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Occupational Chronic X-Ray Exposure and Its Effects on Blood Cell Profiles in Radiology Staff

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ABSTRACT

Occupational exposure to ionizing radiation from radiology equipment is believed to impact the health of healthcare professionals, particularly those working in radiology departments. This study investigates the long-term effects of chronic X-ray exposure on hematological parameters in radiology staff across multiple hospitals in Raniya City. This cohort study was conducted in six government hospitals in the Raparin district of Sulaimaniyah Governorate. A total of 96 participants were enrolled: 48 radiographers (case group) with prolonged exposure to X-rays and 48 medical laboratory professionals (control group) without such exposure. The study focused on evaluating the correlation between annual radiation dose and changes in the hematological parameters (cases/ controls), including white blood cell (WBC), red blood cell (RBC), and platelet (PLT) counts. A minimum and maximum value of occupational chronic X-ray exposure for the radiographer was 1.69 µSv to 414.27 µSv, respectively**.** A significant increase in risk was observed when the X-ray dose exceeded 100 µSv. WBC count shows very weak and non-significant negative correlation with radiation dose. RBC count shows strong and statistically significant negative correlation, suggesting radiation exposure is associated with lower RBC counts. PLT count shows moderate and significant negative correlation, indicating platelet counts tend to decrease with higher radiation doses

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التعرض المهني المزمن للأشعة السينية وتأثيراته على ملفات خلايا الدم لدى العاملين في مجال الأشعة

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الـــخُـــلاصـــة

الكلمات المفتاحية:

أن التعرض المهني للإشعاع المؤين من معدات الأشعة يؤثر على صحة العاملين في مجال الرعاية الصحية، وخاصة أولئك الذين يعملون في أقسام الأشعة. تبحث هذه الدراسة في الآثار طويلة المدى للتعرض المزمن للأشعة السينية على المعايير الدموية لدى موظفي الأشعة في مستشفيات متعددة في مدينة رانية. أجريت هذه الدراسة الجماعية في ستة مستشفيات حكومية في منطقة رابرين بمحافظة السليمانية. تم تسجيل ما مجموعه 96 مشاركًا: 48 مصور أشعة طبي (مجموعة الحالة) تعرضوا للأشعة السينية لفترات طويلة و48 متخصصًا في المختبرات الطبية (مجموعة الضبط) دون التعرض لمثل هذا التعرض. ركزت الدراسة على تقييم العلاقة بين جرعات الإشعاع السنوية والتغيرات في نسبة المعايير الدموية) (الحالات / الضوابط)، بما في ذلك عدد خلايا الدم البيضاء (WBC) وخلايا الدم الحمراء (RBC) والصفائح الدموية (PLT). كانت القيمة الدنيا والقصوى للتعرض المزمن المهني للأشعة السينية لمصور الأشعة 1.69 ميكروسيفرت إلى 414.27 ميكروسيفرت، على التوالي. لوحظت زيادة ملحوظة في المخاطر عند تجاوز جرعة الأشعة السينية المُعرَّضة 100 ميكروسيفرت. يُظهر تعداد خلايا الدم البيضاء ارتباطًا سلبيًا ضعيفًا وغير ذي دلالة إحصائية مع جرعة الإشعاع. يُظهر تعداد خلايا الدم الحمراء ارتباطًا سلبيًا قويًا وذي دلالة إحصائية، مما يُشير إلى أن التعرض للإشعاع يرتبط بانخفاض عدد خلايا الدم الحمراء. يُظهر تعداد خلايا الدم البيضاء ارتباطًا سلبيًا متوسطًا وذي دلالة إحصائية، مما يُشير إلى أن تعداد الصفائح الدموية يميل إلى الانخفاض مع زيادة جرعات الإشعاع.

بوليانيلين,
بولي بيرول
الأشعة السينية
تعداد الدم الكامل
تعداد خلايا الدم البيضاء
تعداد خلايا الدم الحمراء
اختبار الصفائح الدموية
فنيو الأشعة

1. INTRODUCTION

Radiographers are routinely exposed to low doses of ionizing radiation, primarily X-rays, over extended periods. Despite protective measures, chronic occupational exposure has raised concerns about subtle but significant biological effects. One critical area of concern is hematological health, given that blood-forming tissues are among the most radiosensitive in the human body [1-3]. X-rays, a form of high-energy electromagnetic radiation (100 eV to 100 keV) with wavelengths ranging from 0.01 to 10 nm, possess enough energy to ionize atoms and disrupt molecular bonds [4,5].

