

Therapeutic action of Vitamin C or E on Serum Biochemical Parameters in Albino Rats exposed to Electromagnetic Field “A Preliminary Study”(*)

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Abstract: The effect of electromagnetic radiation on vital tissue is an important issue due to the increase usage of mobile communication. The present study was designed to understand whether electromagnetic field (electric field strength of 40 - 120 V/m) generated by mobile telecommunication antenna could act as an environmental insult and cause changes in the biochemical parameters in the serum of albino rats. It also aims to study the therapeutic action of vitamin C or vitamin E (150mg/L) against the harmful effects that might be induced by the electromagnetic field.

Albino rats are randomly divided into four groups each contains 6 animals. Group one served as control group. The other three groups were subjected to electromagnetic field for eight hours then rest eight hours without exposure, and treatment was continued for two weeks. Two groups were treated by vitamin C or E through the experiment. We found that the electromagnetic field exposure decreased the concentrations of serum glucose, triglycerides, total cholesterol, total protein and globulin. While the concentration of albumin, urea, uric acid and creatinine were increased.

Key words: electromagnetic field, blood serum, kidney function, glucose, protein, nonprotein, nitrogenous constituents, lipids, albino rats, therapeutic effect, vitamin C or E.

دور فيتامين ج أو ه في علاج المعايير البيوكيميائية في مصلى الجرزان البىضاء المعرضة للمجال الكهرومغناطيسى

ملخص: أصبح تأثير الإشعاع الكهرومغناطيسى على الأنسجة الحيوية مسألة هامة نظرا لزيادة استخدام الإتصالات المتنقلة. ولقد أجريت هذه الدراسة لفهم ما إذا كان الإشعاع الكهرومغناطيسى (قوة الحقل الكهربائى مقدارها 40 -- 120 فولت / م) المتولدة من هوائى الإتصالات المتنقلة يمكن ان يكون خطرا بيئيا ويسبب تغيرات على بعض المعايير البيوكيميائية فى مصلى الجرزان البىضاء.

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كما ان الدراسة تهدف إلى دراسة الدور العلاجي لفيتامين ج أو هـ (150مليجرام/لتر) ضد التأثيرات الضارة التي قد تحدث نتيجة التعرض للمجال الكهرومغناطيسي. ولقد تم تقسيم الجرذان البيضاء بشكل عشوائي إلى أربع مجموعات كل مجموعة تحتوي على 6 حيوانات. المجموعة الاولى هي المجموعة الضابطة. بينما تم تعريض المجموعات الأخرى للمجال الكهرومغناطيسي لمدة ثماني ساعات ثم تبقى ثماني ساعات من دون التعرض للإشعاع ولمدة أسبوعين. ولقد تم معالجة اثنان من المجموعات خلال التجربة باستخدام فيتامين ج أو هـ. ولقد وجدنا أن التعرض للمجال الكهرومغناطيسي أدى الى انخفاض تركيز الجلوكوز في الدم والدهون الثلاثية والكوليسترول الكلي والبروتين الكلي والجلوبيولين. بينما زاد تركيز الزلال واليوريا وحمض اليوريك والكرياتينين. ووجدنا أيضا أن فيتامين (ج) أو هـ كانوا قادرين على زيادة مناعة الفئران البيضاء ضد بعض هذه التغييرات.

الكلمات المفتاحية: مجال كهرومغناطيسي، مصل الدم، وظائف الكلي، الجلوكوز، البروتين، المكونات النتروجينية غير البروتينية، الدهون، فئران بيضاء، تأثير علاجي، فيتامين ج أو هـ.

Introduction

Electromagnetic field is an important environmental factor that has become a topic of considerable interest in recent years. The constant natural or artificial magnetic fields are not readily felt or detected directly by any of the human sense. Such magnetic fields are different from other physical environmental stimuli, where all may be perceived directly by at least one of the human sensory organs [1].

