Reduction of Blood Trauma in Electromagnetic Field *In Vitro*

Sh. S. Tashaev, N. V. Stogova, V. I. Tsyura, S. A. Aganezov, O. V. Galibin, and A. R. Os'mak

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 123, No. 1, pp. 33-35, January, 1997
Original article submitted October 27, 1995

Effects of altering geomagnetic field and rotating electromagnetic field on the stability of blood formed elements are studied under the following conditions: circulation of whole blood in an artificial closed circuit and blood bubbling with N_2. The frequency of magnetic field markedly affects all studied parameters of the blood.

Key Words: *magnetic field; resistance; hemoglobin; erythrocytes; extracorporeal circulation*

Blood trauma to the blood caused by extracorporeal circulation may induce a number of serious disorders. For example, damage to blood cells is one of the factors giving rise and aggravating the postperfusion pulmonary syndrome [1]. Blood trauma has been diminished by improving the performance of the artificial circulation device (ACD) and pharmacological modification of blood properties and organism's functions. Electromagnetic field (EMF) may increase blood resistance *in vitro*. The effects of EMF and geomagnetic field (GMF) on the organism [3,4] and on the blood [2] have been documented.

The purpose of this study was to find out how EMF changes the resistance of blood cells *in vitro*.

MATERIALS AND METHODS

Blood was collected from 29 mongrel male dogs weighing 14±2 kg. After premedication with kalipsol (50 mg/kg) and droperidol (1 mg/kg), the femoral vein was exposed in the upper third of the femur under intravenous thiopental anesthesia and sterile conditions, and blood was drawn into standard 250-ml vials with Glugicir from the inferior vena cava via a catheter inserted into it through the femoral vein. In the first series of experiments, blood was run through an ACD for 2 h at a rate of 60 ml/min. In the second series, blood was bubbled with gaseous nitrogen (N_2). Thus, the blood was tested for the ability to resist the influences occurring in clinical practice. Experiments were performed under natural conditions and under conditions of a magnetic field with altered characteristics: leveled GMF (accuracy ±5%) and rotating sinusoidal EMF with a frequency of 70 Hz (the first series) or 3 Hz (the second series) and 125,000 nT (both series). Before and immediately after tests the following blood parameters were measured: erythrocyte resistance in a 0.4% NaCl solution, plasma hemoglobin level, number of microaggregates, and number of aggregates formed by sludged blood cells.

Research Center, I. P. Pavlov State Medical University, St. Petersburg

RESULTS

After 1 h of circulation in ACD, the resistance of erythrocytes to 0.4% NaCl was above baseline in some samples and below it in others (Table 1). Therefore, these samples were assigned into two groups, consisting of 30 and 21 samples.

In group 1, the erythrocyte resistance after 1- and 2-h circulation of blood in the ACD h increased significantly both after exposure to leveled GMF and rotating EMF of 70 Hz, while the number of aggregates formed by sludged blood cells differed significantly from the control value only after 1 h of circulation in the ACD (Table 1).

In group 2, the erythrocyte resistance decreased significantly after 1 h of circulation under conditions of EMF and after 2 h of circulation under conditions of

0007-4888/97/0001-0028$18.00

TABLE 1. Characteristics of Blood Trauma (Percent of Baseline Values)

Index		First series		Second series
		group 1	group 2	
Erythrocyte resistance in 0.4% NaCl solution				
1 h	control	81.30	116.87	110.0
	test 1	96.86**	105.71	182.0**
	test 2	101.10***	101.81*	
2 h	control	85.03	112.70	
	test 1	101.80*	92.70*	
	test 2	103.55*	107.00	
Number of groups of sludged formed elements				
1 h	control	139.14	89.00	110.8
	test 1	119.75	101.44	187.3**
	test 2	103.36*	105.43*	
2 h	control	122.57	115.26	
	test 1	122.67	134.10	
	test 2	129.52	135.22*	
Number of microaggregates				
	control			96.0
	test			60.6*
Plasma level of hemoglobin				
	control			177.0
	test			110.3**

Note. Test 1: leveled GMF; test 2: rotating EMF. *$p<0.05$, **$p<0.02$, ***$p<0.001$ compared with the control.

leveled GMF; the number of aggregates was significantly higher than in the control only after 1 and 2 h of circulation under conditions of rotating EMF (Table 1).

In the second series (bubbling with gaseous nitrogen), the erythrocyte resistance in 0.4% NaCl after exposure to rotating EMF (3 Hz) was 72% higher than in the control; the number of aggregates formed by sludged erythrocytes increased by 77.5%, whereas the number of microaggregates and plasma hemoglobin content were 35.4% and 67.3% lower, respectively, than in the control group (Table 1).

These findings indicate that alteration of the GMF parameters induce substantial changes in the response of blood to damaging factors. The differences in responses observed in groups 1 and 2 in the first series may be explained in terms of the three types of response of any living organism to the same stressor: adaptation, activation, or inhibition, depending on the initial state of the organism. The stronger response of blood samples in the second series, where the frequency characteristic ("information") of the EMF differed from that in the first series (3 Hz *vs.* 70 Hz), while the GMF "intensity" remained the same, may indicate that magnetic fields produce informational ("controlling" or "triggering") but not energetic effect on living systems. Presumably, the frequency of 3 Hz is optimal for the blood, since blood circulating under natural conditions is influenced primarily by the sympathetic nervous system. The mean frequency of the background electric activity of this system is almost 3 Hz. The finding that changes in the resistance of erythrocytes and the number of aggregates formed by sludged blood cells are unilateral and opposite to changes in the number of microaggregates (Table 1), suggests that sludge is an adaptive response which increases the resistance of blood cells to unfavorable conditions.

It is likely that magnetic field exerts a substantial protective effect on the blood system. If so, further studies of this phenomenon are necessary. In the future, magnetic fields may be successfully used to minimize blood trauma in extracorporeal circulation devices.

REFERENCES

1. V. A. Voinov, "The postperfusion pulmonary syndrome," Author's Synopsis of Doct. Med. Sci. Dissertation [in Russian], Leningrad (1985).
2. S. N. Ivanova, V. V. Lisin, and L. I. Runich, in: *Recent Developments in the Use of Magnetic and Electromagnetic Fields in Medicine* [in Russian], Leningrad (1990), pp. 27-28.
3. J. Olcese, S. Reuss, and P. Semm, *Life Sci.*, **42**, No. 6, 605-613 (1988).
4. M. Villa, P. Mustarelli, and M. Caprotti, *Life Sci.*, **49**, No. 2, 85-92 (1991).