X-rays are widely used in medical fields for both diagnostic and therapeutic purposes. However, whether they administered at low or high doses, X-rays have the potential to cause cellular damage, with associated health risks increasing with prolonged exposure duration [6-8]. As artificial sources of ionizing radiation, medical X-ray devices represent a significant risk when exposure is chronic or poorly controlled. Ionizing radiation is known to produce harmful biological effects by damaging living cells, either destroying them outright or impairing their normal physiological functions [9,10]. Under certain conditions— especially at high doses, X-ray exposure can result in

biological changes, including adverse effects on liver function and enzyme levels [11].

Several studies have approved that the long exposure to low dose of X-ray can have an impact on hematological system of the radiographers which based on period of exposure. Salata et al. [12] the associated, study reported a consistent decrease in total WBC counts, particularly in lymphocytes, in workers exposed to long-term low-dose X-radiation. Abdolmaleki et al. [13] indicated that the chronic radiation exposure can lead to decreased RBC count and hemoglobin (HGB) levels, and increased red cell distribution width (RDW).

Nuraeni et al. [14] clarified the correlation between **radiation dose and blood** changes, and they classified the extent of hematological impact as positively correlated with the cumulative radiation dose (measured in μSv or mSv) and duration of exposure (years of employment). Gunal et al. [15] concluded that platelet may show slight reductions in count in some cases, and fluctuations depending on individual radiosensitivity and duration of exposure, also platelets are still vulnerable to radiation effects due to their derivation from megakaryocytes in the bone marrow. UNSCEAR [16] summarized that the long-term occupational exposure to low-dose X-rays among radiographers is associated with subtle but potentially significant changes in hematological parameters, especially lymphocytes and hemoglobin levels.

Given this context, the present study aimed to evaluate and compare complete blood cells (CBC) levels among radiographers employed at some of public hospitals of Iraqi Kurdistan region. The research focused on chronic exposure patterns, including the duration of annual exposure and work habits. It also compared radiographers with non-radiographer hospital staff who were not routinely exposed to X-ray radiation.

2. Research Method

2.1 Materials and Methods

A cohort study was conducted at six major government hospitals in the Raparin region, including Ranya Teaching Hospital, Ranya Maternity and Children's Hospital, Shahid Ahmad Ismail Hospital, Chwarqurna Hospital, Hajiawa General Hospital, and Qaladze General Hospital. Dose Rate Meter GRAETZ GammaTwin. The GRAETZ GammaTwin is a compact electronic dose rate meter featuring a "twin display" that simultaneously shows

dose rate and cumulative dose. It measures ambient dose equivalent H*(10) within a range of 0.5 µSv/h to 70 mSv/h. This dosimeter (Fig.1) was used to measure the scatter radiation dose from the X-ray rooms in the hospitals mentioned above.

2.2 Experimental Procedure

The study included 48 medical radiographers as the exposed group (cases), who were chronically exposed to X-rays due to their occupation, and 48 medical laboratory (ML) workers, who were not exposed to X-rays, serving as the control group. The annual exposure dose for each radiographer was estimated based on the number of cases handled per year multiplied by the radiation dose per X-ray case [17].

Venous blood samples (3 ml) were collected from all participants in both groups to measure CBC tests using Hematology analyzers that is computerized, highly specialized machines which count the number of different types of red and white blood cells, blood platelets, haemoglobin, and haematocrit levels in a blood sample. The blood analysis machine was (HbA1c Analyze, Horiba). The blood samples were divided into two equal groups: the first 48 tubes corresponded to the control group, and the second 48 to the case group.

2.3 Statistical Analysis

The SPSS software version, used to analysis the impacts of radiation dose on the CBC components based on t-test and a nova to getting the significant values.

2.4 Limitation of the research

Monitoring the quality of the donor's blood samples was difficult, as was the medical history of each donor. In general, the limited number of donors we had to work with and obtain blood samples was a barrier to obtaining additional samples.

3. Results and Discussion

The effects of cumulative X-ray exposure in radiography technicians were analyzed based on their annual exposure dose, with data collected considering exposure duration and working hours per day the number of X-ray case. The results, summarized statistically in Table 1, categorize exposure groups by average annual dose and case percentage. A significant increase ($p< 0.05$) in risk was observed when the exposed X-ray dose exceeded 100 µSv. These findings suggest that stricter shielding measures and exposure limits should be enforced for

occupations with high radiation exposure. Table 2 presents the classification of CBC level alterations (WBC, RBC, and PLT) based on low and high equivalent X-ray doses, with 27 cases classified as low dose (≤ 100 μSv) and 21 as high dose (> 100 μSv). This fixed threshold follows radiation safety standards using 100 μSv as a dividing point.