The magnetic field directly or indirectly affects the central nervous system [2]. In the past, no changes due to the magnetic fields have been reported or confronted. However, some doses of electromagnetic energy (EME) are medically applied in the treatment of rheumatic diseases [3]. Recently, the interaction of magnetic fields on animals and human were studied by few investigators [4]. Numerous biochemical studies have been carried out to evaluate the effect of electric and magnetic fields on the metabolism of the cell in animals and human [5]. The studies showed significant disturbances in the metabolism of carbohydrate, lipid and protein reflected by alteration in blood glucose level and accelerated glycolysis and glycogenolysis with a metabolic block of conversion of pyruvic acid to acetylcoenzyme A. The levels of total protein and its fractions were also changed. The Krebs cycle was disturbed due to metabolic block of conversion of alpha-ketoglutaric acid to succinyl – coenzyme A. it is likely that the disturbances lead to adaptive changes, which in turn result in altered lactate dehydrogenase activity and accelerated transmutations processes. Electromagnetic fields penetrate the human body and act on all organs, altering the cell membrane potential and the distribution of ions and dipoles [6]. This alteration may

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influence biochemical processes in the cell, thus changing both biochemical parameters and enzyme activities of serum. Data on the effect of electric and magnetic field on human health are inconsistent probably due to differences in the experimental design.

Vitamin C is a water soluble antioxidant which can directly scavenge superoxide and hydroxyl radicals. Many clinical trials have focused on single antioxidants [7].

Vitamin E, the principal chain-breaking antioxidant in the lipid phase of the cell membranes, may effectively counteract the reactive oxygen species, generated by toxic or carcinogen-induced oxidative damage, by trapping reactive oxy radicals [8]. The consequences of vitamin E deficiency have been studied extensively. Increased dietary vitamin E gave protection against increased lipid per oxidation [9]. The present work is aimed to study the harmful effect of electromagnetic field exposure on Albino rats and the therapeutic action of vitamin C or E.

Materials and Methods

Twenty four adult male albino rats (*Rattus norvegicus*) each weighing (150 ±20) g were used throughout the study.

Rats were randomly divided into four groups as follows:

- 1- The first group served as the control group, where commercial balanced diet and water were continuously and regularly supplied to animals all over the experimental period.
- 2- The second one was subjected to electromagnetic field.
- 3- The third group was subjected to electromagnetic field and received vitamin C.
- 4- The fourth group was subjected to electromagnetic field and received vitamin E.

Each vitamin was given orally in dose of 150 mg/kg each day all over the experiment period. The animals were exposed to split dose of electromagnetic field with constant power in the range from (1.4–4.7) mW/cm² and electric field with the range (60-130) V/m. The treated animals were subjected to electromagnetic field for eight hours then rest eight hours without exposure. The process of exposure and rest for the same time interval were repeated for two weeks. The electromagnetic field applied was generated by using an antenna installed at the laboratory at Islamic University of Gaza. The antenna received the signal from mobile base station at the area of Islamic University of Gaza. The mobile system used in Gaza is GSM with frequency equals 900 MHz. The animals were kept in a wood box and the antenna place at 20 cm away from the rats such

that the whole body exposed to the electromagnetic field. Animals from both control and experimental groups were decapitated at the end of the experiment

Blood samples were collected in 10 ml plain tubes for serum preparation. Clear serum samples were separated by centrifugation at 3000 r.p.m for 20 min.

Serum glucose was determined according to the method of Trinder [10]. The kits were purchased from Randox lab LTD, UK. Serum triglyceride concentration was determined enzymatically according to the method of Fossati *et al.* [11]. Serum total cholesterol levels were determined following instruction manuals of Randox reagent kit [12]. Serum total protein was determined according to the Biuret reaction as described by Bellossi *et al.* [13]. The kits were purchased from Biotech laboratories, U.K. Serum albumin was determined using Randox reagent kits and following their instruction manual according to the method of Doumas *et al.* [14]. The concentrations of globulin were calculated by the following equation:

Concentration of globulins (gm/dl)=Total protein-Albumin.

