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## Biochemical Study on the Impact of Radiation-induced Oxidative Stress on Radiographers in the X-ray and CT-scan Departments

Jian Lateif Hussein<sup>1</sup> 

Salih Omer Haji<sup>2\*</sup> 

<sup>1</sup>Department of Chemistry, College of Science, University of Salahaddin, Erbil, Iraq.

<sup>2</sup>Department of Physics, College of Science, University of Salahaddin, Erbil, Iraq.

\*Corresponding author: [salih.haji@su.edu.krd](mailto:salih.haji@su.edu.krd)

E-mail addresses: [jian.hussen@su.edu.krd](mailto:jian.hussen@su.edu.krd)

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### Abstract

The consequences of ionizing radiation-induced oxidative stress on radiographers in X-ray and CT-scan departments utilizing several biochemical were analyzed. The study found highly considerable discrepancies in the interplay between radiation levels and gender in terms of mean Malondialdehyde (MAD), Vitamin D3 (Vit.D3), Triiodothyronine (T3), Thyroxine (T4), and High-Density Lipoprotein (HDL), but not Thyroid Stimulating Hormone (TSH), cholesterol, triglyceride (TG) and Low-Density Lipoprotein (LDL). The findings indicated that malondialdehyde is a useful biomarker for assessing oxidative stress in radiographers with exposure to ionizing radiation.

**Keywords:** Ionization radiation, Lipid profile test, Oxidative stress, Reduction, Vitamin D3.

### Introduction

Radiology began in the latest 18<sup>th</sup> Century by a physicist called (Wilhelm Konrad Roentgen) who discovered X-rays<sup>1</sup>. Ionizing radiation (IR) is broadly applied in medicine, including diagnosis and therapy<sup>2,3</sup>. Around the world, X-rays are applied in medical establishments and research institutions and are a major source of ionizing radiation<sup>4</sup>. A high dosage of ionizing radiation was shown to harm people, including cancer induction in numerous organs<sup>5</sup>. The possible hazards and effects of low-dose radiation on occupationally exposed individuals are being discussed. The majority of studies have emphasized the effects of short-term and high-dose radiation exposure, while few have investigated the effects of long-term, low-dose radiation exposure on exposed individuals<sup>6</sup>. Oxidative stress is caused by free radicals and oxidants, and it is a damaging process that can harm various cellular structures, including membranes, lipids, proteins, lipoproteins, and (DNA)<sup>7,8</sup>. When there is an imbalance between the ability of cells to remove free radicals and the accumulation of free radicals, oxidative stress materializes. Excess hydroxyl radical and peroxy-nitrite, for instance, can cause lipid peroxidation, leading to damage to cell membranes and lipoproteins. This, in turn, leads to the creation of

malondialdehyde and conjugated diene molecules, both of which are cytotoxic and mutagenic. Because lipid peroxidation is a radical chain reaction that affects a large number of lipidic molecules, it spreads swiftly. In other hand Lipid profile has been measured utilizing commercially available kits, while the serum MDA and glutathione levels are measured by means of sandwich ELISA test using commercially available kits<sup>9,10</sup>.

The methodology of harmful Ionization Radiation (IR) impact is directly attributed to greater oxidative stress in exposed tissues<sup>3</sup>. Ionizing radiation can enter the cells of biological organisms and trigger the ionization of both organic and inorganic molecules<sup>11</sup>. Vit. D3 is a fat-soluble vitamin that has several functions in the human body. Sunlight is the primary source of Vit. D3 in the body, and it has been discovered to serve numerous regulatory activities, including influencing the body's oxidative-antioxidant balance. As a result, its usage to avoid the negative effects of irradiation has been considered<sup>12,13</sup>.

The hypothalamus-pituitary thyroid axis regulates thyroid gland function by producing thyroid hormones such as (T3) and (T4). Pituitary glands are regulated by Thyroid hormones, which

(TSH) is modulated by hypothalamic thyrotropin-releasing hormone<sup>14</sup>. Thyroid hormones have a significant impact on energy metabolism and temperature regulation<sup>15</sup>. Finally, thyroid hormones serve a significant and vital function in regulating sodium pump activity and controlling ionic stability in body fluids by regulating iodide pump efficiency, which enhances the rate of iodine acquisition by thyroid cells<sup>16</sup>.

