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RESEARCH PAPER

The Influence of MRI, X-ray, and Nano-Scale Effects on Hospital Workers' Health

Huda Mohammed Khilf [1,2*], *Mohammed Ubaid Hussein* [3], *Abderrazek Oueslati* [1]

[1] *Laboratory of Spectroscopic Characterization and Optical Materials, Faculty of Sciences, University of Sfax, Tunisia*

[2] *Director of Education, Anbar, Ministry of Education, Iraq*

[3] *Department of Medical Physics and Physiology, Medicine College, University of Anbar, Iraq*

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ABSTRACT

The technique of taking visual images of the human body's interior for diagnostic and therapeutic reasons is known as medical imaging. Medical imaging comes in several forms, the most often used being nuclear medicine, magnetic resonance imaging, ultrasound, and radiography. Medical imaging technologies have brought about a revolution in healthcare, resulting in better patient outcomes and public health benefits. Electromagnetic radiation is used in radiography to create internal body pictures. The most popular type of radiography is x-rays, which use high-energy waves to scan the body and detect the waves' reflections off of hard tissues like bones to produce a picture. The way of working and studying, the study included (402) patients who were visited to the diagnostic radiology department for periodic examinations of them; and in various hospitals of his/her area, the areas and center of Al Anbar-Iraq, in (Al-Ramadi Teaching Hospital), patients with blood disorders and those undergoing open heart surgery and receiving anticoagulant factors were excluded, and diabetics and chronic pressure who are previously receiving surgical treatment were also excluded. The study was divided into two groups comprising (222 male), (180 female), and then divided into the same group by age into three subgroups, the first (22-35 years) which are group A, the second (36-45 years old) which is group B, the third (46-55 years old) which is group c. Samples of blood (white blood cells WBC, red blood cells RBC), blood platelets PLTu HGB blood hemoglobin) have been examined for patient loyalty in two stages, first stage before exposure to (X-Ray and MRI) and the exposure when time and intensity of the magnetic field changes is considered in proportion to the magnetic resonance in addition to the sort of test, such as an X-Ray, and then repeat the same steps after a duration of three months.

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INTRODUCTION

In the past, X-ray devices were only utilized in high-security locations, but with the rise in national and international terrorism, they are now preferred in many settings, including malls, hotels, congress centers, public institutions, business centers, plazas, hospitals, and educational institutions [1]. A stationary source directs the X-ray (Rontgen)

* *Corresponding Author Email: huda_alheety@yahoo.com*

onto photo diodes. The X-rays will pass through any item that stands between them and the photo diodes and arrive at the opposite surface. When an item is exposed to X-rays, photo diodes absorb the shape, type, and atomic weight of the object and reflect the information back as an image on the screen. The transmitted picture can be either black or white, and colorful images can be conveyed at higher segments, depending on the quality of the X-ray detector. The colored tones of the thing on the monitor indicate which atoms are present in it. The test will be identical to the others, both before and after exposure. To generate the rays, an X-ray tube is often found within an X-ray generator. It's possible that radioisotopes can also produce X-rays [2]. A cathode that guides an electron stream into a vacuum and an anode composed of tungsten to collect the electrons and remove heat from the collision are the two components of a basic vacuum tube, or X-ray tube. About 1% of the energy generated when the electrons collide with the target is released as X-rays, while the remaining 99% is released as heat. Although different materials can be employed, especially in XRF applications, the target is often composed of tungsten due to the tremendous energy of the electrons that approach relativistic speeds [3, 4].

THEORY

The patient must remove any jewellery or clothing that might block the inspection site's exposure. A gown will be available in case the patient has to take off their clothes. The desired body part is carefully placed between the X-ray machine and a cassette carrying the X-ray film while the patient lays on an X-ray table. During certain tests, the patient could be requested to sit or stand. Body parts not being photographed can be shielded or covered with a lead apron to prevent exposure to X-rays. Next, the area that has to be photographed is the focus of the X-ray beam. The patient needs to be quite still for the picture to be clear. As the technician steps behind safety glass, the photo is taken. Several radiographs at various angles, such as the front and side views for a chest radiograph, may occasionally be required [5-7].

