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Effect Of Lowing Long-Term Levels Of Ionizing Radiation On Some Of Physiological Parameters and Oxidative Stress Among Radiologic Technologists

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***Abstract**. Technicians in radiology departments are continuously exposed to ionizing radiation, which can affect biological systems. This study aimed to investigate the effects of low-level ionizing radiation (IR) on antioxidant enzymes and blood components in radiology personnel. The study involved forty participants aged 30 to 45 years, divided into three groups: G1 as the control group (n=10), G2 consisting of 15 radiologists, and G3 comprising 15 radiology technology workers. Participants in G2 and G3 had work experience ranging from 5 to 15 years and were employed in X-ray and CT scan departments at General K1 Hospital, Kirkuk. The measured parameters included white blood cells (WBCs), platelets, and lymphocytes, as well as malondialdehyde (MDA), superoxide dismutase (SOD), total antioxidant capacity (TAC), and albumin as indicators of redox status. The results showed a significant increase in MDA levels among radiology workers compared to the control group, while SOD, TAC, and albumin levels decreased (P<0.05). Additionally, radiation-exposed workers had a higher mean count of WBCs and lymphocytes than the control group (P<0.05), whereas platelet levels were significantly lower (P<0.05). This study indicates that occupational radiation exposure can cause short-term changes in blood cells and increase the circulating redox state in healthcare workers operating in CT and IR environments compared to those not exposed to radiation. These findings highlight the importance of regular health monitoring for radiology personnel to mitigate potential long-term effects of radiation exposure.*

***Keywords**: Low-level ionizing radiation,MDA, Oxidative stress,Radiologic technologists ,SOD.*

Abstrak.Teknisi di departemen radiologi terus-menerus terpapar radiasi pengion, yang dapat memengaruhi sistem biologis. Studi ini bertujuan untuk menyelidiki dampak radiasi pengion tingkat rendah (IR) terhadap enzim antioksidan dan komponen darah pada tenaga medis radiologi. Penelitian ini melibatkan empat puluh partisipan berusia 30 hingga 45 tahun, yang dibagi menjadi tiga kelompok: G1 sebagai kelompok kontrol (n=10), G2 terdiri dari 15 radiolog, dan G3 terdiri dari 15 pekerja teknologi radiologi. Para peserta dalam G2 dan G3 memiliki pengalaman kerja antara 5 hingga 15 tahun dan bekerja di departemen sinar-X serta CT scan di Rumah Sakit Umum K1, Kirkuk. Parameter yang diukur mencakup jumlah leukosit (WBCs), trombosit, dan limfosit, serta kadar malondialdehida (MDA), superoksida dismutase (SOD), kapasitas antioksidan total (TAC), dan albumin sebagai indikator status redoks. Hasil penelitian menunjukkan peningkatan signifikan kadar MDA pada pekerja radiologi dibandingkan dengan kelompok kontrol, sementara kadar SOD, TAC, dan albumin mengalami penurunan (P<0,05). Selain itu, pekerja yang terpapar radiasi memiliki jumlah rata-rata WBCs dan limfosit yang lebih tinggi dibandingkan kelompok kontrol (P<0,05), sedangkan jumlah trombosit lebih rendah secara signifikan (P<0,05). Studi ini mengindikasikan bahwa paparan radiasi di tempat kerja dapat menyebabkan perubahan jangka pendek pada sel darah serta meningkatkan status redoks sirkulasi tenaga medis yang bekerja di lingkungan CT dan IR dibandingkan dengan individu yang tidak terpapar radiasi. Temuan ini menyoroti pentingnya pemantauan kesehatan berkala bagi pekerja di bidang radiologi untuk mengurangi dampak potensial dari paparan radiasi jangka panjang.

Kata kunci: MDA, Radiasi pengion tingkat rendah, SOD,Stres oksidatif, Teknolog radiologi

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1. INTRODUCTION

Ionizing radiation has significant biological impacts on the human body and is generally categorized into two types of exposure. The first type involves high radiation doses over a short period, which can cause immediate or acute effects. Meanwhile, the second type consists of prolonged exposure to low radiation doses, which can lead to long-term or chronic damage. Ionizing radiation is widely used in the medical field, particularly in patient diagnosis and treatment. Radiology, computed tomography (CT), nuclear medicine, and radiotherapy departments rely on radiation-based technology, making healthcare workers in these fields more frequently exposed to radiation than other professionals (Kochanova, D., et al., 2023).

