Bioeffects of 1.5T Static Magnetic Field on the DNA Strand of Human Leukocytes in Vitroduring MRI Scan

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Abstract

Background: The non ionization of magnetic resonance fields effect sreported with radical pair recombination. Which is one of the familiar methods by which static magnetic felid interact with biological systems. Exposure to static magnetic fields can effect on the paramagnetic free radicals by increasing the concentration, the activity and life time of paramagnetic free radicals, which might lead to genetic mutation, oxidative stress, and in some times with apoptosis.

Objective: To estimate the genotoxicity on DNA molecule during expose to static magnetic field 1.5T of magnetic resonance imaging.

Patients and Methods: The five blood samples were irradiated to 1.5T static magnetic field at different periods (10,20,30,40,and 50 minutes correspondingly). All exposures were performed at room temperature. Cellular DNA damage had been analyzed by the alkaline comet assay.

Results: The results approved a significant increasing in the rate of recurrence of single-strand DNA breaks next to the exposure of a 1.5T of magnetic resonance imaging at 50 min. According to these results the exposure with 3T magnetic resonance imaging encourage genotoxic effects in human lymphocytes could be suggested.

Conclusion: To conclude, in the present study, employing alkaline comet assay, it has been demonstrated thatmagnetic resonance imaging- induced DNA damages is significant in leukocytes at 50 minute after exprosure to 1.5T magnetic resonance imaging.

Key words: Static magnetic fields, magnetic resonance imaging, DNA, comet assay

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Introduction

Magnetic resonance imaging (MRI) is an imaging equipment that has been increasingly used as diagnostic method in giving images with high quality by using non-ionizing radiation. It provides electromagnetic fields with three different frequency types ;static magnetic field(SMF),radiofrequency fields RF in the MHz and gradient magnetic fields GMF in the kHz range with time varying [1][2][3]. By utilizing the three types of magnetic fields. MRI exam give excellent different level of contrast with any part of the body tissues including the musculoskeletal system, spine, and the brain. A number of epidemiological studies have shown that exposure to low-level electromagnetic field raises the risk of diseases for example:

leukemia among people whose jobs expose them to EMF or the brood who reside near the power lines[2,4]. Some researchers have been examined the degree of genetic damage of human cells and bacterial after an exposure at MRI scan up to 1.5T : the hypothesis for these studies is approving a documented evidence of significant connection between carcinogenesis and significantly increased genetic damage [1][5].For that reason, it was a necessity to systematically reveal the effect of staticmagneticcfield static (MFS) on the human during or after MRI scan. Consequently to elucidate the possible effects of static magneticcfield, it is essential to organize them as weak (<1 mT), moderate (1 mT to 1 T), strong (1–5 T), and ultra-strong [>5 T] [6][7][8].SMFs do not vary with time and with considered intensity.

The SMF consist of four parameters in relation with the interactions with the biological system: magnet characteristics, target tissues, dosing regimen, and magnet support device [9]. staticmagneticcfield are complicated to the shield and can go through biological tissues during the MRI freely [10]. On the other hand, not only the intensity of the main field has significant role in biological effects, but as well the gradient field has ability to biological effect too[11, 12]. SMF has direct interaction with moving charges (ions, electrons,etc.) and materials with magnetic properties which are present in the tissues through plentiful physical mechanisms [7].

Comet assay well-known as single Cell Gel Electrophoresis (SCGE), can measure DNA damage in eukaryotic cells individually. Comet assay principle is that unfragmented DNA keeps a well-organized structure in the nucleus, but turn into disrupted when the cell is injured. It identified both single-strand and double strand breaks, and has a uncomplicated and low-cost arrangement [13][14].

Of the three procedures of DNA migration frequently used percent tail DNA, tail moment and, tail length. In current days, The using of the present tail DNA as primary end point or preferred metric is an increasing emphasis [14]. At the same time the relative fluorescent intensity in the tail and head has been measured by the present tail DNA [15]. The tail moment is an index that takes into consideration the both factors of genetic matter and the total amount of his DNA. The-olive-tail-moment((OTM))is the-product of the tail length-and the fraction tail DNA[16]. The criteria-for determining the end of the tail could be affected-and unsatisfactory in the same time, if it measured by Tail length, because it is sensitive-to the surroundings intensity of the image analysis and the length only enlarges at relatively low-damage levels .

This study aim to evaluate the genotoxicity of 1.5T static magneticcfield MRI on DNA molecule.

Patients and Methods

Subjectsand Samples

Five blood samples were collected from each of (5) apparently healthy female child donors from health center in Al-dorah. The ages were ranged between 5-8 years-MRI.

