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Study of the effect of magnetic fields emitted by magnetic resonance device (MRI) on blood and body temperature

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Original Research

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Abstract:

This work, discusses the effects of an MRI device on human blood, through evaluating exposure of two human groups electromagnetic radiation emitted from MRI devices during the diagnosis of diseases. The work was carried out at the teaching hospital of Fallujah by taking nine samples of blood from people of different ages ranging 10 - 60 - 10 years for both sexes. A complete blood count (CBC) measure of these samples, was undretaken for each of the following platelet count (PLT), red blood cell (RBC), and white blood cell (WBC). Results show that the MRI device produce no effects on the human blood of PLTs number, nor RBCs and WBCs. Consequently, we find that use of MRI device is safe on human blood cell counts.

Keywords: MRI device; Electromagnetic; Radiation; Hospital; Fallujah

1. Introduction

Magnetic resonance imaging (MRI) is a medical non-surgical test used by physicians in the diagnosis and treatment of medical cases. Magnetic resonance imaging utilizes strong magnetic field pulses and frequencies for wireless and a computer to make images in detail and members of the soft tissues, bones, and all other internal body structures, and uses ionizing radiation (X-rays) [1]. Magnetic resonance imaging systems are used routinely in nearly every central hospital in the world due to their effectiveness in diagnostic medicine. However, with the increasing exposure of patients to electromagnetic fields from magnetic resonance imaging systems, questions about patient integrity became more urgent. However, with the development of magnetic resonance imaging devices, patients are exposed to stronger fixed magnetic fields as well as more intense and higher radio frequency (RF) electromagnetic fields, as well as to fast-switching magnetic field gradients. It is important to study the effects of these EMFs on patients as well as on operating personnel to identify potential hazards and ensure safety [2].

For more than a century ago, there was a discussion about safety issues associated with exposure to magnetic fields, such as constant exposure to the largest magnetic field available at that time (about 0.15 Tesla). Where many of the experiments were conducted in the laboratory on nerve-muscle cells in live animals, and it proved that the static magnetic field has no effect as a threat to health [3]. Experiments showed that after exposing the erythrocyte sediments to a magnetic field of (0.79 Tesla), there was no cytolysis, but in contrast, a number of cells with a deformed appearance appeared, and they were nearly four times larger than the control cells. However, the results of the microscopic examination when exposed to a magnetic field of (1.2 Tesla) showed that the deformed cells were mainly sporadic and rare shapes. Spherical shapes, which differ from previous shapes that occur in an irreversible process, Pierron found

that these distortions occurred 20 to 25 minutes after exposure to the magnetic field [4].
The purpose of this work was to study the effect of radiation emitted from the MRI device on the blood during the diagnosis of the disease.

2. Theory

Radiofrequency magnetic fields are of great importance for excitation nuclear and for the reception signal in imaging in the magnetic resonance imaging device (MRI). The interactions between these domains and human tissues in anatomical engineering result in a different and diverse set of effects related to the integrity and clarity of the image and the safety of the human being [5].
The definition of magnetic induction, or what is also called heavy flow, as the numeral of lines of the force that can pass during a unit of substance area is measured by magnetic flux density unit tesla (T).
Force that move power lines through a well-known material is the magnetic force is named the intensity of field and symbolized by the symbol (H-domain), and field strength is measured in units of ampere per meter [6].
Also, the magnetization or intensity of magnetization of the material is linked with the magnetism induced in the matter and thus can be considered the density volumetric of the dipoles magnetic induced in matter. Field strength, magnetization H, magnetic induction M, these parameters are related to the equation one:

$$B = \mu_0(H + M) \tag{1}$$

where μ_0 is called the permeability of free space and its value $4\pi \times 10^{-7}$ NA^{-2}. In the vacuum, $M = 0$, and M is very minimal in the water and air, such as for metal treatment also Equation (1) can be simplified to the following Fig. as in Equation (2):

$$B = \mu_0 H \tag{2}$$

where H (the magnetic field intensity) is proportionate to B (the induced flux density value) [6].
Magnetic susceptibility (χ) is known as the proportion of the magnetization intensity produced in the matter applied to the field of magnetic, which produces magnetization and is expressed in Equation (3):

$$\chi = \frac{M}{H} \tag{3}$$

By combining Equations (1 & 3), it cane get on the Equation (4):

$$B = \mu_0 H(1 + \chi) \tag{4}$$

χ for the paramagnetic materials is a small and positive constant; for magnetic materials it is a very smaller and negative constant. Also, the magnetic susceptibility (χ) of magnetic material depends on the field of magnetic, and decreases together with the force of the field when the material becomes saturated [6].