The study aims to investigate the effect of radiation on people under continuous exposure conditions in radiology departments operating X-ray and CT-scan facilities to determine the health impact associated with their working condition including oxidative stress induced by radiation. This will be achieved by determining levels of malonaldehyde (MDA), vitamin D, thyroid hormone (TSH, T4 and T3) and analyzing lipid profile in blood samples of the study subjects.

## Material and Methods

### Materials:

Thiobarbituric acid (TBA) and trichloroacetic acid (TCA) were laboratory reagent grade from BDH, England.

### Method:

#### Sample Collection:

The study included 30 subjects (21 male and 9 female) X-ray and CT-scan radiographers working in Rizgary and Komary hospitals in Erbil City and Teaching Hospital in Sulaymania City, Kurdistan Region – Iraq. The control group included healthy volunteers consisting of 14 males and 11 females. The sample collection was completed over three months (September to December 2021).

A 5-ml blood sample was obtained for cases and control. The blood samples were collected in plane tubes, then centrifuged at 3000 rpm for 15 minutes. Serum fasting, cholesterol, triglyceride, HDL, LDL, Vit. D3 and T3, T4, and TSH tests were performed using Randox laboratory kits. Serum MDA level was determined by (Weinstein et al., 2000)<sup>17</sup>.

The study was conducted in the Department of Chemistry - College of Science at Salahaddin University-Erbil-Iraq.

## Statistics Evaluation

All statistical evaluations were used by SPSS software version 21. The mean and standard

deviations have been used to describe quantitative data, whereas absolute frequencies and percentages were used to express qualitative variables. The two unpaired & two-tail variables (T-test) were used to compare the characteristics of the two groups. If the *p*-value was less than 0.05, the difference between groups was regarded as statistical significance.

## Result

The average age for radiographers was approximately 39 years (range 22 to 54 years), while that for control was 42 years (range 25 to 55 years). Radiographers worked an average of 8 hours per day, 4 days per week. The length of radiation exposure was calculated using years of exposure ranging from 1 to 27.

Table.1, illustrates that there were significant relationship differences between exposures and non-exposure in the median MDA level. The mean MDA for exposed males and females was substantially higher than in the non-exposed group (13.19  $\mu\text{mole/L}$ , 2.91  $\mu\text{mole/L}$ ) and (10.235  $\mu\text{mole/L}$ , 2.55  $\mu\text{mole/L}$ ); (*p*-value=0.000) respectively. There were significant differences in the mean levels of T3 and HDL between exposed groups and non-exposed groups, also it was found that the mean T3 level for exposed males was significantly higher than that among non-exposed men (2.05 nmole/L vs. 2.02 nmol/L; *p*-value = 0.03), and the mean HDL despite the mean for the exposed group was smaller than that among non-exposed males (41.57 vs. 50.57; *p*-value = 0.025). In addition, there were highly significant interaction differences between exposed and non-exposed in the mean T4 level. Within the groups, there were significant differences in the level T4 for exposed, males and females, which were higher than that among non-exposed ((98.3  $\mu\text{mole/L}$ , 80.7  $\mu\text{mole/L}$ ) and (97.22  $\mu\text{mole/L}$ , 77  $\mu\text{mole/L}$ ); *p*-value=0.004 and *p*-value =0.000) respectively. Furthermore, there were statistically important variations in the level of Vit-D3 between the exposed and non-exposed groups, within-group, there were significant differences between female exposure and non-exposures.