Exposure to ionizing radiation can affect human health by generating free radicals, damaging chemical and DNA molecules, and inducing apoptosis or programmed cell death (Vakifahmetoglu, H., et al., 2008). Over time, these effects can increase the risk of cancer (Shin, E., et al., 2020). Radiation exposure is not limited to occupational settings but also comes from natural environmental sources, medical research, and consumer products (Hall, E. J., & Giaccia, A. J., 2006). The biological effects of ionizing radiation depend on dosage, exposure rate, and biochemical processes involved. These effects may occur spontaneously, rapidly (within a week), or more gradually, depending on the conditions of exposure (Rühm, W., et al., 2015).

The damage caused by ionizing radiation varies depending on cell type and the absorbed dose. Peripheral blood cells, for instance, are highly sensitive to radiation because they are part of a regenerative system consisting of rapidly dividing cells. As a result, blood cell counts can drop significantly following prodromal symptoms due to radiation exposure (Sanzari, J. K., et al., 2013). However, in theory, the hematopoietic system can maintain its function across a wide range of dose rates, from extremely low to very high levels. Unfortunately, the total dose required to induce hematopoietic failure in tissue approaches extremely high values at very low dose rates (Kutkov, V., et al., 2011).

One of the primary mechanisms through which ionizing radiation exerts its biological effects is through the production of reactive oxygen species (ROS). Superoxide (O2 •−) is one of the key ROS involved in radiation-induced biological effects. The human body has various antioxidant systems to counteract excessive ROS levels. Studies have shown that when eukaryotic cells are exposed to ionizing radiation, water radiolysis immediately generates ROS, leading to indirect radiation effects (Spitz, D. R., et al., 2004). This sudden surge in ROS causes oxidative stress, which damages essential biomolecules in the cell, including lipids, proteins, and DNA.

In addition to non-enzymatic antioxidants such as glutathione and albumin, the body also has enzymatic antioxidant systems to protect cells from oxidative damage. Enzymes such as glutathione peroxidase (GPx), catalase, and superoxide dismutase (SOD) play crucial roles in detoxifying ROS. SOD converts O2 •− into hydrogen peroxide (H2O2), which is then broken down by catalase into water and oxygen, preventing excessive ROS accumulation in cells (Shin, E., et al., 2020). Understanding these mechanisms underscores the importance of continuously monitoring radiation exposure among healthcare workers and developing effective radiation protection strategies to mitigate its adverse health effects.

2. MATERIAL AND METHOD

Study design

In this study, forty individuals between the ages of 30 and 45 were separated into three groups: G1, G2, and G3. G1 (control Group) ten peoples, G2 fifteen worker (Radiologists) and G3 fifteen worker (radiology technological) . Period of staff working ranged from five to fifteen years working in X rays and CT scan departments, General K1 Hospital, Kirkuk. All samples are collected from 1st December 2023 to 5th February 2024, and all the workers were in healthy state with normal lifestyle (without taking medicines or suffering from any chronic diseases).

Blood Samples

Blood samples were taken and separated into two groups:

1. Added as an anticoagulant to sodium stratum for determining WBCs and platelets.
2. Without anti-coagulant used to Albumin , SOD, MDH and TAC and centrifuged to obtain serum at 5000 rpm for 10 minutes.

Blood Tests

The investigated parameters included white blood cells (WBCs), lymphocytes (LYM), and platelets.

Malondialdehyde(MDA),Superoxide dismutase (SOD) and Total antioxidant capacity(TAC) levels.

Activity of antioxidant enzymes in serum was measured using the CUPRAC method for total antioxidant capacity assay (Apak, R et al., 2005), Guidet &Shah method for MDA (Schmedes, A., & Hølmer, G.1989) and Modified photochemical nitroblue tetrazolium method for SOD assay (Zhang, C. et al., 2016).

Albumin levels

Use Agappe Diagnostic Switzerland GmbH kit for determine albumin in serum.

Statistical analysis

The means ± SEM are used to express all data. For statistical analysis, Minitap edition 17 for Windows was used. Pearson's correlation test was used to calculate the correlations between the variables. At $P < 0.05$, every statistical evaluation was deemed significant.

3. RESULT AND DISCUSSION

	Albumin g\dl	**WBC $\times 10^9$**	**PLT $\times 10^9$**	**Lymph.%**
G1	4.29±0.36	6.75±1.38	332.7±38.0	35.0± 2.0
G2	2.43±0.77	7.75±1.95	237.3±27.1	44.67± 5.69
G3	3.71±0.38	8.0±1.52	316.7±28.9	34.75±3.4

Table 1. The impact of lowing-long term radiation on albumin, platelets, lymphocytes, and WBCs.

The current study's results indicate that there are notable differences between the blood parameters of radiation workers and the control group (table 1).

