i.e., it characterizes the changes in lipid-lipid interaction. The shift of this break point to the low-temperature region under the influence of ADP, aspirin, and α-tocopherol indicates the effect of these compounds on the platelet membrane phospholipid regions. A high-temperature break point in the presence of aspirin and α-tocopherol is likely to appear as a result of their influence on protein-lipid interactions, since a high-temperature transition is currently thought to depend upon the protein-lipid interactions, as has been determined by an erythrocyte membrane study [1].

Evidently, both inhibitors affect the cyclooxygenase pathway of arachidonic acid metabolism. Aspirin has been shown to block cyclooxygenase activity by enzyme acetylation, while α-tocopherol, due to its antioxidant properties, is able to compete with the enzyme for oxygen binding. Besides, α-tocopherol when inserted in the platelet membrane, reduces the latter structural flexibility and increases the local bilayer's microviscosity, just as cholesterol does [3].

Possibly, the metabolic processes dependent on membrane fluidity are inhibited in this case. Therefore, α-tocopherol, apart from its structural-functional role, seems to be directly involved in metabolism regulation, namely, in blocking the synthesis of endoperoxides, prostaglandins and thromboxane A_2 by the uptake of oxygen.

Since the data concerning with a significant drop of the malonic dialdehyde level confirm the effect of aspirin on platelet membrane metabolism, and taking into account the slight effect of α-tocopherol on malonic dialdehyde formation, it is more likely that α-tocopherol has a predominant effect on the structural properties of the platelet membrane.

LITERATURE CITED

1. A.N.Goloshchapov, and E.B.Burlakova, [in Russian] *Biofizika* **20**, 816 (1975).
2. S.V.Konev , I.D.Volotovskii, *Biomembranes:Structure, Function and Methods of Investigation.* [in Russian] Riga, 42 (1977).
3. T.I.Torkhovskaya, L.G.Artemova, B.G.Khodzhakuliev, *et al.* [in Russian] *Byull.Eksp.Biol.* 675-680.(1980).
4. A.Gaarder, and S.Lalend, *Nature*, **202**, 909 (1964).
5. M.Hamberg, *Proc. Nat. Acad. Sci. USA.* **71**, 3824 (1974).
6. K.Ohki, A.Imai, Y.Nozawa, *Biochem. Biophys. Res. Commun.*, **94**, 1249 (1980).
7. R.P.Rubin, *Pharmacol. Rev.*, **22**, 389 (1970).
8. M.Steiner, *Biochim. Biophys. Acta.*, **640**, 100-105 (1981).

0007-4888/93/0001-0016$12.50

The Effect on the Blood of Prolonged Mortal Hypoxia Endurance under the Extracorporeal Influence of a Magnetic Field

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UDC 615.847.8:615.4:612.1].07

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 115, No. 1, pp. 17-20, January, 1993
Original article submitted July 15, 1992.

Key Words: *hypoxia; magnetic field; canine blood.*

Among the great number of studies of the influence of a constant magnetic field on the organism [1-3, 11], there are only a few concerning the antihypoxic effect of this factor [5,6]. There is no consensus in these studies, because the analyzed results were obtained under the influence of the magnetic field on the whole organism. At the same time it is known that, depending on the functional state of the organism and the preferential action of that factor on different regions (the head - the central nervous system, the adrenal sphere - the endocrine system, the main blood vessels, the parenchyma, *etc.*), the integral direction of all the physiological reactions can vary greatly: in some cases an antihypoxic effect is shown, while in others, the opposite result is achieved [7,8,10].

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In this connection the investigation of the mediated (through the blood) influence of a magnetic field on the organism under extreme conditions is of special interest. It is possible that the blood, as a liquid tissue with universal gas-transporting, metabolic-energetic and protective properties, when subjected to the influence of a magnetic field during circulation in the extracorporeal contour, can have a definite effect on the organism in a state of severe hypoxia. In that case the accessory (often negative) direct influence of the magnetic field on the vital organs and systems can be eliminated [4, 12].

In the present study we aimed to investigate the effect of the prolonged endurance of the state of mortal hypoxia under the extracorporeal influence of a magnetic field on the blood.

MATERIAL AND METHODS

The two series of experiments were carried out on dogs of both sexes weighing 7-10 kg. In the control (23 dogs) and main (15 dogs) series the animals anesthesized with ketamine (3-4 mg/kg) and the muscle relaxant ditiline (1 mg/kg) were intubated and placed on artificial lung ventilation (ALV) using an RO-6 apparatus; through access to the femoral and jugular veins a veno-venous shunt was applied for drainage and blood transport with the aid of a pump (AT-1 apparatus) and taigon communications from the vena cava inferior to the right auricle. The filling volume of the extracorporeal system (ECS) with isotonic solution was 150 ml; the volume blood flow rate in the shunt was 20-25 ml/min per 1 kg of weight.

