SHORT REPORT

Impacts of X-Ray irradiation on RBC, WBC and PLT by low doses (40kV and 80kV)

Najeba Farhd Salih[1], Shatha Farhan Alhous[2], Murtadha Shakir. Aswood[3], Ansam Fadhel Showard[4]

Abstract

This study aimed to assess the impact of irradiation on red blood cells (RBCs), white blood cells (WBCs), and platelets (PLTs) using modest doses of X-ray radiation (40 kV and 80 kV).

The blood samples were exposed to X-ray irradiation at 40 and 80 kV. A haematology analyzer system with automated capability was used to quantify cellular components, specifically WBCs, RBCs, and PLTs, both before and after exposure to radiation.

The study found that irradiation reduced WBC and PLT numbers. When exposed to 40 kV and 80 kV voltages, the WBC and PLT improved statistically significantly (p = 0.001). Nonetheless, the statistical analysis revealed no statistically significant difference (p > 0.05) in red blood cell count between 40 and 80 kV doses.

It can be concluded that the haematopoietic system exhibits a high degree of sensitivity to radiation exposure.

Keywords: X-Rays, Erythrocytes, Leukocytes, Radiation, Hematopoietic, Haematology

DOI: https://doi.org/10.47391/JPMA-BAGH-16-82

Introduction

X-ray beams are classified as a type of electromagnetic radiation characterised by a relatively short wavelength, typically less than 10 nm. These beams typically serve as both diagnostic and therapeutic tools. X-rays are similar to gamma rays, although they possess lower energy levels. The formation of this substance occurs through the absorption of highly charged particles[1,2]. The red blood cells (RBCs) do not exhibit high sensitivity to radiation, they are a suitable choice for assessing the impact of radiation on the bloodstream. Direct exposure to a radiation source has a deleterious impact on an active blood cell as a result of the cell's inherent susceptibility to radiation, leading to cell death or genetic alteration[3,4]. In contrast, white blood cells (WBCs) exhibit a higher degree of radiosensitivity compared to other fully developed blood cells, rendering them more susceptible to the deleterious impacts of ionising radiation. Following a period of exposure, there is a drop in the white blood cell (WBC) count relative to the red blood cell (RBC) count. This discrepancy arises from the fact that RBCs possess a longer lifespan compared to WBCs, resulting in a gradual replacement process[5]. While the PLT is commonly characterised as a platelet count below 150,000 platelets per cubic millimetre of blood[6]. The objective of the study was to examine the impact of X-ray irradiation on the key constituents of blood, namely red blood cells (RBCs), white blood cells (WBCs), and platelets (PLTs), utilising two distinct voltages, specifically 40 and 80 kilovolts (kV).

[1-2]Department of Physics, Koya University, Koya, Kurdistan Region.[3] Department of Physics, University of Al-Qadisiyah, Al-Diwaniyah, Iraq.[4] Department of Radiological Techniques, Al-Mustaqbal University College, Hilla, Iraq.

Correspondence: Shatha Farhan Alhous
Email: shathaf.alfatlawi@uokufa.edu.iq

Methods

The research was approved by Human Research Ethics Committee, Mustansiriyah University, College of Medicine (No: 0044; date: 1 / 10 / 2022). A convenient sampling technique was adopted, and participants who met the inclusion criteria and agreed to participate for the specified period of the study (November 2022 to December 2022) were included. The blood samples were collected from healthy adults with no medical history of major illnesses or history of taking medications for major diseases. Blood samples were collected from all the adult participants in the Kurdistan region of Iraq. Healthy adult volunteers (20 female, 13 male) ranging in age from 18 to 60 years, provided blood samples. They participated in the experiments voluntarily after understanding the aim of the research. These samples were obtained with the aim of investigating the potential effects of X-ray exposure on adults. The evaluation of key components of human blood, namely WBCs, RBCs, and PLTs, was conducted using appropriate sample preparation procedures. Thirty-three human samples of 3ml each were withdrawn using a syringe and placed in an EDTA tube to prevent the clotting process. All the blood samples were tested in the clinic before irradiation (control) and then immediately transferred into a tube containing ethylenediamine tetra acetic acid to prevent clotting. If the samples were not used immediately, they were kept in a refrigerator at 4 °C and used within 2 days of collection. The samples were then irradiated by X-rays at 40 and 80 kV doses with a distance (50 cm) between the sample and source for one-minute. This was done by using an automated haematology analyser system (Sysmex, KX-21,Japan) to measure the effect of Xray's on the blood cells (WBC, RBC, and PLT) before and after radiation (in vitro X-ray irradiation) at 23ºC. The statistical analysis of Pearson correlation, Wilcoxon signed rank test, and paired t test (analysis of variance) was conducted using SPSS version 22.0. This analysis aimed to evaluate the significant difference among each point source of irradiation samples. The t-test was employed to conduct a comparison between the samples from the control group and the samples subjected to irradiation.