2.1 Magnetic resonance

The magnet are the main component of an MRI scanner, which polarizes the sample and the shim coils to rectify shifts in the homogeneity of the major magnetic field; the system of gradient which is utilized localize the area to be scanned, and the radio frequency system, this leads to excitation of the sample and thus detects the nucleation signal from the nuclear magnetic resonance(NMR). Control of this system is entirely through one or more computers. Magnetic resonance device scan requests a strong regular magnetic field for a few parts of each million request. Most systems operate at a field strength of the magnet of 1.5 Tesla, but commercial systems are available between 0.2 and 7 Tesla [7]. More recently, MRI has also been shown in very low fields, that is, in the microtesla to milli tesla domain, where adequate signal quality is made possible via pre-polarization and measurement of Larmor preemptive fields at about 100 μT with Superconducting Quantum Interference Devices (SQUIDs) [8–10].
The unit of magnetic flux density or induction is Tesla (T). The earth's magnetic field is about 0.05 metric Tesla (0.5 G) [11].
The magnetic field produces top MR signals stronger, with the increase in the signal-to-noise ratio (SNR) theoretically rising with the failed; this mean you obtain twice the SNR at (1 T) as compared to (0.5 T). From a practical point of view, the gains in the SNR of the area are often offset in part by factors of force other. In the mesial and low-power points, it is easy to produce a more open magnetic design to reduce claustrophobia. Most systems in clinical utilize are (1.5 Tesla). Occasionally used the strengths of the field of higher clinically but more common in the search.
Pulse radio frequency (RF); it is generated by the sender of the file and is surrounded by the whole body or part of it. To image the head or limbs, small transmission coils are occasionally utilized. It detects magnetic resonance (MR) signals that are produced in the body by using a file receiver. Magnetic resonance (MR) signals are sensitive and very weak to electrical interference. It was contracture a special shield in the magnet room called (the Faraday cage) to reduce interference from radio-frequency sources outside room magnetic resonance imaging. It is important to keep the door of the magnet room closed during the survey to the full Faraday cage [11].
Provided the magnetic resonance phenomenon (nuclear magnetic resonance, NMR, and electron resonance Albarramagnatisa, (EPR1) today, the most reliable measure of homogeneous magnetic field standards typically achieves an accuracy of 0.1 ppm and better-controlled conditions. For this reason, today is the basic standard NMR for calibration. Observed NMR for the first time in the molecular beam in 1938 by Raabe and his colleagues [8]. A few years later, in 1946, this phenomenon was observed in liquids and solids by two independent [9–11]. It can be the principle of measuring the magnetic field using magnetic resonance intuitively.
Begin to explain the observation that when a particle with a magnetic moment and angular momentum is placed in a backward magnetic field with a force of B advancing around

the field direction. Proportional to the frequency f of the initiative, which is also called Larmor frequency, with the magnetic field:

$$f = \gamma B \tag{5}$$

where the constant of proportionality is called the ratio of gyromagnetic. The latter is a property of the particle that can be returned to standard values, such as those listed in Table 1.

2.2 Biological effect of magnetic resonance imaging

Medical imaging using an MRI machine is safe because it has the ability to change the position of atoms only, and it does not change its properties or composition as ionizing radiation does. It must be taken into consideration that there are fundamental risks if these medical devices are used, despite their use of magnetic fields in medical examination of patients and people working inside MRI examination [12]. To diagnose biological damage that may be dangerous as a result of the use of magnetic resonance imaging, there have been many studies in previous years, and their results were controversial [13]. A strong magnetic field can affect metal materials and medical devices inside the human body, so those working on these devices must ask patients, monitor them, and be alert for any emergency [14].