An MRI scanner's gradient system finds the region to be scanned, the RF system excites the sample and detects the subsequent NMR signal, the main magnet polarizes the sample, and shim coils rectify variations in the homogeneity of the main magnetic field. These are an MRI scanner's principal parts. The entire system is controlled by one or more computers. For MRI, there must be a strong magnetic field that is consistent across the scan volume to a few parts per million. In commercial systems, the magnet field strength is measured in Teslas, which vary from 0.2 to 7 T. The majority of systems run at 1.5 T. Whole-body MRI machines are useful for scientific reasons in, for instance [8-11],[12]. Hydrogen nuclei, which are made up of just one proton, provide signals in most medical applications. These signals are processed to build a picture of the body based on the density of hydrogen nuclei in a particular area. Because the protons in some compounds are influenced by the fields of other atoms to which they are linked, it is possible to distinguish responses from hydrogen. The subject is placed inside an MRI scanner, which creates a strong magnetic field around the area that has to be examined, in order to conduct the research [13].

(a) **(b)**

Fig. 1. (a) X ray Device, and (b) MRI Device.

Unless instructed differently, you should be able to eat, drink, and take any medications as normal on the day of your MRI scan. Upon completion of the inquiry, you will often be required to sign a consent form before the scan may proceed. It's crucial to take out any metal things from your body since the MRI scanner generates powerful magnetic fields. Among them are Items that can be found include watches, jewelry (necklaces, rings, etc.), piercings (nipple, ear, and nose rings), dentures with artificial teeth, hearing aids, and wigs (some of which include metal traces). If you must bring valuables with you for your scan, they should usually be stored in a closed container,

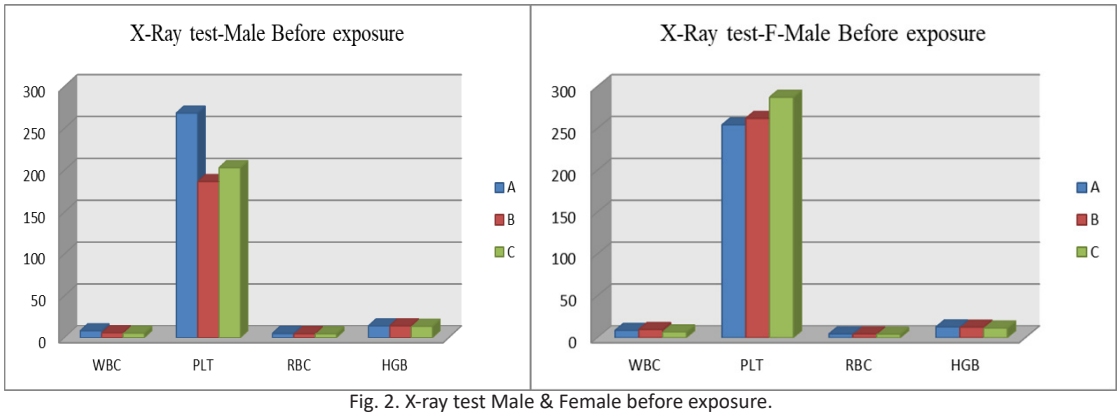

Fig. 2. X-ray test Male & Female before exposure.