The study was based on two sessions, the first session included main magnetic field testing in Baghdad hospital with 1.5T MRI machine (PHILIPS, ACHIEVA) type. This session is depending on the effects of time-varying in relation to them main magnetic field on peripheral blood sample.

Exposure conditions

The five blood samples were irradiated to 1.5T static magnetic field at different periods (10,20,30,40 ,and 50 minutes correspondingly).All exposures- applications were carried out at room temperature. Then,

tubes were placed in small ice portable fridge till carried back to the laboratory.

In consideration of the homogeneity of the radio frequency (RF) field in the coil and the gradients are in their linearrregime. This was situated inside the MRI scanner on the tablewith distance approximately 1 to 4 cm from the iso-center of the individual tubes.

Comettassay for measurementtof DNA stranddbreaks

The theory of the comet assay is that DNA molecule with smaller size migratesmore rapidly in an electric field in compare with the larger DNA molecule size[13]. The treateddcells are encapsulated inngel and lysed by alkali, which also denaturessthe DNA. following electrophoresis leads to the migration of the DNA. The damaged DNAwhich containing cleavage and strand breaks will produce a comet tail shape because they will migrate furtherr than intacttDNA.Cellular DNA damageewas analyzed by the alkaline comet assay (Cell Biolabs' OxiSelect™ Comet Assay,Cell BIOLAB,INC,(USA).

Statistical analysis

The value represents Mean ± Sd. Statistical analysis of the means between different study groups was carried outby one way analysis of variation (ANOVA). A P value < 0.05 was considered statistically significant.

Results

Analysis of results was based on percentages of DNA in the comet "head" DNA (amount of genetic material distributed in the nucleus) and in "tail"DNA (amount of genetic material distributed in the fragmented pieces) and Tail length (µm). It examines ≥ 100 cells for each sample.

The results showed that SMF exposure (1.5T, during 10,20,30,40 min) did not cause DNA damage in leukocytes.Although the DNA damage was significant differences were observedin the 5 healthy samples at 50 min after exposure to SMF(Table 1).

Table (1): Comet assay results (HeaddDNA,TailDNA,Tail length) in Healthy control samples.

Group	No.	SMF exposure(min) / sample	No.ofCell analyzed	Head DNA %	Tail DNA %	Tail lengthµm
Healthy control group	5	50	100	35.4 ±0.52*	14.35 ± 0.52*	9.95 ± 0.21*

* p<0.05 significant

Discussion

These outcomesrecommendthat exposure to 1.5T during MRI scan makes genotoxic effects in lymphocyte (DNA damage) discovered using single cell gel electrophoresis.

According to the results of the present study, there are disagreements with Amara *et al.* [17]. Considered the result of SMF exposure into harming of DNA in monocyte linee. Though, cell culture had been exposed with 250 mT of SMF for the period of 1st, 2nd, and 3rdhoursaccordingly. The data illustrated the viability of the cells was a little lesser in SMF exposed groups in compare with the same exposed group. The analysis of DNA by comet assay showed that the exposure of SMF did not induce any DNA damage by 1st and 2nd hours. On the other hand, it exerted a little level of DNA abreaks subsequent to three hours of exhibition.

Other studies approved When lymphocytes were exhibited to SMF during MRI scanning in clinical exam protocols of brain: three-channel head coils for 22, 45, 67, and 89 minutes. It found alargeelevate in the percentage of DNA damage subsequent scanning to 3 T MRI[18]. These data

illustrate that undergoing exposuree to 3T MRI stimulates genotoxic effects in the lymphocytes of human.

The real reasons for the changes in DNA which in exposure with EMF by this method is unknown. Because the level of energy of EMF exposure is not sufficient to make direct breakage of molecules chemical bonds. The cells indirect or secondary effected might belong to other induced biochemical changes. For example could belong to the DNA is damaged by free radicals that are formeddinside cells. Cells could be damaging protein, membrane lipid and DNA by the influence of the free radicals.

Many previous studies have showed that EMF has increased free radicals activity in the cell, especially by the Fenton reaction [17]. The Fentonreaction is a processs catalyzed by iron-in which hydrogen peroxide. A product of oxidative respiration in the mitochondria will be converteddinto hydroxyl free radicals, which are very potentt and-cytotoxic-molecules[19].

Inconclusion,the present study, employing alkaline comet assay, it has been demonstrated that MRI- induced DNA damages is significant in leukocytes at 50 min after exprosure to 1.5T MRI.

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