2.3 Devices and materials

The effect of magnetic emission from MRI devices on some blood types has been studied with ages ranging from 10 - 20, 20 - 30, 30 - 40 to 40 - 60, and for both sexes in Fallujah Teaching Hospital. Hema-screen18 was used to measure some blood parameters like platelet count (PLT), red blood cell (RBC), and white blood cell (WBC), before and after exposure, as shown in Fig. 1. Where the intensity of the magnetic flux of the device is 1.5 T.

3. Results and discussion

Complete Blood Count (CBC) for nine blood samples was taken for people of different ages ranging from 10 - 20, 20 - 30, 30 - 40, 40 - 50, and 50 - 60 for both sexes, complete blood count (CBC) for nine blood samples were taken for people of different ages ranging from 10 - 20, 20 - 30, 30

Table 1. Calculations of normal blood parameters such as white blood cell (WBC) and its first values (WBC1) after exposure for MRI and its second values (WBC2) after the exposure and for different ages and different sex.

Ages (year)	WBC1	WBC2	WBC
	10^9/L (40 min)		10^9/L
10 - 20	8.2	8.2	9.4
20 - 30	8	7.9	10
30 - 40	7.1	6.6	7.6
40 - 50	10	9.6	11.2
50 - 60	11.6	11.8	13.1
Average	8.98	8.8	10.2

Figure 1. Hema screen 18 was used to measure some blood parameters like White blood cell (WBC), red blood cell (RBC), and platelet count (PLT) before and after exposure.

- 40, 40 - 50 and 50 - 60 for both sexes, measured of these samples was done for each of the following parameters PLT, RBC, and WBC, then the samples were saved in the EDTA tube.

The samples were putted in the magnetic domain in the MRI device with a time of 40 minutes at first exposure. Where the average WBC measurement before and after exposure and for all ages were 10.2 and 8.98, respectively, which is within the standard range $4 - 11 \times 10^9$ per L [15]. The rate of RBC measurement before and after exposure for all ages were 4.55 and 4.6, respectively, within the measurement of the universally accepted RBC $0.3 - 5.2 \times 10^{12}$ per L [16], while the PLT measurement rate was before and after exposure and for all ages were 226.8 and 283.6 respectively, within the measurement range PLT $135 - 317 \times 10^9$ per L [17] as shown in Figs. 2-4. The samples were again exposed to the magnetic field generated in resonance devices for a shorter period of time to confirm the results of the exposure, as shown in Tables 1- 3.

To confirm the results obtained, Blood samples were taken from men and women aged 60 - 50 years to 20 - 10 years, and the samples were exposed to the magnetic field emitted by the MRI device on the same day. The results showed that none of the blood parameters (WBC, RBC, PLT) were affected after exposure, as shown in Table 4. The same

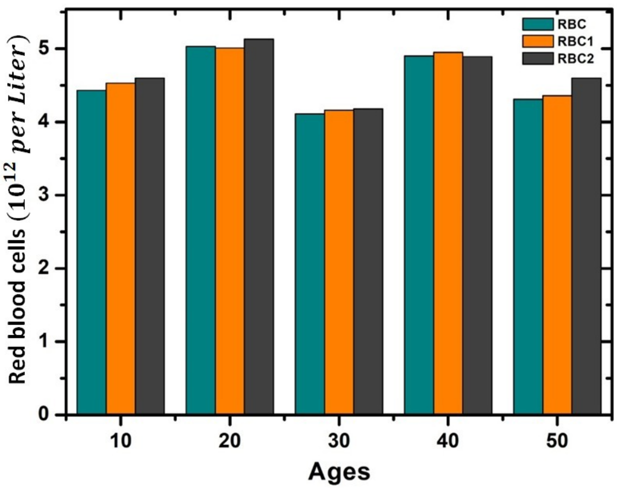

Figure 3. Measure RBC before and after exposure to magnetic waves.

