Effects of Static Magnetic Field in Albino Rats Blood Electrolytes

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Abstract: ***The effects of static magnetic field of 1.5 Tesla during exposure time of 0-3 hours have been characterized among four groups (E_0, E_1, E_2 and E_3) of Rat's tissues (brain, lungs, liver and pancreas) and blood electrolytes (Na^+, K^+ and Ca^{+2}). Before the exposure, the average levels for electrolytes were 116.81± 3.67, 5.16 ± 0.28 mmol/l and 10.23 ± 0.07 mg/dl respectively. Then a significant (R^2 =98, P = 0.05) reduction in Na^+, Ca^{+2} have been noticed following the exposure time in a linear correlation observed and the reduction was 31.55% and 15.59% respectively, while the K^+ increased following the exposure time in a linear form and the increment percent at 3 hours of exposure was 47.76%.***

Keywords: Biological, Effects, Static, Magnetic, Field, Blood electrolytes (Na^+, K^+ and Ca^+)

1. Introduction

Recently the exposure to electromagnetic field (EMF) has been increased rapidly as the sources and the applications of such technologies increases. The sources of such EMF represented in micro-wave cooker, stations of electricity, electric motors and electronic equipment's [1]. The excessive exposure to EMF from these sources have accompanied with considerable neurological degeneration and heart diseases [2], although the components of MRI system such as (magnetic field, gradients pulsed magnetic field, RF pulses, and electrodes) could induce reversible effects in patient under examination. However with a lack of vigilance or the ignorance of certain basic safety requirements could lead to serious adverse effects, including death [3].

The effects of exposure to EMF have reported by several studies in this realm, Leo and Rio, [4] showed desirable effects on Okra plants after exposed to EMF such as faster growing, increment in height, weight, sizes and number of fruits per plant as well as less number of insects and pests, while the negative effects were seen in tomato plants. While in the medical field; Markov, [5, 6] stated that: EMF generated by power lines and electrical appliances induces the risks of cancer as an example the risk of childhood leukemia has been noticed to be associated with exposure to extremely low frequency (ELF).Other confirmed significant effects associated with exposure to SMF with strength of 1.5 -4 T; was shown by Domenico and Sergio, [1] it was the sensations of nausea, vertigo, and metallic taste. The effects of static magnetic field also have been described by Pacini et al, [7], in which the exposed human neural cell culture developed branched dendrites with changes in physiological function after 15 minutes of exposure, such branched dendrites increased with magnetic field strength in stimulating media collagen gel [8].This result could be utilized to improve and repair of transected peripheral nerves by directing and stimulating axonal growth through a tube filled with magnetically aligned collagen gel. The decrease in apoptosis and cell proliferation with an increase in cell necrosis was observed in Vero cells exposed to 0.5 mT SMF, although, in the same conditions, Rat astrocytes showed a significant increase in these three parameters [9, 10]. While the damage of lymphocytes by SMF (7 mT) increases up to 20% when they have been treated by ferrous chloride ($FeCl_2$) [11, 12]. Moreover exposure to SMF could increase the activity, concentration and lifetime of paramagnetic free radicals that leading to oxidative stress, genetic mutation and apoptosis [13, 14] as well exposure to SMF initiates an iron-mediated process that increases free radical formation in brain cells, leading to the breaking of DNA strands and cell death [15].

Human lymphocytes were simultaneously exposed to 4.75 T for static component and 0.7 mT for the pulsed component at 500 MHz generated by an NMR apparatus for 1 h. This exposure increased the Ca^{2+} influx without any proliferative or pro-inflammatory effect on either un-stimulated or PHA-stimulated lymphocytes [16, 12]. Also the Human skin fibroblast cell morphology was modified with a concomitant decrease in the expression of some sugar residues of glycol-conjugates after 1h exposure to a 0.2 T static magnetic field [17].

The worst but limited reports attributed to MR scanning, were seven deaths incidents: one death during examination for cerebral infarction, one involving a ferromagnetic cerebral aneurysm clip, and five related to inadvertent scanning of patients with cardiac pacemakers [18].

