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Research Article

Evaluation of some Haematological Parameters among Radiographers in Imo State, Nigeria

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Abstract

Long-term exposure to low doses of ionizing radiation has been reported to have adverse effects on the human cells especially that of the radiation workers. These effects may result in various hematological disorders. This study was aimed at determining the levels of PCV, Hb, RBC, TWBC, MCV, MCH, MCV and MCHC among radiographers. This was a cross-sectional study carried out at three major hospitals in Imo State (Federal University Teaching Hospital, Owerri, Imo specialist hospital, Owerri and Imo State Teaching Hospital Orlu). A total of 40 individuals which comprised of 40 radiographers and 40 non- radiation workers were recruited for the study. Informed consent was obtained from patients and questionnaires administered after which blood sample was collected. The procedure was carried out at the hospital laboratory using standard laboratory procedures. The results of the tests were analyzed using SPSS version 27. The mean values of PCV (32.00±2.53) %, haemoglobin (10.67±3.45) g/dl, MCV (78.53±6.85) fL, MCH (27.66±2.99) pg/cell and TWBC (5.47±1.88) x109/L were significantly higher in radiographers when compared to controls (35.73±2.88) %, (11.91±1.96) g/dl, (89.78±8.87) Fl, (30.78±3.30) pg/cell and (7.93±2.05) x109/L(p=0.000). The mean value of RDW (38.19±6.21) % was significantly raised in radiographers when compared to controls (31.16±7.00) % (p=0.000). There was no significant difference in the mean values of RBC (3.85±0.50) x1012/L and MCHC (33.50±2.75) g/dl in radiographers when compared to controls (3.99±0.53) x1012/L and (33.75±1.74) g/dl (p=0.235 and p=0.628). This study has shown that levels of PCV, haemoglobin, RBC, TWBC, MCV, MCH and MCHC are altered in practicing radiographers, and duration of practice affects the levels of PCV, haemoglobin and TWBC in radiographers. Therefore, radiographers should use appropriate shielding such as lead aprons, thyroid shields, and lead gloves, maintain a safe distance from radiation sources and conduct routine blood tests to monitor potential radiation-induced changes.

Keywords: packed cell volume; haemglobin; red blood cell; total white blood cell; red cell indices, radiographers; radiation

1.Introduction

Medical radiographers are healthcare professionals exposed to ionizing radiation as part of their routine occupational activities. Although modern radiation protection protocols aim to minimize exposure, prolonged or repeated exposure may have biological effects, including alterations in hematological parameters. Hematological indices such as packed cell volume (PCV), hemoglobin concentration (Hb), red blood cell (RBC) count, total white blood cell (TWBC) count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) are essential indicators of overall health and hematopoietic function. Changes in these parameters could suggest hematopoietic suppression, oxidative stress, or an increased risk of radiation-induced disorders (Mettler et al., 2018).

Several studies have reported that chronic exposure to ionizing radiation may lead to subtle hematological alterations, even when exposure levels remain within occupational safety limits (Mansour et al., 2021; Ravanat et al., 2020). Ionizing radiation is known to generate reactive oxygen species (ROS), which can induce DNA damage, lipid peroxidation, and apoptosis in bone marrow progenitor cells, leading to potential disruptions in erythropoiesis and leukopoiesis (Hall & Giaccia, 2019). Reduced RBC count, PCV, and Hb levels may indicate radiation-induced anemia, while fluctuations in TWBC

count could reflect changes in immune function due to radiation exposure (Schauer & Linton, 2019). Additionally, variations in RDW and indices such as MCV, MCH, and MCHC may provide insights into the functional state of erythropoiesis and the potential development of hematological disorders (El-Ghazaly et al., 2022). Despite the implementation of radiation safety protocols, the long-term effects of occupational exposure on hematological parameters remain a topic of concern. This study aims to evaluate the hematological profiles of medical radiographers to determine whether chronic radiation exposure has any significant impact on blood cell indices. This research study may help in the development of improved radiation protection strategies and early intervention measures to safeguard the health of radiographers.

2. Materials and Method

2.1 Study Area

The study was conducted at the Federal Teaching Hospital, Owerri, Imo Specialist Hospital,Umuguma, Owerri, and Imo State University Teaching, Hospital (IMSUTH) Orlu, all in Imo State.

2.2 Study Design

This was a cross-sectional study carried out at three major hospitals in Imo State (Federal University Teaching Hospital, Owerri, Imo specialist hospital, Umuguma, Owerri and Imo State Teaching Hospital, Orlu). A total of 40 individuals which comprised of 40 radiographers and 40 non - radiation workers were recruited for the study. Informed consent and questionnaires were administered before sample collection, and 3 milliliters of venous blood was collected from each subject. The procedure was carried out using standard laboratory procedures. The results of the tests were analyzed using SPSS version 27.