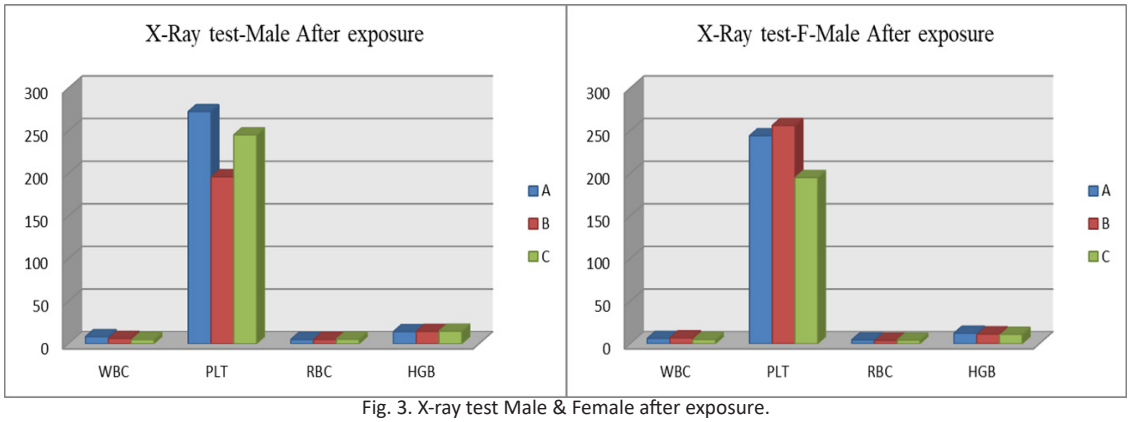

Fig. 3. X-ray test Male & Female after exposure.

Table 1. (a- Male, b- Female).

No	age	WBC	PLT	RBC	HGB
1	A	8.3	272.28	4.94	14.2
2	B	6.26	195.85	4.94	14.5
3	C	4.97	245	5.33	14.8
No	age	WBC	PLT	RBC	HGB
1	A	8.71	254.3	4.55	12.8
2	B	9.85	262	4.50	12
3	C	7.02	287.3	4.29	11.6

even if it's best to avoid doing so [14]. Depending on the part of your body being scanned, you might need to wear a hospital gown throughout the procedure. An MRI scanner is a short, open-ended cylinder. You will lie on a motorized bed that is within the scanner. You will either insert your feet or your head through the scanner first, depending on the part of your body being scanned [14, 15]. Because this frame contains receivers that pick up on the signals your body puts out throughout the scan, it can help produce a higher-quality image. A computer controls the MRI scanner, which is kept apart from other equipment in order to shield it from the magnetic field it generates. Since the radiographer is the one who operates the computer, they will also be in a separate room from you. But during the scan, you will be able to speak with them, usually over an intercom, and they will always be able to see you through the viewing glass and on a television display [16, 17].

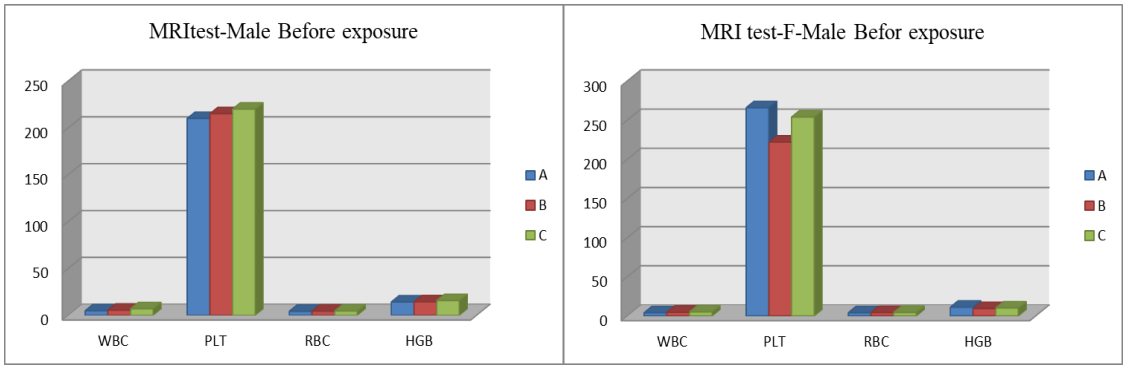

Fig. 4. MRI test for Male & Female before exposures.

Table 2. (a- Male, b- Female) After exposure.