Urea determination is based upon the cleavage of urea with urea's (Berthelot's reactions) according to Fawcett [15]. The kit was purchased from Boehringer Mannheim GmbH Diagnostica. Serum uric acid was determined using the Spinreact reagent kits and following their instruction manual and as described by Fossati *et al.*[11], Serum creatinine was determined without protein precipitation.

Data analysis:

Data were analyzed using SPSS program (statistical package for the social sciences Inc. Chicago, Illinois). Means were compared by independent-sample t-test. All values are expressed as mean + SE. Significance are taken as follows: $P > 0.05$ is non-significant, $P \leq 0.05$ is significant, $P < 0.001$ is highly significant.

Results

The data presented in table (1) summarize the effect of electromagnetic field and the role of vitamin C or E as the protective agents on rats serum glucose, triglycerides and total cholesterol. Electromagnetic field exposure decreased serum glucose level by 11.01% compared to the control level. The treatment of rats subjected to electromagnetic field by vitamin C or E reduced the increment rate to 21.9% and 3.98% compared to the control level.

The recorded values of serum triglycerides were 82.1, 78.80, 90.83, and 110.2 mg/dl for the control group, group exposed to electromagnetic field,

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group exposed to electromagnetic field electromagnetic field and treated by vitamin C, and group exposed to electromagnetic field and treated by vitamin E respectively. While the cholesterol values were 156.01, 123.66, 103.95 and 153.11 mg/dl respectively.

From table (1), one can show that treatment by vitamin C decreased serum glucose and cholesterol level by 12.2% and 15.9% respectively, and increased triglycerides by 15.3% compared to the exposed to electromagnetic field level. The treatment with vitamin E increased glucose, cholesterol and triglycerides levels by 0.8%, 23.8% and 39.8% respectively compared to exposed electromagnetic fields.

Table (1): Distribution of Serum parameters in the 4 groups of albino rats exposed to electromagnetic field with and without therapeutic action of vitamin C or E

parameter	Control N=6	Electromagne tic field N=6	Electromagneti c field + vitamin C N=6	Electromagn etic field + vitamin E N=6
Glucose(mg/dl) %change P value	110.5 ± 5.11	98.33 ± 4.40 -11.01% <0.05	86.3 ± 3.90 -21.9% < 0.01	106.10 ± 2.19 -3.98% <0.05
Cholesterol(mg/dl) %change P value	156.01 ± 2.81	123.66 ± 2.77 -20.7% < 0.01	103.95 ± 2.60 -33.4% < 0.01	153.11 ± 3.19 -1.9% < 0.01
Triglycerides(mg/dl) %change P value	82.1 ± 3.4	78.80 ± 2.50 -4% <0.05	90.83 ± 2.17 10.6% <0.05	110.20 ± 3.50 34.2% <0.001

Protein and non-protein nitrogenous constitutions concentration in albino rats serum after electromagnetic field exposure and the therapeutic action of vitamin C or vitamin E were tabulated in table (2). In general, the electromagnetic field exposure significantly increase urea, uric acid and creatinine compared to control level. The effect of electromagnetic field was more pronounced on uric acid. However vitamin C and /or E were able to lower the elevated values.

Table (2): Distribution of urea determination in 4 groups of albino rats exposed to electromagnetic field with and without therapeutic action of vitamin C or E.

