

# Changes of Cortisol and Glucose Concentrations in Rats Exposed to MR Imaging Field

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## ABSTRACT

**Background:** MR imaging is one of the best diagnostic modalities in medicine. During an MR imaging examination, three types of field are employed to produce images. Various experimental studies have been performed about the effects of each single type of field but only few studies are available on their combination to generate MR imaging. The main objective of this research work is to study the effects of MR imaging on the level of glucose and cortisol hormone.

**Methods:** 40 adult male Wistar rats ( $220 \pm 10$  g) were randomly divided into 2 groups of exposed (20) and control (20) groups. They were exposed under diagnostic MR imaging of 1.5 T field strengths for 25 minutes. Then, immediately blood samples were isolated and level of serum glucose measured by Auto-analyzer and cortisol content of blood sera was assayed by radioimmunoassay (RIA).

**Results:** Findings showed significant decreases in the levels of glucose and cortisol hormone after 25 minutes of exposure .

**Conclusion:** MR imaging may have adverse effects on the level of glucose and cortisol hormone.

## Keywords

MRI, Cortisol, Glucose Concentration, Rats, Blood

## Introduction

During the last decades, a number of electromagnetic devices have added to the electronic pollution in the atmosphere which may have potential damaging effects on living organisms. Important sources of man-made electromagnetic pollution are represented by diagnostic tests. It has been reported that the medical sources of radiation amounted to about one fifth of the natural one in 1987, while only ten years later it was close to 100% [1]. It is well established that ionizing radiation imposes risk to human health and environment, not much is known about possible effects of EMF relevant to patient's safety. The interaction between EMF and biological systems raise some fundamental, unanswered scientific questions and may lead to fields being used as tools to probe basic biology. Furthermore, using of MR imaging in diagnostic examination as a powerful imaging modality, the number of people exposed to EMF has increased dramatically. Although to date there is an extensive base of literature on the use of EMF for medical applications, the overall research strategy into this phenomenon has been quite fragmented. Today, the great number of available MR scanners and routine clinical application does not even allow a calculation of

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how many exams are performed in the world [2]. Numerous biochemical studies have been carried out to evaluate the effects of magnetic fields on the metabolism of cell [3-6]. The studies have shown significant disturbances in the metabolism of carbohydrate, lipid and protein reflected by altered blood levels and by 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 probably due to a metabolic of conversion of alpha-ketoglutaric acid to succinyl-coenzyme A. It is likely that the disturbance lead to adaptative changes, which in turn result in altered lactate dehydrogenase activity and accelerated transamination processes [7-9]. Electromagnetic fields penetrate the animal body and act on all organs, altering the cell membrane potential and the distribution of ions and dipoles. These alterations may influence biochemical processes in the cell, thus changing both biochemical parameters and enzyme activities of serum. Data on the effects of electric and magnetic fields on human health and other animals are inconsistent probably due to differences in the exposure conditions, populations and parameters studies [10-12].

A lot of experiments have been done in relation to the effects of EMF on the endocrine system. It is also reported that magnetic fields cause changes in hormonal secretions such as glucagons, cortisol and thyroxin in rats [13-14]. The main goal of this study was to evaluate the possible direct effect of 1.5 T field strengths on the level of glucose and cortisol hormone.

## Materials and Methods

### Animals

Adult male Wistar rats ( $250 \pm 10$  g, 3 months old) were randomly selected and used in the experiments. They were raised in the animal house unit in the Faculty of Medicine at Isfahan University of Medical Sciences. They were

maintained under controlled temperature of  $21 \pm 1$  °C in 12 h light and 12 h darkness schedule. Food (manufactured by Pars Company (Karaj) according to standard recipes) and tap water were freely available in the cage.

### Experimental Setup

MR imaging system (1.5 T) operating at 64 MHz (Sigma MR System, General Electric Company, Milwaukee, WI) was used. 40 males were randomly split in 2 cages made of polypropylene (20 rats in each cage). one cage was placed in the coil of MR imaging (exposed group) for 25 minutes, because MRI diagnosis is usually performed within this time. Another cage (control group) was placed in MR imaging while it was off (without magnetic field). Blood samples were taken immediately after MR imaging process. All biological determinations were performed in a blind manner [15].

### Hormone Assay

Blood samples were taken from the tail region of the animals. The blood samples were taken at 12 noon and centrifuged at 5000 rpm for 4 min, and the serum samples were stored at -70 °C for future analysis. Samples were then analyzed for levels of glucose serum by an auto-analyzer instrument (Al Instruments, France) and Serum hormone levels were assayed using sensitive Radioimmunoassay (RIA) kits (Immunotech, USA).

### Statistical Analysis

Data are expressed as mean  $\pm$  standard deviation (SD). Differences between control and exposed groups were analyzed by Mann-Whitney test. The P values of less than 0.05 were considered statistically significant.

### Results

Table 1 summarizes the effects of MRI (1.5 T field strength) on the level of glucose and cortisol hormones. As this table shows, there is a statistically significant decrease in both the

**Table 1:** Effects of exposure to MRI (1.5 T) on the concentration of glucose and cortisol hormones in adult male rats (results are expressed as mean  $\pm$  SD).

Hormone level	Control	Exposed (25 min)
Glucose (mg/dl)	113 $\pm$ 8.1	*78.1 $\pm$ 14.1
Cortisol (ng/dl)	545.2 $\pm$ 4.4	**245.1 $\pm$ 109.1

\*: P < 0.05 significantly different from the control group (Mann-Whitney test).

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\*\* : P < 0.005 significantly different from the control group (Mann-Whitney test).

serum levels of glucose (P < 0.05) and cortisol (P < 0.005) hormones.

## Discussion

The main objective of this research work was to study the effect of MR imaging on the level of glucose and cortisol hormone. Many previous studies of 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 [16-19].

The effect of an electromagnetic field on the living organism is a complex phenomenon. The initial mechanism is physicochemical in nature and afterwards biological effects develop. The physicochemical action of an electromagnetic field consists in electron, ion and dipolar, macrostructural and electrolytic polarization. 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, 19]. These physicochemical changes may affect the biochemical parame-

ters of serum. Many studies showed changes in protein levels the changes occurred in all electrophoretic in-vivo protein fraction of serum, but the levels of albumines and  $\gamma$ -globulins were most affected [20, 21].

In this study, findings showed a decrease in cortisol and glucose levels. Zare et al reported a significant decrease in glucose and cortisol concentrations in Guinea pigs exposed 2 h/day for 5 days to 5 Hz, 0.013  $\mu$ T magnetic field strength [22]. The decreases may have resulted from hormone synthesis in the glands, which controlled by peptides hormones. The availability of tissue proteins, release of amino acids and their metabolism in the liver are triggered by the catabolic action of glucocorticoids but the changes observed in glucose level can be attributed to change glycolysis and glycogenolysis with a metabolic block of conversion of pyruvate to acetylcoenzyme A only. The action of glucocorticoids is also determined by the function of the liver and nutritional status [18, 20, 23]. The results here showed that MR imaging is able to decrease the cortisol and glucose level after 25 minutes. Further investigations are required to clarify the subcellular action of applied MF, as well as to establish the biological significance of this phenomenon.

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