No	age	WBC	PLT	RBC	HGB
1	A	8.3	272.28	4.94	14.2
2	B	6.26	195.85	4.94	14.5
3	C	4.97	245	5.33	14.8
No	Age	WBC	PLT	RBC	HGB
1	A	6.2	244	4.55	12.3
2	B	6.95	256	4.08	11.5
3	C	4.96	195	4.22	11

Table 3. (a- Male, b- Female) before exposure.

No	age	WBC	PLT	RBC	HGB
1	A	4.2	210	4.22	11.3
2	B	4.8	215	4.35	9.5
3	C	5.2	220	4.56	10.3
No	age	WBC	PLT	RBC	HGB
1	A	4.8	210	4.22	14.2
2	B	5.4	215	4.35	14.3
3	C	6.9	220	4.56	15.7

RESULTS AND DISCUSSION

The X-ray device

The test will be identical to the others, both before and after exposure.

Ionizing radiation has been shown to have effects on blood cells, and it is thought that these effects have a role in the development of hematopoietic syndrome, which is a condition that occurs in both people and animals following total body irradiation. Low amounts of radiation may be encountered by diagnostic technicians while doing their duties, particularly if they disregard the radiation protective equipment that we observed them using at the hospital where our study was conducted. Although the technicians' individual radiation exposure is minimal, the cumulative effects of their exposure over time (known as stochastic effects) raise their occupational risk. Long-term exposure to routine medical treatments can have detrimental effects on health that are potentially lethal [6].

The researched samples in this study were split into groups based on their daily working hours and job experience. All groups showed a highly significant increasing value for the parameter measuring reactive lymphocytes when compared to the controls, however only group A and 7 hours per day showed a substantial increase in lymphocytes. This indicates that the technicians' reactive and lymphocyte-producing cells may change as a result of long-term x-ray exposure. a little rise in lymphocytes, on average six hours every day, in group B. Radiation had a stronger effect on reactive lymphocytes than on lymphocytes. This might be because lymphocytes have a lower radio sensitivity than reactive cells do, and their repair mechanisms function more quickly.

Hemoglobin (HGB), white blood cells (WBC), platelets (PLT), and neutrophils decreased after exposure to low-dose, prolonged natural terrestrial ionizing radiation, while only two parameters—red blood cells (RBC) and lymphocytes—increased. Since the x-ray technicians' lymphocyte count was found to be considerably growing, the results of this study and our own investigation fit very well [7, 8, 18].

According to the results, the amount of working hours each day has a discernible effect on

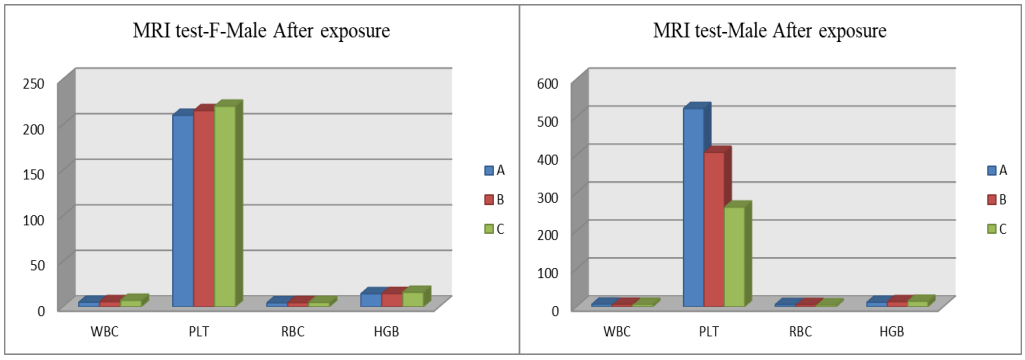

Fig. 5. MRI test for Male & Female After exposures.

Table 4. (a- Male, b- Female) After exposure.

