

Effects of short-term exposure to pulsed electromagnetic field on some biochemical parameters in mice

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Five-months-old male albino mice were subjected to an electromagnetic field (EMF) of 5 mT of magnitude with a frequency of 60 Hz for 8hr of single application. Analysis of blood sampled on hourly basis (up to 8 hr) for levels/activities of total protein, albumin, globulin, uric acid, creatinine, cholesterol, and alkaline phosphatase indicated no significant differences ($p>0.05$) from that of the control group.

Keywords: Pulsed EMF, biochemical parameters, short-term exposure

Living beings are subjected to electromagnetic fields (EMFs) since beginning¹. EMF may owe its origin to the general structure and geophysical nature of the earth, in addition to some household electrical instruments^{2,3}. Previous studies have shown that EMFs could increase the osteoblastic activity in bone fractures, though safety of such an application is a matter of concern as patients are inevitably exposed to EMF of high amplitude^{4,5}. Significant changes in some blood parameters have been reported on long-term exposure to EMF of different frequencies and magnitudes⁶⁻¹². However, effects of short-term exposure to pulsed EMF of low frequency and amplitude have not been studied. In this study, we have attempted to examine the effects of exposure to short-term pulsed EMF on some biochemical parameters in mice.

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Materials and Methods

Male, 5-months-old albino mice, weighing 35-40 g were divided into 2 groups, control and experimental, comprising of 40 mice each. The animals of experimental group were placed equally in 4 cages of 10 mice. The control group were also divided equally, into 4 separate cages. The experimental group was exposed to EMF device with a frequency of 60 Hz and a field magnitude of 5 mT for 8 hr of single application from 9.00 hr to 17.00 hr. EMF device was composed of two different parts, both connected to each other, part 1, having 5 coils placed parallel, and part 2, comprising an electric circuit provided the pulsed current to the coils. Part 2 regulated frequency of the system between 20 and 100 Hz and maintained the field magnitude between 1 and 5 mT. The blood was sampled on hourly basis from both groups after every hour (period I represents 10.00 hr, ..., and period VIII, 17.00 hr) and the levels/activities of albumin, globulin, total protein, creatinine, uric acid, cholesterol and alkaline phosphatase (ALP) were determined, using Olympus autoanalyser and related kits. Data are expressed as arithmetic mean \pm SD. Non-parametric Mann-Whitney U test was used to evaluate differences between the two groups.

Results and Discussion

Earlier studies have indicated that factors, such as frequency and amplitude of EMF and the exposure time are crucial for the determination of the possible negative effects of EMF⁶⁻¹⁵, including a low protein level in serum, disturbances in protein synthesis at chromosomal levels and damage of kidney and liver tissues¹⁶⁻¹⁹. Disturbance in kidney functions is reported to enhance filtration of proteins leading to reduction in plasma protein levels²⁰. However, in an earlier study, experimental rats exposed to 50 Hz and 5 mT magnetic field for 10 days, 8 hr daily, did not show significant changes in total protein, albumin, and globulin levels⁷. In our study, where mice were exposed to 60 Hz and 5 mT magnetic field for 8 hr of single application, although marginally, the total protein levels showed a decrease for first 6 hr of exposure, but increased at 7th and 8th hr. Similarly, the albumin levels reduced steadily for first 5 hr, followed by inconsistent increase and decrease for 6, 7 and

Table 1 — Some biochemical blood parameters in mice estimated every one hour (up to 8 hours) with exposure to electromagnetic field (EMF) at a frequency of 60 Hz and 5 mT magnitude for single application