Although recent study focused on exposure from mobile radiofrequency RF [19]; the trend of this study stressed in the study of static magnetic field effects of MRI in rats' tissues such as (brain, liver, spleen, pancreas and lung) and the blood electrolytes serum such as (Na^+, K^+ and Ca^{+2}) with specific consideration that: the human body electrolyte as

Sodium Na^+, Potassium K^+ and Calcium Ca^{+2} level are 145 mmol/l, 4.5mmol/l and 5 mmol/l respectively while for Rats: the Sodium Na^+ level was 149 (145-154) mEq/l (male) and 149 (143-154) mEq/l (female), the Potassium K^+ level was 6.8 (5.9-7.8) mEq/l (male) and 6.4 (5.5-7.4) mEq/l (female) and Calcium Ca^{+2} level was 11.7(10.8-12.7)mg/dl (male) and 11.6 (10.7-12.6)mg/dl (female) [20].The contemplated biological effects of SMF could be ascribed to the interaction of magnetic fields with biological tissues which are characterized as electrodynamics effects in electrolyte flows or magneto-mechanical leading to induction of electrical potential and currents [21]. As the strength of the static field in MRI has increased from 0.015 to 12 T during the last 25 years, which are about 800 fold increment. In addition to low and high field systems 1.5 - 4 T, ultra-high field systems with field strengths above 4 T are now available for human MRI [8]; therefore the researchers sense the inevitability of safety procedures to be considered with the introduction of superconducting magnets in MRI which lead to magnificent human exposure to SMF up to several teslas (T) [22].

For the sake of avoiding hazards of SMF, the Center for Devices and Radiological Health (CDRH, 1982) suggested that in case of diagnostic magnetic resonance applications exposure to SMF must not exceeding 2 T. And the National radiological protection board (NRPB, 1984) recommends that: the exposure to SMF (*for MRI patients or volunteers*) should not exceed 2.5 T for the whole or a substantial portion of the body. While the Federal Health Office (FHO, 1984) recommends that: patients imaged in MRI should not be exposed to SMF exceeding 2 T and if the patients re-exposed to field higher than 2 T, there should be monitoring for cardiac and circulatory functions. The current situation of EMF applications, possibly accompanied with potential hazards specially when the field strength exceeding 2-2.5 T or even within 1.5 T with considerable duration of exposure. Therefore the current study presents the confirmation view for biological effects due to EMF exposure with 1.5 T and time variation up to 3 T.

2. Method

Forty (40) healthy Swiss Albino rats with average weight 187.2g have been kept at a temperature of 20 ºC and 50% humidity; this was maintained by using a thermometer and hygrometer respectively and the space was protected from any interference of EMF by covering the rats housing by conducting foil of Aluminum, and before starting the experiment; the rats were fed on wheat, meat extract, soya extract, folic acid and vitamin A as the well water supply by water tap. The sample divided into four groups: control group and E1, E2 and E3 exposed to 1.5T for 1, 2 and 3 hours respectively using MRI system (Philips - super conductive magnet). Then the serum electrolyte as Na^+, K^+ have been measured before and after preparation using Electrolyte analyzer- Roche 9180 and Cromatest Calcium-Methylthymol Blue (Bio system calcium kit), was used for Ca^{+2} analysis.

3. The Results

The correlation between the Na^+, Ca^{+2}, and K^+ electrolytes level and the rat number are: ($y = 0.27x + 112.6$, $y = 0.32x + 98.35$, $y = 0.27 + 86.41$ and $y = 0.17x + 78.55$), where x refers to rat number and y refers to level of Na^+ electrolyte, with a coefficient $R^2 = 0.1$ in average (for Na^+ - Fig. 1). ($y = 0.003x + 10.2$, $y = 0.002x + 9.69$, $y = 0.007x + 9.14$ and $y = 0.01x + 8.56$), where x refers to rat number and y refers to level of Ca^{+2} electrolyte, with a coefficient $R^2 = 0.1$ in average (for Ca^{+2} – Fig. 3). ($y = 0.03x + 7.41$, $y = 0.02x + 6.7$, $y = 0.01x + 6.1$ and $y = 0.02x + 4.96$) where x refers to rat number and y refers to level of K^+ electrolyte, with a coefficient $R^2 = 0.21$ in average (for K^+ - Fig. 5). while the correlation with the times of exposure to SMF of 1.5T for a duration of 0-3 hours, the Na^+ and Ca^{+2} electrolytes showed a linear reduction following the time of exposure with an equation fitted in $y = -12.29x + 115.01$ (Fig. 2) and $y = 0.52x + 10.24$ (Fig. 4) where x refers to time of exposure in hours and y refers to Na^+ and Ca^{+2} electrolytes level in mmol\l and mg\l respectively and the average significant coefficient $R^2 = 1$, $P = 0.05$. However the K^+ electrolytes showed an increasing rate based on the equation: $y = 0.81x + 5.25$ (Fig. 6) where x refers to time of exposure in hours and y refers to K^+ electrolytes level in mmol\l with an average significant coefficient $R^2 = 1$, $P = 0.05$.