The optimum blood parameters that most affected by X-ray exposure identified based on statistically evaluate the strength and significance of the relationship between X-ray **dose** and each blood parameter. The correlations (positive or negative) indicate greater effect identified according to Pearson correlation coefficients to determine linear relationships between X-ray Dose vs. each CBC parameter; |Pearson r| > 0.4 (moderate effect); p-value < 0.05 (statistical significance). Table 3 is the results of Pearson correlation analysis to explore the relationship between the total radiation dose and the blood parameters. Fig.2 illustrate the differing responses of WBC, RBC, and PLT to radiation dose regarding the correlation coefficient (r). Here are the graphs showing the relationships between radiation dose and:

WBC (White Blood Cells) – A general decreasing trend is observed with higher dose.

RBC (Red Blood Cells) – Slight fluctuations, but relatively stable across doses.

PLT (Platelets) – A noticeable decrease with increasing dose.

Descriptive statistics of 48 cases and 48 controls summered in Table 4, and it is based on the ratio factor between CBC results of cases / control for each hospital. The correlation between radiation exposure and the variation of blood components (WBC, RBC, and PLT) were weak (positive and negative). This indicates that the counts of the mentioned blood components show only weak variability in response to the total radiation dose received by the radiographers, and this is in agreement with the essential of biological response of CBC components, and with the previous studies [18-21].

4. Conclusion

Alterations in blood parameters levels due to chronic X-ray exposure in radiographers depend on both the exposure dose and duration. Low-dose exposure (27 cases ≤ 100 μSv) and high-dose exposure (21 cases > 100 μSv) have correspondingly low and high impacts on CBC parameters. There

was week correlation (r) between ratio (case/control) of WBC (very weak positive), RBC (very weak negative), and PLT (very weak negative) with total occupational chronic X-Ray exposure for the radiographers.

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1. Reference

[1] International Commission on Radiological Protection. (2012). ICRP statement on tissue reactions and early and late effects of radiation in normal tissues and organs: Threshold doses for tissue reactions in a radiation protection context (ICRP Publication 118). Annals of the ICRP, 41(1–2), 1–322. https://doi.org/10.1016/j.icrp.2012.02.001

[2] Kesavachandran, C. N., Rastogi, S. K., Das, M., Khan, A. M., & Pangtey, B. S. (2006). Haematological and radiological study of X-ray technicians and controls to assess occupational radiation effects. Indian Journal of Occupational and Environmental Medicine, 10(2), 63–66. https://doi.org/10.4103/0019-5278.22891

[3] Ismail, A. H., Hamad, M. A., & Harki, E. M. T. (2012). Radiation exposure of leukemia blood samples and its impacts on the density of RBC, WBC, and PLT: *In vitro*. *Open Journal of Biophysics, 2*(4), 149–152. https://doi.org/10.4236/ojbiphy.2012.24016

[4] Podgorsak, E. B. (2005). Radiation physics for medical physicists. Springer.

[5] Hall, E. J., & Giaccia, A. J. (2012). Radiobiology for the radiologist (7th ed.). Lippincott Williams & Wilkins.

[6] Hall, E. J., & Giaccia, A. J. (2012). Radiobiology for the radiologist (7th ed.). Lippincott Williams & Wilkins.

[7] United Nations Scientific Committee on the Effects of Atomic Radiation. (2008). Sources and effects of ionizing radiation: UNSCEAR 2008 report to the General Assembly with scientific annexes (Vol. I). United Nations.

[8] Brenner, D. J., & Hall, E. J. (2007). Computed tomography—An increasing source of radiation exposure. *The New England Journal of Medicine, 357*(22), 2277–2284. https://doi.org/10.1056/NEJMra072149

[9] International Atomic Energy Agency. (2014). *Radiation protection in diagnostic and interventional radiology*. International Atomic Energy Agency.

[10] Mettler, F. A., Huda, W., Yoshizumi, T. T., & Mahesh, M. (2008). Effective doses in radiology and diagnostic nuclear medicine: A catalog. *Radiology, 248*(1), 254–263. https://doi.org/10.1148/radiol.2481071451.

