An Investigation of the Effect of Antioxidant on Biochemical Parameters in ELF-EMF Exposure

The effect of ELF-EMF on biochemical parameters

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Abstract
Aim: The purpose of our study was to investigate the effect of electromagnetic fields originating from high voltage lines and antioxidant on serum biochemical values of Wistar albino male rats. Material and Methods: A total of 48 rats were included in the study and 3 groups were formed in two different time periods (26/52 days) as follows: Group 1- High voltage (HV), Group 2- HV+Ganoderma lucidum (GL), Group 3- Control. The magnetic field and the electric field were measured. Ganoderma was administered at a dosage of 20 mg/kg/day as a gavage. Results: In the implementation that took 26 days, no significant difference was found between groups in terms of AST, ALT, Ca, amylase, glucose ve creatine values (P>0.05), and a significant difference was found between groups in terms of urea variable (P<0.01). In the implementation that took 52 days, no statistically significant difference was found between groups in terms of AST, ALT, Ca, amylase, glucose, creatine and urea values (P>0.05). Discussion: It is seen that extremely low - frequency electromagnetic fields generated by high voltage lines may cause changes in serum biochemistry values and the use of some antioxidant (ganoderma) products may be beneficial.

Keywords
Biochemical Values; High Voltage; Electromagnetic Field; Ganoderma, Rat
Introduction

With the development of technology, electromagnetic field exposures increase. The extremely low frequency electric and magnetic field exposures caused by the electrical energy used from 50 Hz power frequency cause concern in the society. Based on limited epidemiological evidence, in 2002 the International Agency for Research on Cancer (IARC) classified ELF-EMF as a possible carcinogen for humans [1]. It is emphasized that working on long term high voltage lines will have negative consequences on human health [2]. However, for many years, researchers have not been able to fully establish a validated correlation of the impact of electromagnetic radiation on human health. The debate on this issue is still ongoing [3]. In recent years, the use of electricity in industry and households has been increasing. The need for electricity leads to an increase in high-voltage lines. High voltage systems are located in the 50/60 Hz frequency band. It is emphasized that the formation of ionic dipoles cause changes in membrane potential and can affect biochemical processes in cells, as electric fields can penetrate into the body [4, 5]. The electromagnetic fields that we encounter in our daily lives have a frequency of 3-300 Hz. They are particularly described as extremely low frequency electromagnetic fields (ELF-EMFs). Studies on the impact of these areas on public health and employee health are insufficient. ELF-EMF domains have effects on metabolic and biochemical processes [6]. In case of continuous exposure to or induction of electric fields, various biological processes can be initiated. It is emphasized that changes in exposure may lead to changes in renal and liver functions [7].

Ganoderma is used in the treatment and prevention of various diseases, especially in eastern countries. Ganoderma is used to prevent oxygen radicals and oxidative damages. It has a protective effect against DNA damage caused by UV radiation and has a good radioprotective effect [8]. Ganoderma, commonly used in traditional Chinese medicine to promote health and longevity, has been widely accepted as herbal supplements. The medical properties of GL can be attributed to antioxidant and anti-inflammatory activities [9]. Ganoderma lucidum may be useful in the treatment of chronic liver damage and in strengthening the body’s antioxidant capacity [10]. It is now impossible to avoid electromagnetic field exposures. These areas are risk and concern. We have created a high voltage line model in the laboratory environment. In this study, we aimed to investigate the effects of a very low-frequency electromagnetic field and antioxidant (Ganoderma lucidum) on some biochemical values.