		I	II	III	IV	V	VI	VII	VIII
Total protein (g/dL)	Control	5.09±0.02	5.52±0.12	5.70±0.05	5.32±0.27	5.32±0.48	5.38±0.02	4.38±0.62	4.63±0.24
	Expl	4.88±0.18	4.91±0.06	4.98±0.21	4.33±0.04	4.73±0.10	4.42±0.56	4.52±0.50	4.80±1.41
Albumin (g/dL)	Control	2.91±0.05	3.06±0.07	3.15±0.02	2.89±0.15	3.10±0.09	3.01±0.07	2.63±0.04	2.48±0.04
	Expl	2.72±0.07	2.71±0.07	2.85±0.10	2.42±0.10	2.61±0.09	3.40±1.26	2.57±0.26	2.82±0.09
Globulin (g/dL)	Control	2.15±0.07	2.45±0.07	2.55±0.07	2.45±0.07	2.45±0.07	2.40±0.20	2.15±0.07	1.85±0.23
	Expl	2.05±0.07	2.20±0.08	2.15±0.07	1.85±0.07	2.10±0.20	2.29±0.26	1.95±0.21	2.15±0.07
Uric Acid (mg/dL)	Control	5.22±0.10	6.58±1.91	5.22±0.09	2.10±0.60	5.12±0.30	8.33±0.56	6.63±0.68	7.30±0.23
	Expl	6.40±0.88	6.21±0.07	4.29±0.06	2.99±0.14	4.39±2.72	7.94±0.39	8.17±0.07	7.42±0.04
Creatinine (mg/dL)	Control	0.61±0.02	0.58±0.07	0.61±0.02	0.51±0.02	0.58±0.04	0.58±0.06	0.47±0.03	0.53±0.02
	Expl	0.62±0.06	0.64±0.04	0.58±0.07	0.53±0.03	0.86±0.26	0.51±0.02	0.48±0.03	0.52±0.03
Cholesterol (mg/dL)	Control	95.50±5.70	116.00±16.97	116.00±3.40	101.50±10.60	113.12±4.07	113.73±4.61	92.50±3.53	89.00±5.65
	Expl	84.00±14.41	93.00±12.72	104.50±10.60	81.00±8.48	91.50±12.02	90.50±13.43	89.00±16.97	93.00±2.82
Alkaline phosphatase (U/L)	Control	142.50±9.19	164.00±12.72	186.50±12.02	185.50±4.94	186.08±12.90	174.00±8.48	184.00±5.65	148.50±4.94
	Expl	182.00±29.69	164.50±9.19	191.00±26.87	173.50±10.70	150.50±21.20	154.90±5.80	160.50±70.00	142.00±12.82

p>0.05

8 hr. Globulin levels have show showed a consistent decrease for all the hours, but for the 8th hr (Table 1). Thus, the reduction in levels of total protein, albumin and globulin may indicate influence of EMF, though the same cannot be categorically inferred, as the results are statistically insignificant.

Uric acid and creatinine play important role in the determination of renal functions^{18,21}. The problem encountered in elimination of these compounds, produced endogenously within the body, results in their increased levels in the blood. In the present study, the changes in both uric acid and creatinine levels are inconsistent and statistically insignificant (Table 1). It has also been observed that changes in the levels of uric acid and creatinine do not corroborate with each other for all the 8 hrs.

The blood cholesterol levels could also be influenced, due to disturbances in the liver²². The decrease in cholesterol levels for the first 7 hrs in the present study (Table 1), possibly suggests a disturbance in cholesterol synthesis pathway in relation to EMF. Earlier, an increase in tissue cholesterol levels due to EMF exposure was also reported²³. Increase in tissue cholesterol levels can indirectly affect plasma cholesterol levels and may lead to its decrease in plasma. However, in none of the parameters mentioned above, a statistical significant difference

was found between experimental and control groups, which could be due to the short duration exposure and the frequency (60 Hz) and magnitude (5 mT) of the EMF.

The kidney is known to have high ALP activity²⁴, and during renal insufficiency, the ALP activity exhibits obvious changes²⁵. Also, the ALP, being concentrated in hepatic biliary epithelia²⁶ is reported to increase in diseases involving the biliary duct²⁷. However, in disorders related to bone tissue, its activity varies. High concentrations of ALP in osteoblast has been reported earlier^{28,29}. In fact, ALP activity within the bone tissue is said to increase at the influence of the EMFs, suggesting an augmentative effect of EMF on bone healing^{28,29}. On the contrary, humans exposed to 100 Hz electromagnetic field for three times a week, 60 min of each, for 3 months did not show significant changes on the serum ALP activity¹⁰. In this study also, the change in ALP activity was not statistically significant (Table 1), indicating no noticeable effect of EMF on the kidney. Although, there was an increase in the ALP activity at 1st and 3rd hr of the experiment, similar to those observed in the liver diseases, the values were statistically insignificant to suggest any hepatic tissue damage. The levels of ALP indicate that application of pulsed EMF in the

treatment of bone fractures is not harmful to the bone tissue.

In conclusion, pulsed EMF of 60 Hz frequency and 5 mT field magnitude applied on 5 months-old mice, for 8 hr of single application did not cause significant disturbance in liver, kidney and bone tissue, as indicated by the levels of albumin, globulin, total protein, cholesterol, creatinine and uric acid levels and ALP activity in the blood.

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