Results

Pre- and post-irradiation assessments were performed. Exposure to a voltage of 40 kV, both before and after radiation, resulted in a notable decrease in white blood cell count (WBC) and platelet count (PLT), ($p < 0.05$, $p < 0.05$, respectively) in comparison with non-irradiated specimens. Table 1 depicts a statistically significant disparity in blood cell counts before and after exposure to radiation at 80 kV. A significant drop in white blood cell count (WBCs) was observed following irradiation ($P< 0.05$). A significant difference in the white blood cell counts following irradiation, with a p-value of 0.009. The findings elucidated that the PLTs exhibited a significant disparity ($p < 0.05$), which subsequently diminished following irradiation as compared to the control samples. There was a significant decrease ($p = 0.001$) observed in the PLT parameter following irradiation. However, there was no significant difference ($p > 0.05$) observed in the red blood cells (RBCs) following irradiation when compared to the control samples. Table 2 presents the recorded results indicating significant correlations between the white blood cell count (WBC), red blood cell count (RBC), and platelet count (PLT) before and after irradiation. The data suggest that when individuals are exposed to irradiation, there is a reduction in the counts of red blood cells (RBCs) and white blood cells (WBCs) in the blood stream. Nevertheless, it is crucial to acknowledge that these decreases are confined to the standard therapeutic range. Previous research has also observed a comparable effect resulting from exposure to low levels of γ radiation and X-ray irradiation. It was discovered that the red blood cells (RBCs) underwent destruction, resulting in a decrease in their intrinsic worth or optimal performance. The primary cause of this damage was predominantly

Table-2: Statistical Analysis of blood cells between laboratory and measurements.

Laboratory measurements		Mean (± SD)	Mean difference ± SD	p value
WBC	Control	6.272 ± 2.073	0.195 ± 0.408	0.009*
	Radiation	6.077 ± 2.143		

Laboratory measurements		Ranks	Number	Mean rank	p value
RBC	Radiation - control	Negative ranks	11	12.17	0.330**
		Positive ranks	10	10.83	
		Ties	1		
		Total	22		
PLT	Radiation – control	Negative ranks	14	11.84	<0.001**
		Positive ranks	6	11.16	
		Ties	2		
		Total	22		

* Paired t test
** Wilcoxon Signed Rank test.

Table-1: Statistical analysis of blood cell in control and after irradiation

Variable	Difference	Ranks	Number	Mean rank	Z value	p value
RBC 40 kV	Radiation – control	Negative ranks	10	5.80	-2.247	0.25*
		Positive ranks	1	8.00		
		Ties	0			
		Total	11			
WBC 40 kV	Radiation – control	Negative ranks	7	4.5	-1.904	0.057*
		Positive ranks	1	4.5		
		Ties	3			
		Total	11			
RBC 80 kV	Radiation – control	Negative ranks	10	5.95	-2.364	0.18*
		Positive ranks	1	6.50		
		Ties	0			
		Total	11			

Variable	Difference	Mean (± SD)	Mean difference	p value
WBC 80 kV	Control - radiation	6.272 ± 1.197		
		6.154 ± 2.073	0.1181	0.046**
PLT 40 kV	Control - radiation	214.909 ± 92.592		
		209.454 ± 93.733	5.4545	0.74**
PLT 80 kV	Control - radiation	214.909 ± 92.592		
		205.363 ± 95.448	0.2727	0.011**