Material and Methods

Animals and experimental protocol

A total of 48 Wistar albino male rats were included in this study. Rats were divided into 3 groups in two different time periods (26 days and 52 days) as follows: Group 1- High voltage group (HV), Group 2- High voltage + Ganoderma (GL), Group 3- Control. Experimental groups were exposed to daily 8 hours during 26 and 52 days. The animals were maintained in an appropriate medium (12 hours light/dark, the temperature of 23±1 °C, and 45-55% humidity). Ganoderma (Gano Excel, Industries Sdn. Bhd., Kedah, Malaysia) extracts were prepared with distilled water according to appropriate standards. Ganoderma was given at a dosage of 20 mg/kg/day as a gavage. Two separate transformers were used to generate the electromagnetic field (for the first transformer, the input was 220 volts, and the output was 10 kilovolts (10kV). For the second transformer, the input was 10 kilovolts, and the output was 220 volts and 5,000 volts amps). Electromagnetic field measurements were performed using Spectran NF5035 (Aaronia, Germany) model device. Electromagnetic field measurements were made in plexiglass cages where rats were encaged during the experiment. Daily measured areas were averaged. The readings were taken in volt per meter (V/m) for the electric field and microTesla (μT) for the magnetic field. Field measurements were 80.3 V/m for electric field and 2.48 microTesla for the magnetic field. Figure 1 shows the experimental setup. This study protocol was initiated after the approval of the Kirsehir Ahi Evran University Animal Ethics Local Ethics Committee decision (AEUHADYEK, 30/10/2019, 20-2) and the study continued according to the standards set out in the Helsinki Declaration.

Blood collection and analysis of biochemistry parameters

At the end of the work, the rats were anesthetized with intramuscular injection (1ml for one rat (0.1 cc xylazine + 0.9 cc ketamine)). Then, the blood of the rats from the intracardiac route was drawn. Blood samples from the control and experimental groups of animals were collected (BD Vacutainer 5.0 ml, UK). Serum was separated directly by centrifugation (NF 1200 R Nuve, Turkey) at 5000 rpm for 5 minutes and was kept at -20°C until the analysis. An automated analyzer method was applied for the analysis of the data (Abbott Architect® c16000).

Statistical analysis

The normality hypothesis was tested by the Kolmogorov-Smirnov and the Shapiro-Wilk tests. The Levene test was used to test the assumption of homogeneity of variances. For the comparison of the groups in the study, ANOVA was used. Comparison of the groups which revealed significant difference was analyzed through DUNCAN multiple comparison test. Descriptive statistics of variables are given as Mean ± Standard deviation. In all statistical analyses, cases with a p-value less than 0.05 were interpreted as statistically significant. Statistical analysis of the study was performed using Statistical Package for Social Sciences version 21.0 software for Windows (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp., USA).

Figure 1. Experimental setup
The effect of ELF-EMF on biochemical parameters

Results

Three different groups (HV, HV+Ganoderma and Control) were tested during two different processes (26 and 52 days) in the study. Statistics of the groups during 26 days of implementation and the results of the analysis are displayed in Table 1. According to the results revealed in Table 1, the difference between the groups was not found significantly related to the AST, ALT, Ca, amylase, glucose and creatine values (P>0.05). The difference between the groups relating to the urea variable is found statistically significant (P<0.01). The value of urea in the control group was lower than Group 1 and Group 2. Statistics of 52 days of implementation of the groups are displayed in Table 2. According to the results in Table 2, no significant difference was found between groups in terms of AST, ALT, Ca, amylase, urea, glucose and creatine values. (P>0.05).

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Table 1. Descriptive statistics of 26 days of implementation and the results of the analysis

| Time   | Groups          | AST (IU/L) Mean±SD | ALT (IU/L) Mean±SD | Ca (mmol/L) Mean±SD | Amylase (IU/L) Mean±SD | Urea (mmol/L) Mean±SD | Glucose (mmol/L) Mean±SD | Creatine (µmol/L) Mean±SD |
|--------|-----------------|---------------------|---------------------|---------------------|-------------------------|------------------------|---------------------------|---------------------------|
| 26 day | Group 1 HV      | 153.0±49.77         | 49.5±2.82           | 9.0±0.51            | 968.3±107.7             | 44.5±4.56a             | 176.0±47.3                | 0.48±0.02                 |
|        | Group 2 HV+GL   | 117.7±24.33         | 45.5±4.0            | 9.0±0.61            | 921.0±113.3             | 43.5±4.65a             | 229.5±61.2                | 0.46±0.05                 |
|        | Group 3 Control | 111.2±47.89         | 47.2±10.4           | 8.8±0.49            | 955.3±110.3             | 36.0±4.14b             | 224.0±65.9                | 0.48±0.04                 |
|        | *0.129          | ~0.495              | ~0.594              | ~0.680              | *0.002                  | ~0.159                 | ~0.762                    |