**Table 1. Mean values of biochemical tests for radiographers compared to control groups. Data represent the mean  $\pm$  SD,  $p < 0.05$ .**

Gender	Exposed group		Non-Exposed group		p-value
	No.	mean $\pm$ SD	NO.	mean $\pm$ SD	
<b>MDA ( <math>\mu</math>mole/l)</b>					
<b>All</b>	30	12.30 $\pm$ 10.13	25	2.76 $\pm$ 0.98	0.000
<b>Female</b>	9	10.235 $\pm$ 9.82	11	2.55 $\pm$ 0.79	0.020
<b>Male</b>	21	13.19 $\pm$ 10.37	14	2.91 $\pm$ 1.11	0.000
<b>Vit.D3 (ng/ml)</b>					
<b>All</b>	30	27.77 $\pm$ 9.53	25	36.38 $\pm$ 6.99	0.000
<b>Female</b>	9	23.26 $\pm$ 10.13	11	36.69 $\pm$ 8.72	0.006
<b>Male</b>	21	29.71 $\pm$ 8.04	14	36.15 $\pm$ 5.84	0.019
<b>TSH (uIU/ml)</b>					
<b>All</b>	30	2.24 $\pm$ 1.82	25	2.8 $\pm$ 1.29	0.189
<b>Female</b>	9	2.0 $\pm$ 0.58	11	2.81 $\pm$ 1.4	0.100
<b>Male</b>	21	2.35 $\pm$ 2.15	14	2.79 $\pm$ 1.25	0.49
<b>T3 nmol/L</b>					
<b>All</b>	30	1.77 $\pm$ 0.62	25	2.04 $\pm$ 0.56	0.05
<b>Female</b>	9	1.61 $\pm$ 0.61	11	2.05 $\pm$ 0.39	0.89
<b>Male</b>	21	2.05 $\pm$ 0.56	14	2.02 $\pm$ 0.37	0.030
<b>T4 nmol/L</b>					
<b>All</b>	30	97.9 $\pm$ 15.6	25	79.08 $\pm$ 12.28	0.000
<b>Female</b>	9	97.22 $\pm$ 10.29	11	77.00 $\pm$ 9.00	0.000
<b>Male</b>	21	98.3 $\pm$ 17.6	14	80.70 $\pm$ 14.40	0.004
<b>Cholesterol (mg/dl)</b>					
<b>All</b>	30	166.47 $\pm$ 27.25	25	156.8 $\pm$ 31.18	0.227
<b>Female</b>	9	169.33 $\pm$ 23.70	11	156.0 $\pm$ 35.34	0.329
<b>Male</b>	21	165.24 $\pm$ 29.11	14	157.5 $\pm$ 28.8	0.445
<b>Triglyceride (mg/dl)</b>					
<b>All</b>	30	164.2 $\pm$ 73.00	25	155.9 $\pm$ 32.05	0.578
<b>Female</b>	9	166.6 $\pm$ 99.19	11	150.2 $\pm$ 35.91	0.648
<b>Male</b>	21	163.16 $\pm$ 61.55	14	160.3 $\pm$ 29.25	0.858
<b>HDL (mg/dl)</b>					
<b>All</b>	30	43.3 $\pm$ 7.97	25	52.36 $\pm$ 17.48	0.023
<b>Female</b>	9	47.33 $\pm$ 6.78	11	54.63 $\pm$ 21.08	0.300
<b>Male</b>	21	41.57 $\pm$ 7.96	14	50.57 $\pm$ 14.64	0.025
<b>LDL(mg/dl)</b>					
<b>All</b>	30	75.38 $\pm$ 25.72	25	71.20 $\pm$ 24.67	0.544
<b>Female</b>	9	83.77 $\pm$ 13.52	11	71.45 $\pm$ 23.25	0.178
<b>Male</b>	21	71.78 $\pm$ 29.00	14	71.00 $\pm$ 26.60	0.936

## Discussion

One of the most pressing challenges in occupational health is the risk of health complications among radiography technologists exposed to low and chronic levels of radiation. The present research sought to determine whether exposed radiographers working in radiology departments were at risk. The use of medical imaging, specifically roentgen diagnostics and computed tomography, exposes both patients and

physician workers to radiation's severe side effects <sup>2, 18</sup>.

The current inquiry revealed highly significant changes in MAD levels comparing exposed and non-exposed groups. Ionizing radiation has a vital role as an inducer of oxidative stress in radiographers under control. Although, there were significant differences in Vit.D3 between exposed and non-exposed groups. The radiographers (exposed subjects) when compared with the control

(non-exposed) (Table 1). It was discovered that chronic IR exposure reduced the level of Vit. D3 active form and caused changes in enzymes involved in Vit. D3 metabolism<sup>3</sup>.