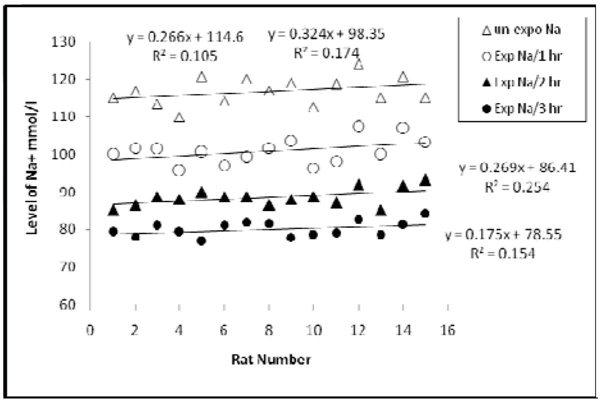

Figure 1: shows the correlation between Rats number and their serum level of Na^+ before and after exposure to 1.5 T of SMF for 0 – 3 hours.

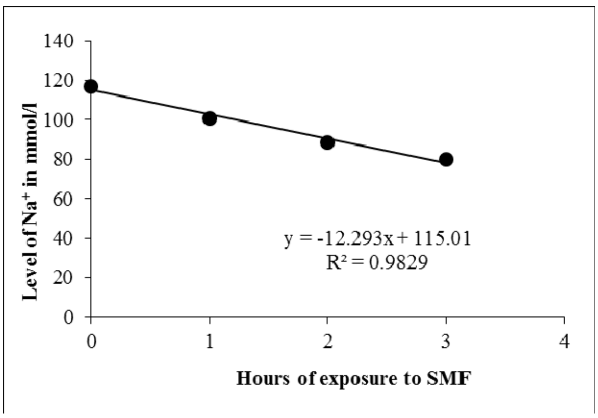

Figure 2: shows the correlation between the times of exposure to 1.5T SMF and serum level of Na^+

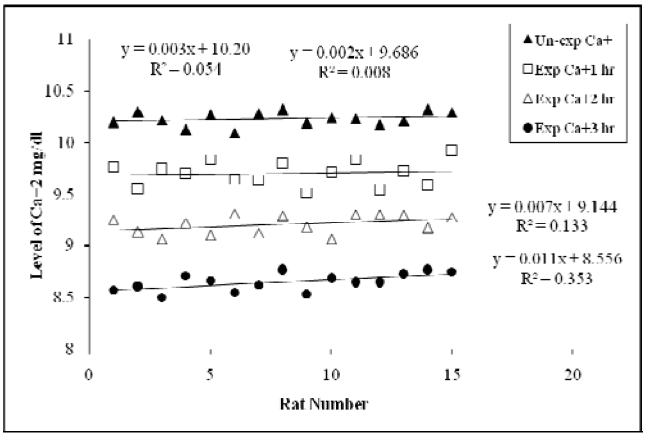

Figure 3: shows the correlation between Rats number and their serum level of Ca^{+2} before and after exposure to 1.5 T of SMF for 0 – 3 hours.

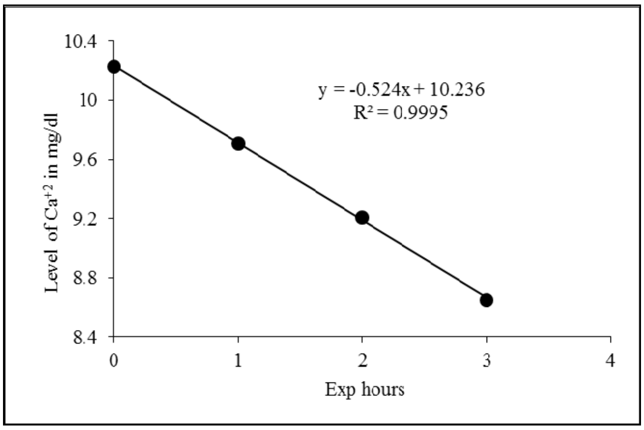

Figure 4: shows the correlation between the times of exposure to 1.5T SMF and serum level of Ca^{+2}.

