MORPHOLOGY AND PATHOMORPHOLOGY

Magnetic Shielding of the Brain in the Vertebrates

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A model of magnetic shielding of the brain and spinal cord in the vertebrates has been suggested. Endogenous magnetic field in this model is formed at the expense of directed transposition of charged blood erythrocytes in the circular venous collectors involving various compartments of the central nervous system. Detected changes in the levels of corticosteroids, erythrocyte count, blood viscosity, hematocrit, and clotting system during exposure to a magnetic field indicate that magnetic shielding is part of the defense and adaptive reaction complex.

Key Words: *venous collectors; magnetic shielding; defense and adaptive reactions; corticosteroids*

Magnetic field (MF) regulates synaptic transfer of nerve impulses and disturbs this process if its threshold value is surpassed [1], which occurs during magnetic storms and under the effect of technogenic fields and may cause the homeostasis disorders. The central nervous system should be protected from MF. We investigated the mechanisms of magnetic shielding of the brain and spine in the vertebrates.

MATERIALS AND METHODS

Venous collectors of the brain and spine were examined in rodents, predators, and humans by the corrosion method using Protacryl M plastic. Changes in erythrocyte counts, blood viscosity, hematocrit, and clotting system were studied in albino rats. Routine methods with the use of Goryaev's chamber, Shklyar's centrifuge, physical viscosimeter, and N-234 electrocoagulographer were employed. The hormonal activity of the adrenal cortex was evaluated by the blood level of 17-oxycorticosteroids (17-OCS) measured in a Hitachi MDF-4 fluorescent spectrophotometer. Magnetic fields were simulated using the Helmholtz rings.

RESULTS

Study of the spatial mutual disposition of venous collectors of the brain and spine [2] showed circular and semicircular structures: 1) upper and lower sagittal

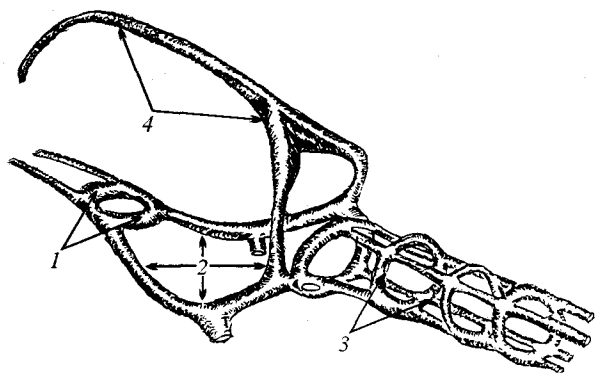

Fig. 1. Structure of venous collectors of the brain and spine of vertebrates. *1*) annular structure formed by cavernous sinuses and intercavernous anastomoses; *2*) annular structure formed by transverse and stony sinuses; *3*) annular structure formed by veins of the internal vertebral plexus; *4*) semicircular structure formed by the upper sagittal sinus.

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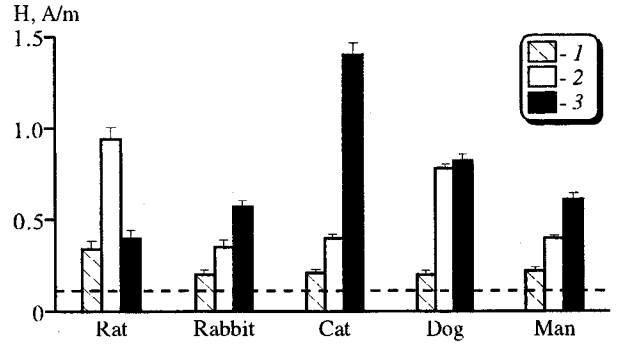

Fig. 2. Parameters of the magnetic screen of the central nervous system of vertebrates. Field formed by the sagittal and transverse sinuses (*1*); sagittal and cavernous sinuses (*2*) and veins of the vertebral plexus (*3*). Broken line shows the fluctuations of the geomagnetic field.

