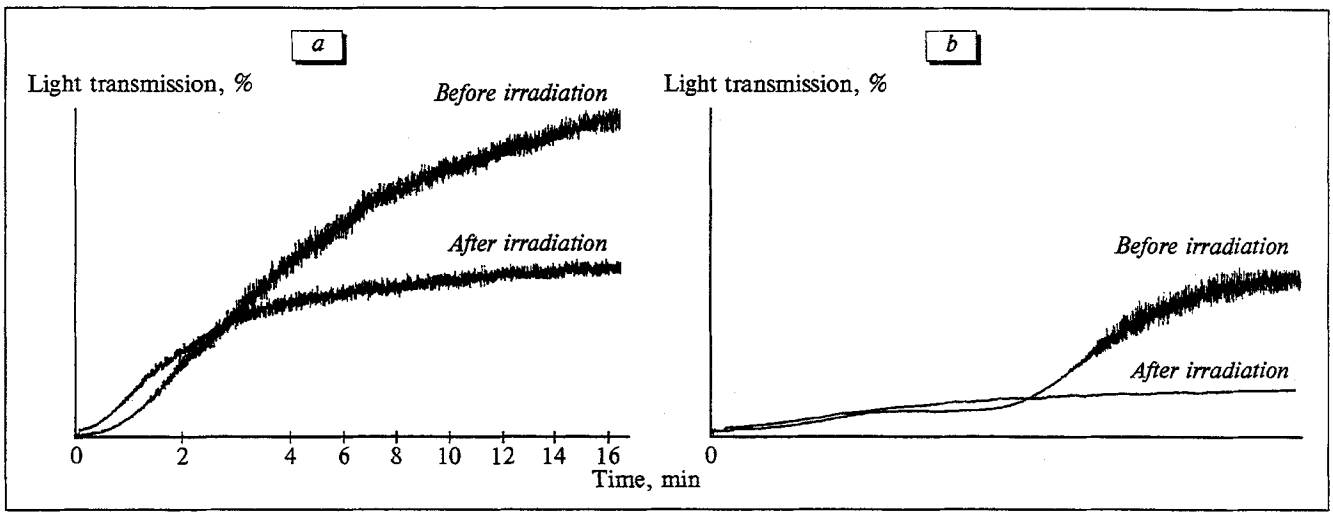

Fig. 1. Platelet aggregating activity immediately after infusion of autologous blood irradiated with a helium-neon laser. Epinephrine (5×10^{-6} M, *a*) and heparin (10 U, *b*) were used as platelet activators.

18-30% at a low shear rate; 2) reduction in blood viscosity by 2-15% at a high shear rate; 3) decrease in hematocrit by 2-7%; 4) reduction in plasma viscosity by 5-14%; and 5) decrease in blood hemoglobin concentration corresponding to a decrease in hematocrit. These changes varied even in the same patient during the course of laser therapy, although the irradiation procedures were standard.

The most plausible explanation of these changes is endogenous hemodilution with interstitial fluid. Obviously, this is associated with changes in the links of the hormonal regulation — vascular permeability — transcapillary fluid exchange chain.

However, all the above-mentioned changes were transient: plasma viscosity and hemoglobin concentration returned to their initial values after 24 h. Blood viscosity and hematocrit also increased, but usually did not reach the initial values. Blood viscosity progressively decreased in a stepwise manner during the course of laser therapy and reached normal values in 10 patients after its completion. On average, blood viscosity decreased by 23% at a low shear rate and by 11% at a high shear rate. Such changes can be regarded as substantial.