* Wilcoxon Signed Rank test
** Paired t test

attributed to the state of dehydration induced by the irradiation[7,8]. Increasing the absorption of photons would expedite the restoration of erythrocyte function and erythrocyte membrane integrity[9]. Based on the findings, it was observed that the X-ray range of 40 kV had a greater impact on the platelet count for the groups under investigation. However, it is worth noting that this alteration fell within the usual range of platelet counts[10]. Several studies have shown that X-rays cause a similar drop in the activity of endogenous respiration and succinate dehydrogenase in pure blood platelets. However, based on the obtained results, it is evident that irradiation leads to a drop in white blood cell count (WBC) and an increase in susceptibility to infection. The inadequate presence of white blood cells (WBCs) in the body hinders its ability to defend against viruses, bacteria, and other microorganisms that can cause DNA damage 9,10.

Limitation: One of the limitations of this research is that the sample size was not calculated using an equation; rather, it was chosen based on the amount of time that was available for data collection. This is a major limitation and could influence the power of the study.

Conclusion

The hematopoietic system demonstrates a notable susceptibility to the effects of radiation exposure, leading to the inference that it is highly sensitive to such exposure. The assertion posits that X-ray radiation could potentially exert an influence on peripheral blood. Red blood cells (RBCs) demonstrated a heightened level of sensitivity in comparison to other constituents of blood, while platelets (PLTs) showed increased resilience in response to the given stimulus.

Acknowledgement: The authors would like to offer special thanks to Al-Mustaqbal University College, Iraq for supporting them to conduct this study successfully.

Ethical Approval: The study protocol was approved by local ethics committee.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Romero-Weaver AL, Kennedy AR. Comparison of Two Methods for the Determination of the Effects of Ionizing Radiation on Blood Cell Counts in Mice. Int J Biomed Sci 2012;8:7-15.
2. Aswood MS, Salih AA, Al Musawi MS. Long-lived gamma-ray measurement in soil samples collected from city central of Al-Diwaniyah, Iraq. J Phys: Conf Ser 2019;1234:012003. doi: 10.1088/1742-6596/1234/1/012003.
3. Al Musawi MS, Jafaar MS, Ahmed NM, Al-Gailani BT, Suhaimi FM. Effects of low power violet laser irradiation on red blood cells volume and erythrocyte sedimentation rate in human blood. AIP Conf Proc 2017;1875:020005. doi: 10.1063/1.4998359
4. Aswood MS, Alhous SF, Abdulridha SA. Life time cancer risk evaluation due to inhalation of radon gas in dwellings of Al-Diwaniyah Governorate, Iraq. Nat Environ Pollut Technol 2022;21:331-7. doi: 10.46488/NEPT.2022.v21i01.040
5. Al Musawi MS, Al-Gailani BT. In Vitro Biostimulation of Low-Power Diode Pumping Solid State Laser Irradiation on Human Serum Proteins. Photobiomodul Photomed Laser Surg 2020;38:667-672. doi: 10.1089/photob.2020.4873.
6. Yahia MJ, Hasan JA, Musawi MS. Biostimulation effect of DPSS laser irradiation with different power densities and radiation times on blood viscosity in vitro. AIP Conf Proc 2020;2213:020118. doi: 10.1063/5.0000438
7. Al Musawi MS, Jaafar MS, Al-Gailani B, Ahmed NM, Suhaimi FM, Suardi N. Effects of low-level laser irradiation on human blood lymphocytes in vitro. Lasers Med Sci 2017;32:405-11. doi: 10.1007/s10103-016-2134-1.
8. Al Alani EA, Al Musawi MS, Mahdi AH. Influence of vitamin C on irradiated mice tissues induced DNA double strand breaks DSB using gH2AX marker. J Pak Med Assoc 2021;71(Suppl 8):s117-22.
9. Faraj KA, Elias MM, Al-Mashhadani AH, Baatout S. Effect of X-and gamma rays on DNA in human cells. Eur J Sci Res 2011;53:470-6.
10. Al Musawi MS, Jaafar MS, Al-Gailani BT, Ahmed NM, Suhaimi FM. In vitro effects of low level yellow laser irradiation on human red blood cells. In: 2016 IEEE 6th International Conference on Photonics (ICP). Kuching, Malaysia: Institute of Electrical and Electronics Engineers (IEEE); 2016. doi: 10.1109/ICP.2016.7510024.