In the main series the ECS main line was placed between magnet plates, creating a constant field with induction 0.1-0.5 Tl for blood treatment.

After the stabilization of homeostasis indications under ALV, the animals were twice placed in a state of hypoxia during the experimental period: in the first cycle ALV was turned off and the clamp was applied to the intubation tube after a 2-min delivery of O_2 to the contour of RO-6; then after 9-10 min, ALV was restored and complete recovery of homeostasis was achieved. After 30-50 min the second cycle of hypoxia was started: the sequence of operations was the same, but after 10 min of hypoxia ALV was not renewed and the animal was brought to the critical state, i.e., clinical death, after which attempts were made to revive the vital functions by the renewal of ALV with O_2 and by closed massage of the heart.

In the main series during the first and second cycles of hypoxia the treatment of blood circulating in the extracorporeal contour by the magnetic field was conducted in the following sequence: 20-25 min before delivery of oxygen to the ALV contour, during 2 minutes of O_2 respiration, and during the whole period of hypoxia.

The state of the animal was estimated on the basis of the gas content in the arterial and venous blood (pO_2, HbO_2 , A-V difference in O_2), the indicators of the acid-base equilibrium (ABE), arterial pressure in the aorta (AP), and the central venous pressure (CVP).

The investigations were conducted with an AME-1 ABE-analyzer (Radiometer, Denmark), an oxiator (Elemer, Sweden), and a Mingograph-82.

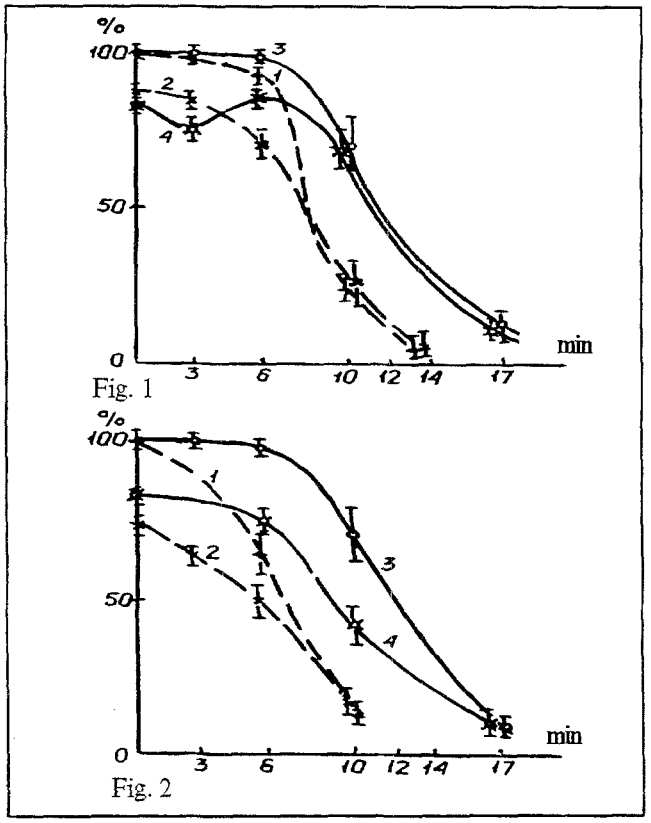

Fig. 1

Fig. 2

Fig.1. Changes in arterial and venous blood saturation with oxygen (HbO_2a, HbO_2v) in control and main series of experiments in the first cycle of hypoxia. O: after 2-min O_2 respiration; 3, 6, 10, 17: after 3, 6, 10, and 17 min of hypoxia. 1) HbO_2a, 2) HbO_2v in control series; 3) HbO_2a, 4) HbO_2v in main series.

Fig.2. The same values in the second cycle of hypoxia (designations are the same).

The determination of the blood indexes (gases, ABE) were conducted after the premedication and anesthesia during ALV (basic data); in the first cycle of hypoxia: after 2 min of respiration with O_2 and on the 3rd, 6th, and 9-10th min of hypoxia; in the second cycle of hypoxia: after 2 min of respiration with O_2 and on the 3rd, 6th, 10th, 13th, and 17-19th min of hypoxia.