[11] Pan, C. C., Kavanagh, B. D., Dawson, L. A., Li, X. A., Das, S. K.,

Miften, M., & Ten Haken, R. K. **(2010).** Radiation-associated liver injury. *International Journal of Radiation Oncology, Biology, Physics, 76*(3 Suppl), S94–S100. https://doi.org/10.1016/j.ijrobp.2009.06.092

[12] Salata, L. A., et al. (2016). Evaluation of hematological parameters in workers occupationally exposed to low doses of ionizing radiation. *Radiologia Brasileira*, 49(2), 95–99.

[13] Abdolmaleki, A., et al., 2012. The effect of electromagnetic waves exposure on blood parameters. *International Journal of Hematology-Oncology and Stem Cell Research*, pp.13-16.

[14] Nuraeni, Y., et al. (2019). Effects of occupational exposure to low-dose ionizing radiation on complete blood count in radiologic technologists. *Journal of Occupational Health*, 61(1), 1–8.

[15] Gunal, M. Y., et al. (2020). Assessment of occupational radiation exposure on blood parameters among radiologic technologists. *Journal of Radiation Research and Applied Sciences*, 13(1), 111–116.

[16] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation). (2010). *Sources and effects of ionizing radiation*.

[17] Ismail, A.H. & Abdulla, K.N., 2021. Biochemical and hematological study of the effects of annual exposure radiation doses on the operators of X-ray and CT-scan in some Erbil hospitals. *Radiation Physics and Chemistry*, 184, p.109466.

[18] Davoudi, P., Alnahhal, M., Khorrami, M., & Riahi-Zanjani, B. (2022). Evaluation of some haematological parameters among radiographers in Imo State, Nigeria. *Auctores Journal of Biophysics, 2*(4). https://doi:10.4236/ojbiphy.2022.24129

[19] Davoudian Talab, A. (2018). Effects of occupational exposure on blood cells of radiographers working in the diagnostic radiology department of Khuzestan Province. *Iranian Journal of Medical Physics, 15*(2), 66–70.

[20] Baria, D. P., Malhotra, A., Khan, F., & Singh, M. P. (year unknown). Effect of ionizing radiation on complete blood count among medical radiographers: a comparative study. *Journal for ReAttach Therapy and Developmental Diversities*.

[21] Taqi, A. H., Faraj, K. A., Zaynal, S. A., Hameed, A. M., & Mahmood, A. A. (2018). Effects of occupational exposure of X-ray on hematological parameters of diagnostic technicians. *Radiation Physics and Chemistry, 147*, 45–52. https://doi:10.1016/j.radphyschem.2018.01.027

Table 1: Analysis the X-ray exposure doses per exposure groups

Exposure Group	Average Annual Dose (μSv)	Case percentage
< 50 μSv	32±4.1	29.17%
50–100 μSv	67.9±8.48	25.00%
> 100 μSv	247.8±30.97	45.83%

Table 2: Analysis the X-ray exposure doses per exposure groups

CBC Parameter	Low Dose (≤ 100 μSv) Mean ± SD	High Dose (> 100 μSv) Mean ± SD
WBC ($\times 10^9$/L)	7.36 ± 1.89	6.95 ± 1.60
RBC ($\times 10^{12}$/L)	4.84 ± 0.60	5.01 ± 0.59
PLT ($\times 10^9$/L)	248.56 ± 88.77	225.71 ± 39.87

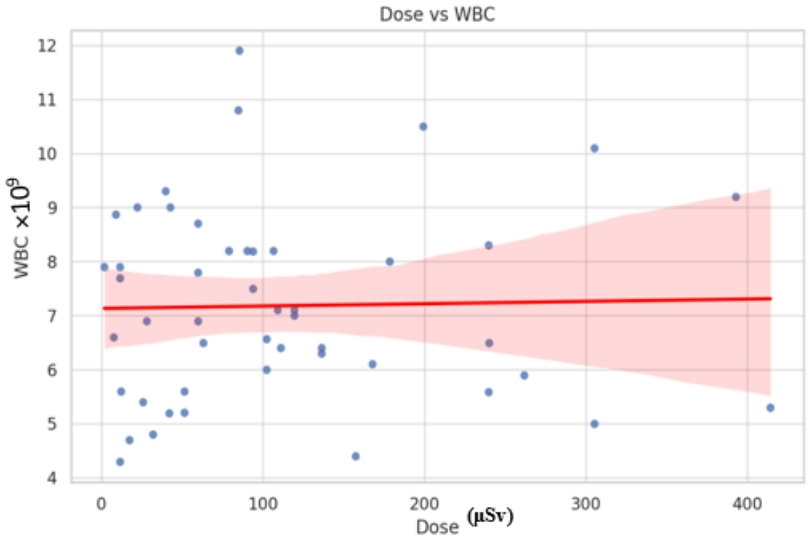
Table 3: Pearson correlation analysis between the total radiation dose and the blood parameters