Plasma viscosity did not change significantly after the course of laser therapy (it even rose slightly in some patients). Consequently, changes in blood viscosity are due to a decrease in hematocrit and degree of blood structurization at a low shear rate and an increase in erythrocyte elasticity at a high shear rate. However, the role of hematocrit is unclear. Since the life-span of erythrocytes is 80-120 days, it seems unlikely that inhibition of erythropoiesis is caused by reduction in respiratory insufficiency (analogously with long-term oxygen therapy). The erythrocytes were neither damaged nor destroyed, as evidenced by the absence of free hemoglobin from the plasma in all patients. Therefore, an increase in the erythrocyte elasticity is plausible. Upon centrifugation, which is used to determine hematocrit, elastic erythrocytes are more densely packed and occupy less space.

Increased blood fluidity undoubtedly improved pulmonary function and general condition of asthmatic patients.

Inhibition of platelet aggregation is another beneficial effect achieved by laser therapy.

Before drug therapy, aggregating activity of platelets from the patients was very high. After reinfusion of irradiated blood, the rate of platelet aggregation increased, while the maximum aggregation and the size of aggregates decreased considerably (Fig. 1, *a*, *b*). Subsequently, platelet aggregation remained low, which may be a consequence of drug therapy. Nevertheless, laser therapy had obviously a strong effect on platelet aggregation. It is believed [2] that platelets play an important, if not decisive, role in the origin and maintenance of bronchospasm and the associated inflammatory reactions in the airways and lungs in both immune and nonimmune forms of bronchial asthma. It should be noted that high platelet aggregating activity often coincides with spontaneous aggregation and occlusion of the microcirculatory bed.

Thus, irradiation of blood with a helium-neon laser improved the condition of asthmatic patients: it reduced the occurrence and severity of attacks, increased the sensitivity to glucocorticoids in hormone-resistant patients, and improved the drainage function of the lungs. In patients with ischemic heart disease, the number of pain attacks decreased so that the daily nitroglycerin dose was diminished.

The beneficial effects of laser therapy can be attributed to the improvement of blood fluidity.

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Pituitary-Adrenal and Sympathetic-Adrenal Systems in Patients with Complicated Spinal Trauma

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Plasma contents of catecholamines and cortisol are measured in patients with spinal trauma and spinal cord injury by high-performance liquid chromatography and radioimmunoassay. Compared with healthy donors and patients with skull injury, the epinephrine content in spinal patients is increased significantly, while the cortisol content shows a tendency toward an increase. This suggests that disturbances both in the transmitter and hormonal systems persist 2-3 weeks after trauma, complicating its treatment.

Key Words: *blood cortisol and catecholamines; spinal and spinal cord trauma*

Generalization of stress reaction may have adverse consequences and complicate the primary disease. The ratio between the transmitter and hormonal regulation determines the nature of nonspecific adaptation syndrome. In light of this, it was interesting to assess the functional state of the adrenals and the activity of the sympathetic-adrenal system. In the present study we investigated plasma contents of catecholamines (transmitter component) and cortisol (hormonal component) in stress reaction.

MATERIALS AND METHODS

The study included patients with complicated spinal trauma (1.5-2 months after trauma, group 1), patients no longer than 1 week (group 2) and 2-3 weeks (group 3) after craniocerebral trauma (CCT), and healthy donors (control, group 4). Plasma samples were stored at -50°C. The content of glucocorticoids was determined by radioimmunoassay using highly specific antiserum [4]. Catecholamines (epinephrine, norepinephrine, and dopamine) were assayed by high-performance liquid chromatography in a Beckman apparatus with a BAS electrochemical detector. The data were analyzed using the Student's t test.

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RESULTS

In patients with complicated spinal trauma (group 1), plasma epinephrine content was significantly increased, while the norepinephrine and dopamine contents were close to normal (Table 1). The cortisol content was higher than in healthy donors (group 4) and patients with CCT (groups 2 and 3). In patients with CCT, plasma cortisol concentration decreased, the decrease being statistically significant in group 3 patients. In patients with the central nervous system (CNS) trauma, changes in the hormonal and transmitter components were related to each other, which was not observed in patients with CCT and spinal patients at the same period after trauma (2 weeks).

It is known that in patients with the CNS trauma blood levels of catecholamines depend on the time

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