There is no significant difference between the means indicated by the same letter in the same column (P>0.05). There is a significant difference between different alphabetic groups. *A significant difference found between the groups (P<0.05). **No significant difference found between the groups (P> 0.05). SD: Standart deviation. AST: aspartate aminotransferase, ALT: alanine aminotransferase, Ca: Calcium.

Table 2. Descriptive statistics of 52 days of implementation and the results of the analysis

| Time   | Groups          | AST (IU/L) Mean±SD | ALT (IU/L) Mean±SD | Ca (mmol/L) Mean±SD | Amylase (IU/L) Mean±SD | Urea (mmol/L) Mean±SD | Glucose (mmol/L) Mean±SD | Creatine (µmol/L) Mean±SD |
|--------|-----------------|---------------------|---------------------|---------------------|-------------------------|------------------------|---------------------------|---------------------------|
| 52 day | Group 1 HV      | 103.5±49.9          | 51.2±8.92           | 8.8±0.62            | 822.7±72.86             | 34.87±3.04             | 189.1±49.82               | 0.45±0.03                 |
|        | Group 2 HV+GL   | 85.1±36.61          | 48.6±10.32          | 9.1±0.64            | 844.6±91.42             | 34.6±7.28              | 209.0±51.96               | 0.47±0.03                 |
|        | Group 3 Control | 87.3±13.26          | 47.7±8.88           | 8.5±0.84            | 820.3±122.64            | 33.12±3.36             | 224.5±43.46               | 0.44±0.03                 |
|        | ~0.557          | ~0.733              | ~0.277              | ~0.862              | ~0.750                  | ~0.362                 | ~0.442                    |

*No significant difference was found between the groups (P> 0.05). SD: Standart deviation.
26 days of high voltage group; and an increase was found in 52 days of implementation according to the control group. In the literature, similar to our study, it is revealed that AST and ALT values are consistent with an increase in the experimental group. Likewise, the results of amylase, urea, Ca, glucose and creatine are similar to the results as in the literature. However, some studies have indicated that there is no change in electromagnetic field exposures.

There are many studies on the protective effect of ganoderma. Ganoderma triterpenoids reduced oxidative stress and inflammation in liver injuries, and because of its rich biological activity, it was emphasized that it may play a role in minimizing the effects of electromagnetic induced exposures and damages in various tissues [10, 14, 15, 16]. In this study, when high voltage (HV) group and HV+GL group are compared, AST and ALT values in HV+GL groups were found lower in 26 and 52 days of implementation. No significant difference was found in Ca and urea groups. As the implementation process increases, it is seen that values in the parameters of amylase, glucose and creatine in HV+GL group increased. In this study, according to results of 26 and 52 days of HV groups, a decrease in AST, ALT, urea and amylase and glucose values may indicate a protective effect of ganoderma.

Although the biophysical and biochemical mechanisms of the biological effects of EMF at low-density levels are not fully known, significant progress has been made in recent years, and there is a great deal of data indicating that these mechanisms can overlap the effects of ELF and RF [17]. Many studies have shown that transduction of weak electrical signals in the ELF range involves interactions with the cell membrane, resulting in cytoplasmic biochemical responses involving changes in cellular functionality and proliferative states [18]. Although the electrical and magnetic field values measured in our study are below the limit values of the International Commission on Non-Ionizing Radiation Protection, it is seen that they can cause some changes in biochemical parameters that is investigated in this study.

Conclusion
In our study, it was found that extremely low-frequency electromagnetic fields caused some increases and partially decreases in serum biochemistry parameters of rats. It is thought that Ganoderma may have shown a possible protective effect. However, in the literature, it is seen that the mechanism of effect on biochemical parameters is not fully known and further researches on effects of ELF-EMF are needed.

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