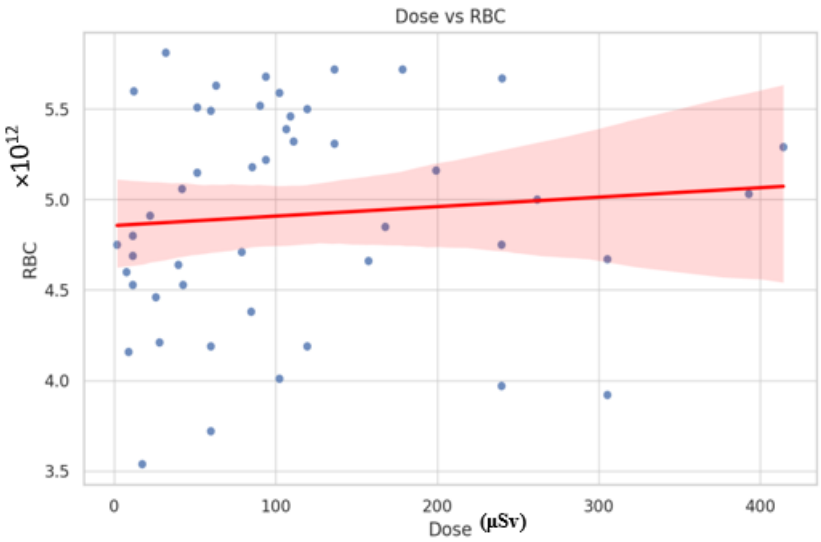
Parameter	Correlation (r)	p-value	Significance
WBC (White Blood Cells)	-0.14	0.36	Very weak and non-significant negative correlation with radiation dose.
RBC (Red Blood Cells)	-0.69	< 0.001	Strong and statistically significant negative correlation, suggesting radiation exposure is associated with lower RBC counts
PLT (Platelets)	-0.47	0.001	**Moderate and significant negative correlation**, indicating platelet counts tend to decrease with higher radiation doses

Table 4: Descriptive statistics of 48 cases and 48 controls based on the ratio factor between CBC results of cases / control for each hospital

Metric	Radiation Dose (μSv)	WBC Ratio	RBC Ratio	PLT Ratio
Mean ±SDV	110.93±101.48	1.066± 0.371	0.979±0.128	1.038±0.346
Minimum	1.69	0.543	0.715	0.180
Maximum	414.27	2.460	1.234	1.650
Median (50%)	87.74	1.019	0.965	0.980
Parameter	**Correlation (r) with Radiation Dose**			
WBC Ratio	**+0.046** (very weak positive)			
RBC Ratio	**−0.036** (very weak negative)			
PLT Ratio	**−0.051** (very weak negative)			

Fig.1: Dose Rate Meter GRAETZ GammaTwin





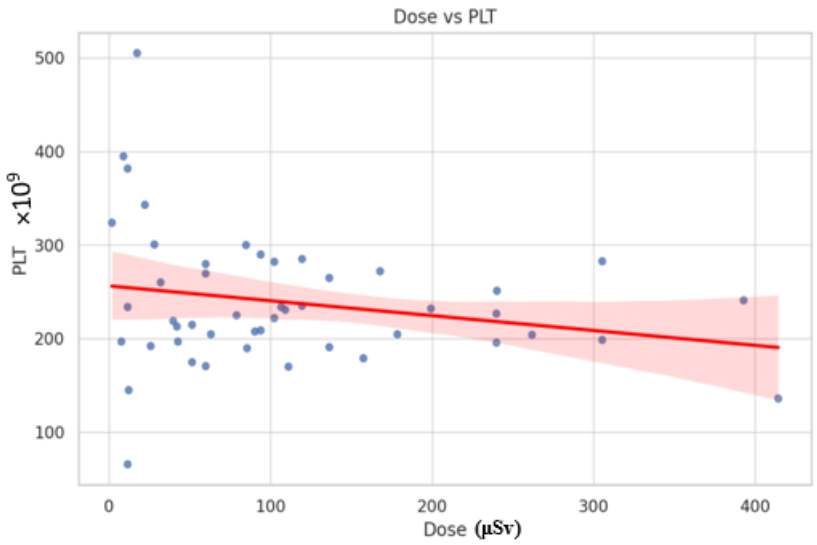


Figure 2: Variation responses of WBC, RBC, and PLT to radiation dose regarding the correlation factor (r).