No	Age	WBC	PLT	RBC	HGB
1	A	6.3	522	5.44	11.4
2	B	5.9	406	5.27	12.8
3	C	5.8	262	4.23	14.1
No	Age	WBC	PLT	RBC	HGB
1	A	8.05	301	3.94	10.6
2	B	7.82	266	3.8	10.3
3	C	6.78	254	3.64	10.2

lymphocyte shape, and x-ray technicians' reactivity and lymphocyte features were significantly impacted by continuous x-ray exposure. The parameter reactive lymphocytes showed a high-significant growing value, whereas the parameter lymphocytes rose considerably. The x-ray technicians gave them an update on the findings and stressed the need of wearing radiation protective gear to prevent overexposure in their daily life [9, 12].

The MRI device

Magnetic Resonance Imaging (MRI) is a non-invasive imaging technique that produces three-dimensional, very detailed anatomical images. It is widely used in illness monitoring, diagnosis, and detection. Using cutting-edge technology, it stimulates and detects the change in the direction of the protons' revolving axis, which is found in the water that makes up living tissues. Tests were carried out in the same way for all three age groups and for both sexes, male and female, both before and after the four recommended examinations were administered:

If a patient has any metallic items in their body, they need to alert the MRI crew or their doctor before the scan. Metallic chips, materials, surgical clips, and foreign objects (such prosthetic devices, metallic bone plates, or artificial joints) can significantly alter the images captured by the MRI scanner. Patients with metal pacemakers, implants, chips, or clips in or around their eyes are not candidates for MRIs due to the risk that the magnet will move the metal in these areas. Similarly, those with insulin pumps, metallic ear implants, mechanical heart valves, bullet fragments, chemotherapy, or other medical conditions should not have MRI screening.

The patient lays within the magnetic tube in a confined space while having an MRI. During the process, claustrophobic feelings may strike certain patients. Patients should thus inform the radiology personnel and the practitioner seeking the test if they have ever experienced claustrophobia. To aid with this discomfort, a little amount of sedative can be administered before the MRI scan. It is standard procedure for the MRI team to be present during the scan.

The following was revealed during the study, which was done on the same individuals, both male and female, after at least six months and under the same settings.

An MRI at a reputed imaging institution in Iraq has no known danger as long as all medical instruments are accounted for and anxiety is under control. There is no risk of radiation exposure because the scan doesn't use radiation as an x-ray does. You should talk to your doctor about any possible side effects if you do need medication to aid with nerves. A very small possibility of a response to the utilized contrast dye exists as well.

It should be able to get on with your day normally as there are no after-effects from the scan, unless you were put to sleep. The largest negative is that an MRI typically takes 30 to 90 minutes to complete. However, it is not a concern at this moment because there is no radiation exposure. The MRI images will be taken by an expert who will then analyze and discuss the results with you.

Pregnant women are not recommended to get an MRI scan unless it is absolutely necessary. This is being done as a precaution rather than because there are known adverse consequences on a pregnancy.

Comprehensive Analysis of Blood Test Results Before and After MRI Scanning, blood tests were conducted on individuals categorized by gender (male and female) both before and after undergoing magnetic resonance imaging (MRI). The results revealed significant changes in several blood parameters, including:

Hemoglobin (HGB), Red Blood Cells (RBC), Platelets (PLT), and White Blood Cells (WBC).A thorough examination of these findings is provided below, along with some possible explanations for the alterations that were noticed.

Analysis of Male Results Before and After MRI Scanning, results Before the MRI Scan (Table 3a): Prior to the MRI, the values were generally within normal ranges then WBC; Ranged from 4.8 to 6.9, indicating a normal immune response, PLT: Ranged from 210 to 220, within the normal range while RBC: Ranged from 4.22 to 4.56. Also HGB: Ranged from 14.2 to 15.7, a normal level indicating no anemia.

While Results After the MRI Scan (Table 4a); Post-MRI, significant changes were observed, WBC increased markedly across all age groups, from 4.8 to 6.3 in Group A, suggesting a potential immune response due to stress from the strong magnetic field. PLT experienced a dramatic increase, especially in Group A, rising from 210 to 522. This significant increase may reflect the body's response to repair affected tissues. RBC increased

in some groups like A and B, while it decreased in Group C (from 4.56 to 4.23). These variations may reflect individual responses based on age or health status. HGB decreased notably in Group A from 14.2 to 11.4, which could indicate a negative impact on hemoglobin synthesis due to stress or the magnetic field.