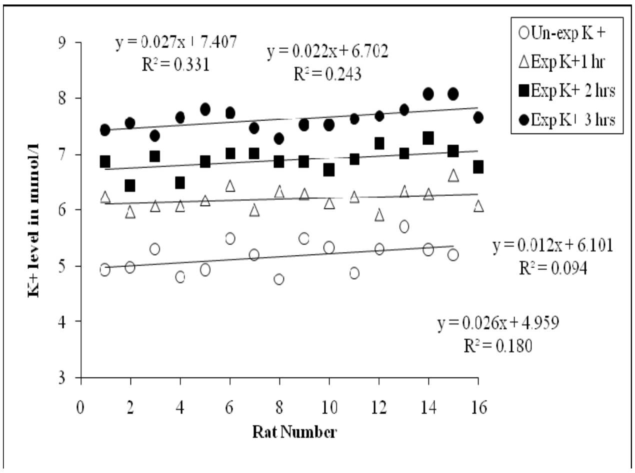

Figure 5: shows the correlation between Rats number and their serum level of K^{+} before and after exposure to 1.5 T of SMF for 0 – 3 hours.

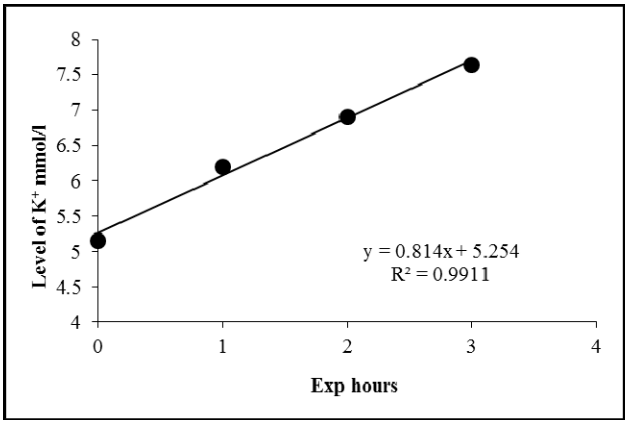

Figure 6: shows the correlation between the times of exposure to 1.5T SMF and serum level of K^{+}

4. Discussion

The effects of electromagnetic field have been a matter of argument for long period, although some scholars have showed some biological effects and morphological ones, here in same trend, the experiments proved that exposure to EMF, specifically to 1.5 T for duration up to 3 hours leading significant reduction in the level of electrolytes (Na^{+} and Ca^{+2}) as hyponatremia and hypocalcaemia respectively. Such decreasing in the serum level of Na^{+} and Ca^{+2} could be ascribed to alteration of the ion-binding to membrane macromolecules [23, 24] and due to emptying of intracellular Ca^{2+} stores and to Ca^{2+} influx from the extracellular medium [25, 26] which is a general phenomenon, independent to the apoptogenic stimulus.

The decreasing effects in the serum of Na^{+} and Ca^{+2} after exposure to SMF, have been shown by Gerasimova and Nakhil'nitskaia, [27]; they observed an increase in K^{+} concentration (hyperkalaemia) during an hour exposure and a decrease in Na^{+} concentration during a three hour exposure to 4500 Oersted constant magnetic field CMF in rats. While the effect of EMF on serum of K^{+} was a significant increasing linear form following the increment of the exposure hours; such increment could be ascribed to the induced electric fields and currents circulating in the extracellular medium which in turn altering the ion-binding to membrane macromolecules, influence ion transport across the membrane, and modify ligand–receptor interactions at the cell membrane surface [28] and has been in agreement with study carried out by Gerasimova and Nakhil'nitskaia, [27].

In contrast with the current sound of EMF effects; the given biological effect proved the hazards arises due to EMF exposure up to specific limits and since the absorbed energy from EMF sources followed the concept of accumulated dose, the dose limits as well as fractionation related to frequency of exposure would be inevitable.

The showed results of such kind of experiments better confirmed by Raman spectroscopy and\or stereological studies to avoid subjective characterization that may affect the significances of induced effects.

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