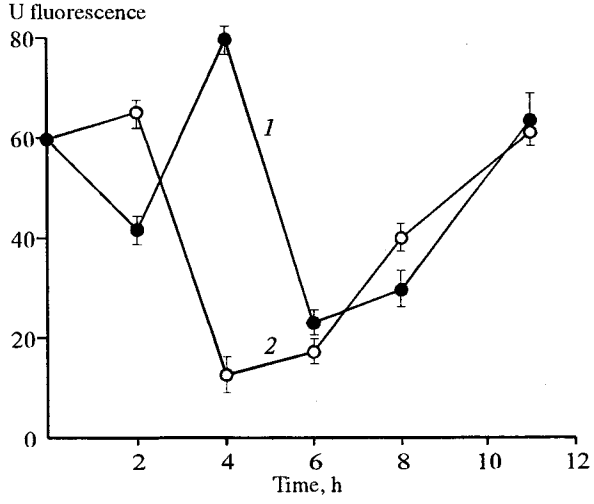

Fig. 3. Time course of blood 17-oxycorticosteroids in albino rats exposed to alternating magnetic field of low intensity (1) and in the control (2).

sinuses shaped as a vertical semicircle; 2) transverse and stony sinuses shaped as horizontal rings and encircling the brain stem; 3) cavernous sinuses with anastomoses connecting them were observed round the pituitary. The spinal veins formed vascular rings round the spinal cord (Fig. 1). They were formed by transverse anastomoses connecting longitudinal stems of the anterior and posterior plexuses. The detected regularity in the structure of venous collectors of the brain and spine served as morphological basis for modeling the magnetic screen of the CNS in the vertebrates. Directed transposition of charged erythrocytes in these circular structures formed an MF, compensating the fluctuation of the external MF. The intensity of endogenous MF was calculated from the following formula: $H=I/2R$, where R is the radius of circular conductor and I is the current, generated by erythrocytes moving in a reservoir. The current was calculated as $I=qnV\Delta S$, where q is erythrocyte charge, n is the erythrocyte count, V is the velocity of the charge carriers, and Δs is the area of the reservoir section.

The estimated values of endogenous MF formed by vascular structures were consistent with the parameters of a magnetic storm (H=0.08 A/m), indicating the probability of a magnetic screen (Fig. 2). The adaptive potential of shielding was based on increasing intensity of endogenous MF due to increase in the erythrocyte count and blood flow rate in the collectors. However, these changes were observed only in response to any environmental stimulus. This suggests that the magnetic shielding of the CNS is a component of a defense and adaptation reaction be assessed by the release of corticosteroids anticipates the development of these reactions [3]. Therefore, blood level of 17-OCS was measured in albino rats exposed to alternating MF. The concentration of corticosteroids increased in

TABLE 1. Blood Parameters of Albino Rats Exposed to Magnetic Fluctuations

Time, h		Endogenous MF tension, E*	Erythrocyte concentration, 10^{12}/liter	Blood viscosity, arb. U	Hematocrit, %	Prothrombin time, sec	Thrombin time, sec	Blood clot lysis time, min
Control	0	0.5	3.56	4.0	46.0	44±11	49±9	7.5±1.0
	2	1.1	3.68	4.4	49.3	42±4	55±1	8.1±1.3
	3	1.4	3.63	4.3	49.5	43±5	54±3	9.0±1.1
	4	2.3	3.64	4.3	48.5	44±5	50±2	9.0±0.9
	5	0.5	3.57	3.8	45.6	43±4	54±4	9.2±1.0
Experiment	0	0.5	3.56	4.0	46.0	44±11	49±9	7.5±1.0
	2	1.1	3.60	4.1	46.0	40±6	29±4	8.0±1.2
	3	1.4	3.98	4.5	45.6	41±6	30±4	8.5±1.0
	4	2.3	4.15	9.7	54.2	47±6	170±5	19.0±1.3
	5	0.5	4.73	15.0	66.7	46±6	50±5	not

Note. *E: Oersted (1 E=79.58 A/m).

parallel with the increase in the MF intensity, reaching the maximum at the point of the maximum magnetic fluctuation (Fig. 3). Changes in the level of 17-OCS were associated with an increase in the adrenal gland weight as a result of plethora. True cellular and nuclear hypotrophy developed no earlier than 9-12 h from the beginning of exposure to the stress factor [4,5]. Analysis of the time course of blood parameters of rats exposed to alternating MF revealed an irregular increase in the count of erythrocytes, hematocrit, blood viscosity, prothrombin and thrombin times, and blood clot lysis at the moment of the maximum release of corticosteroids (Table 1).

In elderly subjects with somatic diseases, pathological shifts in the function of the above-mentioned organs and systems may lead to a decrease in the level of defense from MF and disorder the homeostasis. Understanding of the mechanisms of magnetic shielding will help develop and substantiate the methods for preventing these disorders.

Our studies demonstrate magnetic shielding of the CNS in vertebrates as a manifestation of the complex of defense and adaptive reactions in mammals and in man.

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