When comparing the current study's results with those of previous investigations, it was generally found that the outcomes of nearly all of the research on radiation workers' blood tests varied. In the current investigation, the levels of platelets in the blood of radiation workers (G2) were lower than those of controls ($P<0.05$).The only factor in the radiation workers' blood that was substantially lower than that of the control group ($P<0.05$)(table 1).Studies (Taqi, A. H. et al., 2018, Faraj, K., & Mohammed, S. 2018) also reported decreased platelet counts in the blood of radiation workers. Blood testing can be used to track radiation workers' overall health since(Heidari, S., et al.,2016, Katerji, M.et al., 2019) found that radiographers had lower platelets and white blood cell counts. However, for the early diagnosis of radiation impacts, supplementary approaches such chromosomal alterations, cytokines, and interleukins evaluation are crucial(Heidari, S., et al.,2016, Katerji, M.et al., 2019).

Table 2. The effect of lowing –long term radiation on SOD, MDA and TAC levels.

	SOD IU	**MDA $\times 10^{-6}\mu M$**	**TCA M**
G1	8.24±0.736	6.92±1.21	1.72±0.06
G2	2.52±1.23	28.6±4.12	1.45±0.068
G3	7.23±0.52	24.9±5.66	1.59±0.13

It seems that ionizing radiation-induced ROS generation is a major factor. According to Andreas MG (Andreassi, M. G. et al., 2005), ROS can cause detrimental health effects such inflammation, fibrosis, necrosis, and cancer. They can also destroy cell structures and, most crucially, DNA. The elevated amount of MDA suggests that systemic oxidative stress may result from long-term low-dose radiation exposure. A change in the balance between the generation and elimination of ROS results in oxidative stress (Kochanova, D.et al., 2023).

In this investigation; we discovered that exposed workers' MDA levels were noticeably significantly than those of the control group (table 2). These results are in line with earlier studies that found people who were exposed to ionizing radiation had higher levels of MDA(Bolbol, S. A et al., 2021 , Fang YunZhong, F. Y.,et al., 2002). Malondialdehyde (MDA) is a biomarker of damage from oxidation that is created when lipid peroxidation occurs which is a process that impact on polyunsaturated fatty acids in the membranes caused by free radicals. Numerous investigations have looked into the possible connection between radiation and lipid peroxidation (Sinha, M., et al., 2012). For instance, (Malekirad, A. Et al., 2005) discovered that long-term prolonged exposure to low-dose ionizing radiation raises MDA levels in the blood of hospital employees, particularly radiology staff. Further,(Arterbery, V. E., et al., 1994) found that both people and animals experience an increase in lipid peroxidation following whole-body radiation. Our current study reports an increase in MDA concentrations in different groups of radiologists, especially in those technologists who work with. Lipid peroxidation-induced damage to cell membranes is the molecular cause of disruptions in gene expression, signal transduction, and the regulation of cell processes related to apoptosis, adaptability, and/or genomic instability, all of which are strongly associated with the development of cancer. There is debate concerning the potential for modest doses of ionizing radiation to cause cancer (Shin, E.et al., 2020).

Our investigation at the radiology technologists' endogenous antioxidant enzyme activity (SOD, TAC) demonstrate a decrease in SOD but not significant and significant TAC activity in radiation-exposed workers compared to control workers, which is very interesting. It should be mentioned that SOD activity was shown to be lower among workers who were exposed to low-dose radiation levels at work in previous research. These findings indicate that free oxygen radicals increase and antioxidant levels decrease in the exposed groups and that the oxidative balance is impaired. These observations are consistent with those of previous studies (Kochanova, D et al., 2023, Bolbol, S. A et al., 2021).

Natural and artificial exogenous chemicals as well as endogenous compounds produced within the body are examples of non-enzymatic antioxidants. A number of them, including albumin, were solely thought to be inactive byproducts of metabolism until recently. Our findings indicate that albumin activity has decreased, indicating a rise in free radicals in the exposed groups relative to the control group (Khaket, T. P., & Ahmad, R. 2011).

CONCLUSION

Healthcare workers operating in CT and IR environments who are exposed to radiation tend to have increased circulating redox states. Blood tests can be used as a general health monitoring method for radiation-exposed workers. However, complementary techniques are required for the early detection of radiation effects. Additionally, the decrease in albumin levels in radiation-exposed individuals indicates a lower defense against free radicals, which may increase the risk of oxidative stress and cellular damage. Therefore, more comprehensive health monitoring and improved radiation protection strategies are necessary to mitigate the long-term adverse effects of radiation exposure.

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