Parameters	Control N=6	Electromagnetic field N=6	Electromagnetic field + vitamin C N=6	Electromagnetic field + vitamin E N=6
Urea(mg/dl)	29.25 ±	37.67 ± 0.07	33.50 ± 0.04	34.50 ± 0.05
%change	0.05	28.8%	14.5%	18%
P value		<0.001	<0.01	<0.01
Uric acid(mg/dl)	2.10 ±	4.46 ± 0.18	3.60 ± 0.15	4.00 ± 0.16
%change	0.12	112.3%	71.4%	90.5%
P value		<0.001	<0.001	<0.001
Creatinine(mg/dl)	0.65 ±	1.8 ± 0.02	1.00 ± 0.03	0.9 ± 0.01
%change	0.03	196.9%	67.7%	52.3%
P value		<0.001	<0.001	<0.001

Using the results in table (2), one can show that urea, uric acid and creatinine decreased by 11.6%, 19.2% and 0.44% respectively when treated with vitamin C compared with the exposure to electromagnetic field alone, and decreased by 0.08%, 10.3% and 0.11% respectively when treated with vitamin E.

Table (3): Distribution of total protein, albumin and globulin in the 4 groups of albino rats exposed to electromagnetic field with and without therapeutic action of vitamin C or E.

parameter	Control N=6	Electromagnet ic field N=6	Electromagnetic field + vitamin C N=6	Electromagnetic field + vitamin E N=6
Total protein(mg/dl)	7.11 ± 0.05	6.96 ± 0.06	7.35±0.02	6.90 ± 0.03
%change		-2.11%	3.4%	-2.95%
P value		<0.05	<0.05	<0.05
Albumin(mg/dl)	3.15 ± 0.05	4.15 ± 0.07	3.69 ± 0.06	3.46 ± 0.03
%change		31.75%	17.14%	9.84%
P value		<0.001	<0.01	<0.05
Globulin(mg/dl)	3.96 ± 0.03	2.81 ± 0.02	3.66 ± 0.04	3.44 ± 0.02
%change		-29.04%	-7.6%	-13.14%
P value		<0.001	<0.05	<0.05

Table (3) presents the total protein values for control group, group subjected to electromagnetic field, group subjected to electromagnetic field and treated by vitamin C, and group subjected to electromagnetic field and treated by vitamin E. In table (3), we noticed that total protein for albino rats decreased when subjected to electromagnetic field with percentage of decrease equals 2.11% compared to the controlled group. The total protein

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also decrease when rats subjected to electromagnetic field were treated by vitamin E with percentage of decrease equals 2.95% compared to the control group.

However, albumin protein was increased compared to the control group with percentage of increase of 31.75%, 17.14% and 9.84% when rats exposed to electromagnetic field, rats exposed to electromagnetic field and treated by vitamin C, and rats exposed to electromagnetic field and treated by vitamin E, respectively. On the other hand, globulin protein was decreased compared to control group with percentage of decrease of 29.04%, 7.6% and 13.14% when rats exposed to electromagnetic field, when exposed to electromagnetic field and treated by vitamin C, and when exposed to electromagnetic field and treated by vitamin E.

We calculated from table (3) the compared the therapeutic effect of the addition of vitamin C or E to the effect of the electromagnetic field alone. We found that total protein and globulins for albino rats were increased when treatment with vitamin C with percentage .056% and 0.36% respectively compared to the group exposure to electromagnetic fields. While Albumin was decreased by 0.11% when treatment with vitamin C. The total protein and albumin also decrease when rats treated by vitamin E with percentage of decrease equals .009% and 0.17% compared to the group exposure to electromagnetic fields. And globulin increased by 0.22%.

Discussion

In the present work, electromagnetic field influence had shown a great effect on biochemical blood parameters. However, most of these changes showed signs of improvement with the treatments with vitamin C and vitamin E.

Previous studies on the effect of electromagnetic fields on living organisms showed that the initial effect of an electromagnetic field is the triggering of key biochemical processes in various metabolic pathways [17]. The physiochemical action, ion, dipolar, macrostructure, electrolytic polarization, and other factors may also play a role such as molecular excitation, biochemical activation, generation of radicals, chemical bond weakening, hydration change, altered relaxation time of atom vibration, and altered spin of dipoles [18].