The major results of this study provided here demonstrated that there are no significant variations in mean TSH between cases and controls, while there were significant differences between radiation exposure and control in the level T4. In addition, despite the results being in the normal ranges, there were significant differences within groups in the T4 level in males and females  $p < 0.05$ . Our results are in a good agreement reported by (Alawneh et al., 2018)<sup>15</sup>. A review that looked into the effects of different radiation doses on the levels of T3 and T4 within the blood of non-irradiated and irradiated rats found that the effect of radiation could be transmitted by the radiation-induced anorexia disorder. Furthermore, Endocrine disease in clinicians may be related to other risk factors such as high work stress and night shifts<sup>14</sup>. Concerning the lipid profile test, we found all data for radiographers of the levels of cholesterol, TG, LDL, and HDL within the reference range, while when comparing HDL levels with control, resulted in a particular difference ( $p < 0.05$ ) between them. As well within-group, there were significant differences between HDL levels in females exposed and non-exposed although these differences were within the normal range (Table 1). The result of lipid profile levels was not influenced by exposure to radiation. Although, some research has revealed that radiation treatment can cause a drop in lipid serum levels, and these outcomes have been verified and confirmed by<sup>19</sup>.

## Conclusion

Free radicals and oxidative stress are both known to be harmful to human health. A large number of studies show that free radicals contribute to the initiation and progression of several pathologies. As a class of compounds is capable of counteracting oxidative stress and mitigating its effects on individuals' health, these compounds have received enormous attention from the biomedical research community, not only because of their efficacy in disease prevention and/or treatment but also because of the general perception that they are safe. The study's primary conclusions were that there is a significant interaction between radiation exposure and gender in terms of mean MDA, Vit.D3, T4, T3, and HDL, but also not TSH, cholesterol, triglyceride (TG), and LDL. The findings indicate that Malondialdehyde is a useful biomarker for

assessing oxidative stress in radiographers who have been exposed to ionizing radiation.

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## Author's declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Besides, the Figures and images, which are not ours, have been given the permission for re-publication attached with the manuscript
- Ethical Clearance: All examined subjects, and procedures were used in accordance with Human Research Ethics Committee (HREC) office (Reference number: 4S/447 Dated: 01/09/2021).

## Author Contributions:

J L H: performed the draft of this study and all biochemical tests in Department of Chemistry - College of Science-Salahaddin University lab. SO H: performed all Statistical analysis and participated in performing the study. Both of two authors have approved final version of manuscript.

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## دراسة كيميائية حيوية حول تأثير الإجهاد التأكسدي الناجم عن الإشعاع على المصورين الشعاعيين في أقسام الأشعة السينية والتصوير المقطعي المحوسب

صالح عمر حاجي<sup>2</sup>

ذيان لطيف حسين<sup>1</sup>

<sup>1</sup>قسم الكيمياء، كلية العلوم، جامعة صلاح الدين، أربيل، العراق.  
<sup>2</sup>قسم الفيزياء، كلية العلوم، جامعة صلاح الدين، أربيل، العراق.

### الخلاصة:

تم تحليل عواقب الإجهاد التأكسدي المتأين الناجم عن الإشعاع على مصوري الأشعة في أقسام الأشعة السينية والتصوير المقطعي باستخدام العديد من فحوصات الكيمياء الحيوية. وجدت الدراسة تناقضات كبيرة ملحوظة في التفاعل بين مستويات الإشعاع والجنس من حيث متوسط مالونديالدهيد (MAD)، فيتامين (D3)، ثلاثي يودوثيرونين (T3)، هرمون ثايروكسين (T4) و بروتين الدهني عالي الكثافة (HDL)، و لكن ليس على هرمون الغدة الدرقية (TSH) والكوليسترول و الدهون الثلاثية (TG) والبروتين الدهني منخفض الكثافة (LDL). تشير النتائج الى ان مالونديالدهيد هو علامة حيوية مفيدة لتقييم الإجهاد التأكسدي في التصوير الشعاعي مع التعرض للإشعاع المؤين.

**الكلمات المفتاحية:** إشعاع التأين، اختبار ملف الدهون، الإجهاد التأكسدي، أختزال، فيتامين D3.