Interpretation (Males): Increase in WBC, Exposure to a strong magnetic field might trigger an immune response, leading to an increase in white blood cells. The body may perceive the MRI scan as a stressor, resulting in elevated WBC levels to counteract any adverse effects. Increase in PLT, the increase in platelets could be a physiological response to repair any damage sustained during the MRI. This response may aim to prevent internal bleeding and accelerate healing. Changes in RBC and HGB, variations in RBC and HGB levels post-MRI might relate to the body's ability to handle the magnetic field. Some individuals may show increased RBC production as compensation, while others might experience a decrease due to potential effects on bone marrow. While, analysis of Female Results Before and After MRI Scanning, Before the MRI Scan (Table 3b), the MRI; the values were as follows: WBC: Ranged from 4.2 to 5.2, within normal limits, PLT: Ranged from 210 to 220, normal. Also, RBC: Ranged from 4.22 to 4.56, indicating stability in red blood cell count. As well as HGB: Relatively low, particularly in Group B, where it was 9.5, suggesting possible anemia before the MRI.

Results After the MRI Scan (Table 4b): Post-MRI, the observed changes were; WBC significantly increased in all groups, especially in Group A (from 4.2 to 8.05), indicating an immune response, PLT increased, but less drastically than in males. Group A saw a notable rise (from 210 to 301). RBC decreased substantially across all groups, particularly in Group C (from 4.56 to 3.64), indicating a negative impact on the body's red blood cell production, as well as HGB showed a slight improvement in some groups (such as A and B) but decreased in Group C.

Interpretation (Females);Increase in WBC, Similar to males, females also exhibited an increase in WBC after the MRI, reflecting a body response to the magnetic field-induced stress, enhancing immune activity, increase in PLT, The increase in platelets among females might be a protective reaction to the magnetic field exposure, though less pronounced than in males, Decrease in RBC and HGB, the decrease in RBC levels in females may result from the MRI's impact on bone marrow or blood circulation. This reduction could be due to physical stress or effects on smaller blood vessels [15, 18, 19].

Analysis of Changes Resulting from MRI Scanning Based on the Provided Results, Changes in Male Results (Tables 3a and 4a); WBC: Before the Scan: Values ranged from 4.8 to 6.9. After the Scan: Increased to 5.8 to 6.3. Interpretation, increase in WBC after the MRI indicates an immune response possibly triggered by stress from the magnetic field. While MRI is non-invasive, it may induce slight psychological or physical stress, prompting an immune response reflected in increased WBC counts.

PLT Values were normal (210 to 220), After the Scan: Increased significantly, especially in Group A (from 210 to 522).

Interpretation, the sharp rise in platelets may signify a physiological response to stress from the magnetic field. Platelets play a role in blood clotting, and their increase could be a general bodily reaction to maintain tissue stability.

RBC and HGB: RBC Before the Scan: Ranged from 4.22 to 4.56; after the scan, values ranged from 4.23 to 5.44, HGB Before the Scan: Ranged from 14.2 to 15.7; after the scan, decreased to 11.4 to 14.1.

Interpretation**,** changes in RBC and HGB suggest that the MRI might have affected blood production balance. These effects could be due to altered blood flow or minor impacts on bone marrow function. A decrease in HGB, especially in Group A, might indicate the body's stress response.

Changes in Female Results (Tables 3b and 4b); WBC: Before the Scan: Ranged from 4.2 to 5.2., After the Scan: Increased to 6.78 to 8.05. Interpretation: Similar to males, the increase in WBC among females reflects an immune response to the MRI's magnetic field, enhancing immune system activity.