These physicochemical changes may affect the biochemical parameters of serum. Data revealed a general decrease in serum glucose levels in albino rats in response to the electromagnetic field exposure and this is in agreement with the results observed by Gorczynska and Wegrzynowicz [19]. Albino rats treated with electromagnetic field plus vitamin C or vitamin E showed a

decreased in serum glucose level. Vitamin C or E may potentiate insulin effects by increasing insulin secretion [20].

Concerning lipid metabolism, results demonstrated that the triglycerides and total cholesterol levels were decreased in response to electromagnetic field exposure as previously reported by Kula *et al.* [17].

The decreased level of total protein in rats subjected to electromagnetic field compared to control is also in agreement with the results of Kula [18]. The decrease in the level of protein, cholesterol, and Glucose can be explained due to male function of the absorption process as a result to the exposure of the rats to the electromagnetic field.

In this study, we observed a decrease in globulins. The decrease may have resulted from disturbed protein synthesis in the liver, which is controlled by steroid hormones. The availability of tissue proteins release of amino acids and their metabolism in the liver are triggered by the catabolic action of glucocorticoids [21].

The elevation of blood urea is a good indicator for kidney disorders. Urea is the principal end product of protein catabolism and accelerated amino acid deamination for gluconeogenesis is possible and acceptable postulate to interpret the elevated levels of urea [22]. Additionally, the presence of some toxic compounds might increase blood urea and decrease plasma protein.

Uric acid is the end product of the catabolism of tissue nucleic acid ,*i.e.* purine bases metabolism [23]. The increase in uric acid concentrations may be due to degradation of purines or to increase uric acid levels by either overproduction or inability of excretion.

Creatinine is the last variable of non nitrogenous protein blood constituents; it appears in serum in amounts proportional to body's muscles mass and is more readily excreted by the kidneys than urea and uric acid. Elevated creatinine concentration is associated with abnormal renal function, especially as it relates to glomerular function [22].

Kaczmarek and Adey [24], reported that electromagnetic field causes changes in the activity of the oxidative enzymes due to some mitochondrial changes and disturbance in the mechanism of mitochondrial membrane permeability. After one day of exposure to electromagnetic field, the tubular epithelial cells were much swollen and a pronounced swelling in the glomeruli and glomerular adhesions with Bowman's capsule, in albino rats was observed by Zaghoul [25].

We also found that treatment by vitamin C decreases serum glucose cholesterol, urea, uric acid and creatinine level and increased triglycerides compared to group exposed only to electromagnetic field. However, the treatment with vitamin E increases glucose, cholesterol and triglycerides

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levels compared to the group only exposed electromagnetic fields. On the other hand, vitamin E decrease urea, uric acid and creatinine level compared to the group only exposed electromagnetic fields.

We found that treatment with vitamin C results in total protein and globulins were increased while Albumin was decreased when compared to the group exposure to electromagnetic fields. When rats treated by vitamin E, the total protein and albumin were decreased and globulin was increased compared to the group exposure to electromagnetic fields.

Vitamin E is naturally lipid soluble antioxidant. It has been suggested recently that vitamin E stabilizes lipid layers through interaction with arachidonic acid [26]. By virtue of its hydrophobicity, vitamin E partitions into lipid membranes, thereby being positioned optimally for maximal antioxidant effectiveness. That is why vitamin E prevented the expected radiation injury [27]. Vitamin C is a water soluble antioxidant which can directly scavenge super oxide and hydroxyl radicals [28].

Conclusion and Recommendations

In this work, we verified the harmful effects of the electric field strength of 40-120V/m generated by mobile telecommunication antenna on the biochemical parameters in the serum of albino rats. We also proposed to use vitamin C or vitamin E to defeat the harmful effects might induced by electromagnetic field.

We found that the electromagnetic field exposure decreased the concentrations of serum glucose, triglycerides, total cholesterol, total protein and globulin. The concentration of albumin, urea, uric acid and creatinine were increased. Consequently, we found that EMF exposure at split dose could be harmful. We also found that vitamin C or E were able to alleviate some of those harmful changes. Further research is needed to test other biological effects of EMF and employing different experiment designs.

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