RESULTS

During the evaluation of the effect of a mediated (through the blood) influence of a constant magnetic field on the organism under conditions of severe (mortal) hypoxia, the experimental peculiarities should be taken

into account. They consist in the fact that the animal was subjected to hypoxia twice during a single experiment. At the beginning, after ALV was turned off, against the background of myorelaxation the animal endured the first cycle of hypoxia, lasting not longer than 9-10 min, and subsequent rehabilitation during 30-50 min; then the second cycle of hypoxia took place, leading to the critical state. The life span after the second hypoxia was influenced by the presence or absence of the factor investigated (the extracorporeal "magnitizing" of the blood by the constant magnetic field).

The comparison of the indicators of blood saturation with oxygen (HbO_2) and its partial pressure (pO_2) in the arterial and venous blood during the first 10 min of apnea after O_2 respiration during 2 min showed definite differences in the course of the first and the second hypoxia in the control experiments and under the magnetic field (Fig. 1,2).

The comparison of the data in the 10th minute of hypoxia is especially demonstrative. In the control series the mean values of HbO_2 and pO_2 in the first cycle were: in the artery 13±2% and 19±1 mm Hg, and in the vein 16±1% and 23±1 mm Hg, respectively; in the second cycle they were: in the artery 26±4% and 32±3 mm Hg and in the vein 28±5% and 32±3 mm Hg, respectively. A tendency for these indicators to increase was noted ($p<0.05$).

Under the influence of the magnetic field on the blood circulating in the extracorporeal contour during 30-40 min, the differences between the blood gases values in the main and control series during the first as well as the second cycle of hypoxia were more expressed and had a distinct tendency to increase. Thus, in the main series in the 10th minute of hypoxia the HbO_2 and pO2 data proved to be in the first cycle: in the artery 70±10% and 64±10 mm Hg, and in the vein 68±5% and 44±4 mm Hg; in the second cycle: in the artery 70±10% and 60±10 mm Hg, and in the vein 43±6% and 37±2 mm Hg. Against the background of a high O_2 content in the arterial and venous blood a higher level of the arterio-venous difference in O_2 in the second cycle could also be observed.

The pattern of AP changes in the course of hypoxia development during the first and second cycle in the main as well as in the control series was typical for this state. However, in the main series the hypoxic rise of AP did not peak so rapidly and the drop to critically low values occurred more slowly: the curve of the rise and the fall of this indicator was more gently sloping. Thus, in the control series during the second cycle of hypoxia AP after 3, 6, 10, and 13-14 min turned out to be 120±21, 170±25, 70±10 and 20±0 mm Hg, respectively; in the main series after 3, 6, 10, 13 ,16, and 17-19 min AP was maintained at 110±32, 125±27, 50±15, 25±5 and 20±0 mm Hg.

The data attest to a remarkable tolerance of animals subjected to the extracorporeal influence of a magnetic field on the blood, a fact which is supported by the integral indication, namely the longer life span of these animals after the second cycle of hypoxia.

In the absence of influence of a magnetic field, the HbO_2 and pO_2 values in the arterial and venous blood became equal at the critically low figures within 9-10 min, after which a rapid (in 1-3 min) fall to zero took place.

The "magnitizing" of the blood led to a prolongation of the "critical point" period in the blood gases of up to 14-15 min and to a delay of the AP fall to zero, i.e. the event of clinical death, of up to 17-19 min. It is striking that in the main series of experiments even after such a long period of hypoxia the extra measures taken to bring the animal out of the state of clinical death were successful in 11 cases out of 15, and the animals remained alive.

Obviously the effect of prolonged endurance of mortal hypoxia depends entirely on the blood-mediated influence of the constant magnetic field on the organism. At the same time, it should not be forgotten that in these experiments O_2 was supplied to the lungs for a short period (2 min) before the start of hypoxia. Thus, the conditions were set for a simultaneous influence of the two factors during a short period: the constant magnetic field with the induction of 0.1-0.5 Tl and the supplementary source of O_2 coming from delivery during ALV. The period of the influence of the magnetic field on the blood circulating in the extracorporeal contour with the volume flow rate of 20-25 ml/min kg was only 30-45 min and continued for some time before the supply of O_2 (20-25 min) and after it was turned off (during the development of hypoxia).

Since the effect of prolongation of the period of mortal hypoxia endurance was achieved owing to the influence of the magnetic field only on the blood and not on the whole organism, so it may be connected only with the changes occurring in the blood after the "magnitizing."

What are these changes? Naturally, a positive effect of a constant magnetic field on the gas-transporting function of the blood is possible. The higher level of HbO_2 and pO_2 during the first as well as the second cycle of hypoxia in the main series in comparison to the control series of experiments speaks in favor of this suggestion. The later onset of the "critical point" in the gases i.e., the equalization of the arterial and venous blood saturation with O_2 on an extremely low level (10-20%), is further evidence.