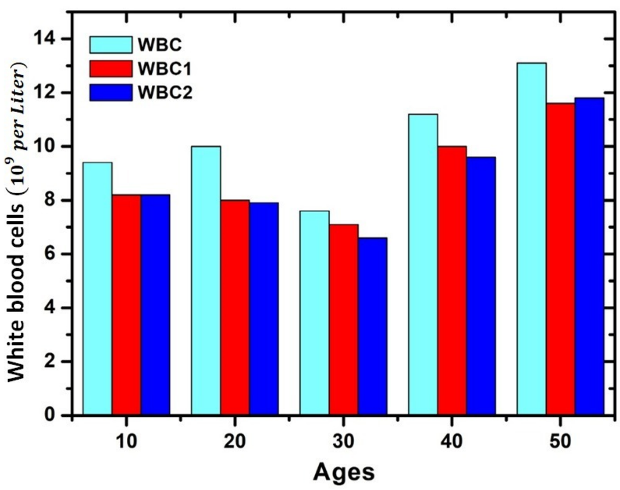

Figure 2. Measure WBC before and after exposure to magnetic waves.

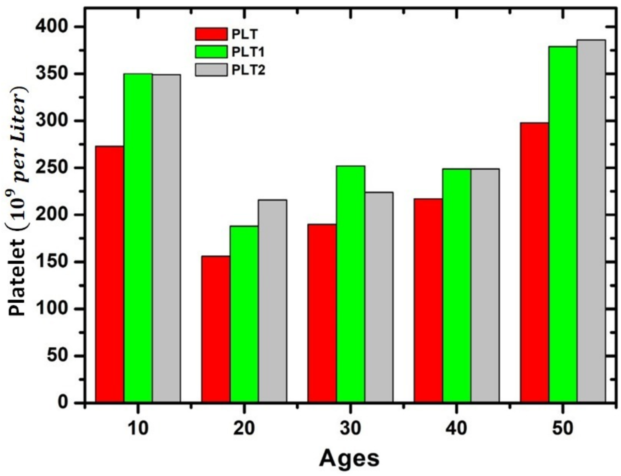

Figure 4. Measure PLT before and after exposure to magnetic waves.

Table 2. Calculations of normal blood parameters such as red blood cell (RBC) and its first values (RBC1) after exposure for MRI and its second values (RBC2) after the exposure and for different ages and different sexes.

Ages (year)	RBC1 10^{12}/L (40 min)	RBC2	RBC 10^{12}/L
10 - 20	4.53	4.6	4.43
20 - 30	5.01	5.13	5.03
30 - 40	4.16	4.18	4.11
40 - 50	4.95	4.89	4.9
50 - 60	4.36	4.6	4.31
Average	4.6	4.68	4.55

Table 3. Calculations of normal blood parameters such as platelet count (PLT), and its first values (PLT1) after exposure for MRI and its second values (PLT2) after the exposure and for different ages and different sex.

Ages (year)	PLT1	PLT2	PLT
	10^9/L (40 min)		10^9/L
10 - 20	350	349	273
20 - 30	188	216	156
30 - 40	252	224	190
40 - 50	249	249	217
50 - 60	379	386	298
Average	283.6	284.8	226.8

Table 4. Calculations of normal blood parameters such as platelet count (PLT), white blood cell (WBC), and red blood cell (RBC) and its first values (PLT1, RBC1, and WBC1) after exposure for MRI and its second values (PLT2, RBC2, and WBC2) after the exposure and for different ages at the same day.

Ages (Year)	PLT	PLT1	PLT2	RBC	RBC1	RBC2	WBC	WBC1	WBC2
20 - 10	200	220	218	4.47	4.64	4.55	6.2	7.3	7.1
60 - 50	261	286	269	4.67	4.82	4.69	13.3	15.8	14.5

changes have been observed, when complete data do not confirm the MRI risk hypothesis; they indicate the necessity for further studies and judicious utilization to obviate needless examinations in accordance with the preventative principle [18].

4. Conclusion

The effect of magnetic field emission from magnetic resonance imaging devices on some blood types was studied, which were taken from people whose ages ranged between 10 - 20, 20 - 30, 30 - 40, 40 - 50 and 50 - 60 for both sexes at Fallujah Teaching Hospital. Hema-screen18 was used to measure some blood parameters such as white blood cells (WBC), red blood cells (RBC), and platelet count (PLT) before and after exposure. The intensity of the magnetic flux of the device was 1.5 Tesla. We did not notice any changes in the parameters of the blood under study after it was placed inside the MRI machine and according to the different periods.

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Authors Contributions
Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials
Data presented in the manuscript are available via request.

Conflict of Interests
The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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