PLT, before the Scan: Values ranged from 210 to 220, after the Scan: Increased to 254 to 301. Interpretation**,** the moderate increase in platelets among females suggests a body response to the magnetic field, though less extreme than in males. This increase indicates an enhanced protective response.

RBC and HGB: RBC Before the Scan: Ranged from 4.22 to 4.56; after the scan, decreased to 3.64 to 3.94. while HGB Before the Scan: Ranged from 9.5

to 11.3; after the scan, ranged from 10.2 to 10.6.
Interpretation: the observed decrease in RBC levels in females post-scan may be due to the MRI's effects on blood circulation or marrow function. This reduction could be a response to stress or effects on smaller blood vessels.
Overall Conclusions Regarding Observed Changes in Pre- and Post-Scan Results, body's Response to Stress: MRI scanning appears to induce a stress response in the body, evidenced by increased WBC counts in both genders. This reaction could be due to the physical or psychological stress associated with the procedure.
Increased Platelets as a Protective Response, the significant increase in platelets, particularly in males, suggests a protective mechanism to enhance blood clotting and tissue repair. This response may be related to the magnetic field's effect on blood vessels or general self-protection mechanisms.
Variability in RBC and HGB Response, the differing responses in RBC and HGB levels between genders suggest variability in how the magnetic field impacts blood circulation. Males experienced stable or increased RBC levels, while females saw a notable decrease, possibly due to hormonal or biological differences.
Temporary and Normal Changes: Overall, these changes in blood parameters following an MRI are likely temporary and do not indicate long-term health issues. The body's response to the strong magnetic field is expected to normalize shortly after the scan.
Recommendations for Post-Scan Monitoring: Monitor Results with Repeated Scans, if individuals undergo MRI scans frequently, it is advisable to monitor changes in blood test results to ensure the body is responding normally.
Consult a Physician for significant changes, Notable alterations in RBC or platelet counts should prompt consultation with a physician to determine if these changes are related to the MRI or other health factors. Reduce Stress Before Scanning: Since stress can affect test results, efforts to minimize stress before the MRI, such as relaxation techniques or deep breathing exercises, are recommended [7, 15, 18].

CONCLUSION

Blood cells have been demonstrated to be impacted by ionizing radiation, and it is believed that these effects contribute to the hematological condition that occurs in both humans and animals after whole body irradiation (Billings et al., 2014). As we saw at the hospital where our study was done, diagnostic technicians may be exposed to low doses of X-rays while working, especially if they neglect radiation protection equipment. while the radiation exposure of the personnel during each specific procedure. Our research leads us to the conclusion that some hematological parameters are measurably impacted by working hours, and that diagnostic technicians' CBC values are affected by low amounts of radiation from X-ray equipment used for diagnosis. Neutrophils, monocytes, basophiles, MCV, RDW, and PLT were found to be substantially reducing, but red blood cells, hemoglobin, hematocrit (HCT), lymphocytes, and hemoglobin were found to be significantly expanding. Our study's findings are concerning and unexpected. The information showed a statistically significant correlation ($P < 0.01$) between the radiation exposure levels in imaging and the waiting rooms for CT scans and X-rays at all of the hospitals that were chosen. The majority of hospitals have thyroid shields and lead aprons in place for radiation protection, but only around 50% have lead glasses and lead shields, indicating that many hospitals still lack basic supplies. Furthermore, the real radiation dosimeter use rates are 57.7% and 68.9%, respectively. Radiation exposure from MRIs and x-rays poses a concern to patients and medical personnel alike, and exposure levels are higher than recommended. Radiation protection equipment is completely absent from many hospitals, and many still lack safety equipment. More research ought to be done to emphasize various facets of radiation exposure dosage and protective gear. When surgical clips, pins, plates, screws, metal sutures, wire mesh, or internal metallic objects like bullets or shrapnel are present, an MRI is also not advised. If you are pregnant or suspect you might be, you should tell your doctor. Pregnant patients should not have MRIs due to the possibility of a harmful increase in the temperature of the amniotic fluid.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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