Among the possible ways of variation of the gas-transporting function in the blood, one that is notable depends upon the conformational change of hemoglobin from the less active T-form to the more active S-

form. This mode of alteration of the oxygen capacity of the blood has not been studied sufficiently.

Together with the main mechanism underlying the gas homeostasis of the organism, a mediated (through the blood) influence of a magnetic field due to changes in the rheological properties of the blood and neurohumoral factors [9,10] is not excluded.

It may be assumed that such a complex influence of several factors accompanying the extracorporeal "magnitizing" of the blood lies at the basis of the effect of a prolonged period of mortal hypoxia endurance.

LITERATURE CITED

1. V. M. Bogomolov, *Vopr. Kurortol.*, No. 4, 2-8 (1981).
2. L. S. Juckson and I. L. Brandt, *Trudy Kazan. Nauchno-Issled. Inst. Klin. Eksp. Khirurgii*, No. 37, 76-80 (1986).
3. B. N. Zhukov, L. A. Trufanov, and S. M. Musienko, *Vopr. Kurortol.*, No. 1, 27-30 (1984).
4. L. D. Klimovskaya, Z. N. Nakhil'nitskaya, and N. P. Smirnova, *Probl. of Kosm. Biol*, **37**, 223- 225 (1980).
5. G. V. Lud, G.V., *Zdravookhr. i Belorussii*, No. 8, 47-49 (1986).
6. Z. N. Nakhil`nitskaya, *Probl. Kosm. Biol.*, **37**, 116-124 (1978).
7. Yu. A. Novikov, *Anesteziol. Reanimatol.*, No. 3, 21-23 (1982).
8. V. L. Semenov, *Patol. Fiziol.*, No.1, 56-61 (1987).
9. L. I. Tyvin and V. A. Gusel, *Byull. Eksp. Biol.*, No. 9, 29-31 (1985).
10. Yu. A. Kholodov, Magnetism in Biology [in Russian], Moscow (1970).
11. M. M. Yakovleva, Physiological Mechanisms of the Effect of the Electromagnetic Fields [in Russian], Leningrad (1973).
12. B. Grinet, and Makowski, *Acta Physiol. Polonica*, **30**, No. 1, 10-11 (1972).

0007-4888/93/0001-0019$12.50

Significance of the Pleura in the Breathing Mechanism

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UDC 616.24-008.4-092:616.25

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, No. 1, pp. 20-21, January, 1993
Original article submitted July 10, 1992.

Key Words: *pleura; breathing mechanism; transpulmonary pressure; respiratory activity; lung elasticity*

Obstructive therapy of breathing mechanism disturbances constitutes the essence of the modern notion of obstructive syndrome pathogenesis. At the basis of this theory lies the Donders paradigm of the view on the breathing mechanism, in which the lungs are considered as a passive elastic body, whose mechanical movements are conditioned by the influence of forces exerted by the thorax and diaphragm [4]. Clinical and experimental investigations of the breathing mechanism have revealed a number of paradoxical observations which do not fit into the paradigm and thus invite a critical attitude toward it [3]. One of these consists in the fact that under the conditions of the Donders experiment an increase in hysteresis occurs and lung elasticity is reduced [1]. The paradoxical phenomena in the breathing mechanism have been studied from the standpoint of the lung mechanical activity theory [2]. The insufficiently studied role of the pleural cavity in the transmission of mechanical force to the lung surface remains a problem.

TABLE 1. Breathing Mechanism Indicators in Life, 60 min after Cessation of Respiration and in the Donders Bell (M+m)

Indicator	in life (n=14)	in the box (n=8)	in the bell (n=7)
MVR, liters/min	0,94±0,17	0,90±0,16	1,0±0,2
TRA, kg·cm/min	3,8±0,6	5,4±1,3	12,0±2,8
SRA, kg·cm/min	4,04±0,29	5,61±0,52*	11,23±0,99*
Ael, kg·cm/min	1,92±0,26	3,40±0,96	4,84±1,02*
Wel/TRA, %	50,5±13,9	62,6±18,3	39,9±20,0
NRA, kg·cm/min	2,92±0,47	4,12±0,82	10,8±2,7*
NRAin, kg·cm/min	1,76±0,42	1,63±0,38	4,59±1,55*
NRAex, kg·cm/min	1,05±0,12	2,15±0,73	3,49±0,87*
NRAact	0,12±0,05	0,82±0,33*	2,72±0,60*
Sdyn, m/cm water	6,0±0,6	3,8±0,7	3,7±1,1

Note. Asterisk - the values are given with $p<0.05$ in comparison to the first indication during the vital period.

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