2.3 Method of Recruitment

All radiographers between the ages of 30 - 60yrs who were working with the three hospitals and gave their informed consents were recruited for the study. Age-matched non-exposed subjects served as controls. For reasons of privacy, all data were kept confidential in accordance with World Medical Association declaration of Helsinki (WMADH, 2008).

2.4 Study Population

A total of forty (40) radiographers and an equivalent number of age- matched non-exposed subjects consisted the study population.

2.5 Ethical Approval

Ethical approval was obtained from the ethics committee of Federal Teaching Hospital, Owerri, Imo state Teaching Hospital, Orlu and Imo state Specialist Hospital Umuguma. All study participants who gave their informed consent were enrolled in the study and samples were taken.

2.6 Selection Criteria

2.6.1 Inclusion criteria

Radiographers from 30 years and above, exposed to radiation

Those without any other infection such as HIV, HBsAg, HCV, Syphilis etc.
Radiographers who gave their informed consent.
Age-matched apparently healthy non - radiographers.

2.6.2 Exclusion criteria

Radiographers below 30 years of age.
Radiographers whose informed consent could not be obtained because they were skeptical about the research.
Those with other infections such as HIV, HCV, HBsAg and syphilis.

3. Laboratory Analysis

3.1 Haematological Parameters

The hematological parameters were determined using haematology autoanalyzer.

3.2 Statistical Analysis

The statistical analysis was carried out using SPSS version 27 (statistical packages for social sciences). All values were expressed as mean± standard deviation. The student-t-test and Pearson correlation were used to determine the differences in the experimental variables. The tests with a probability $P \leq 0.05$ were considered statistically significamt.

4. Results

Parameter	Test	Control	t-value	p-value
PCV (%)	32.00±2.53	35.73±2.88	6.14	0.000*
Haemoglobin (g/dl)	10.67±3.45	11.91±1.96	1.22	0.000*
RBC ($x10^{12}$/L)	3.85±0.50	3.99±0.53	1.19	0.235
MCV (fL)	78.53±6.85	89.78±8.87	6.35	0.000*
MCH (pg/cell)	27.66±2.99	30.78±3.30	4.43	0.000*
MCHC (g/dl)	33.50±2.75	33.75±1.74	0.49	0.628
RDW (%)	38.19±6.21	31.16±7.00	4.75	0.000*
TWBC ($x10^9$/L)	5.47±1.88	7.93±2.05	5.62	0.000*

Table 1: Mean Values of PCV, Haemoglobin, RBC, MCV, MCH, MCHC, RDW and TWBC in Radiographers (Test) and Non- Radiographers (Controls)

PCV (32.00±2.53)%, haemoglobin (10.67±3.45)g/dl, MCV (78.53±6.85)fL, MCH (27.66±2.99)pg/cell and TWBC (5.47±1.88) $x10^9$/L were significantly reduced in radiographers when compared to controls (35.73±2.88)%, (11.91±1.96)g/dl, (89.78±8.87)Fl, (30.78±3.30)pg/cell and (7.93±2.05) $x10^9$/L (t=6.14, p=0.000, t=1.22, p=0.000, t= 6.35, p=0.000, t=4.43,p=0.000 and t=5.62 ,p=0.00). The mean value of RDW (38.19±6.21) % was significantly raised in radiographers when compared to controls (31.16±7.00) %. (t= 4.75, p=0.000). There was no significant difference in the mean values of RBC and MCHC in radiographers (3.85±0.50) $x10^{12}$/L and (33.50±2.75) g/dl when compared to controls (3.99±0.53) $x10^{12}$/L and (33.75±1.74) g/dl. (t=1.19, p=0.235 and t=0.49, p=0.628).

KEY:
PCV: Packed Cell Volume
RBC: Red Blood Cell
MCV: Mean Cell Volume
MCH: Mean cell Haemoglobin
RDW: Red cell Distribution Width
TWBC: Total White Blood Cell

*: Significant p value

Parameter	(3-10) yrs	(11-18) yrs	(>18) yrs	f-value	p-value
PCV (%)	34.18±2.23	31.10±1.97	30.14±1.86	11.09	0.000*
Haemoglobin (g/dl)	11.80±0.78	10.79±0.81	10.43±0.79	7.96	0.001*
RBC (x10^9/L)	4.01±0.47	3.83±0.50	3.56±0.56	1.71	0.195
MCV (fL)	80.82±4.69	78.80±7.53	76.29±8.28	0.91	0.413
MCH (pg/cell)	28.73±1.79	27.32±3.37	27.00±3.69	0.95	0.396
MCHC (g/dl)	33.55±2.07	33.55±3.20	34.14±2.34	0.13	0.878
RDW (%)	40.55±5.36	37.07±5.96	35.49±5.36	2.03	0.147
TWBC (x10^9/L)	7.03±2.36	4.83±1.38	5.27±1.09	6.20	0.005*

Table 2: Comparison of the PCV, Haemoglobin, RBC, MCV, MCH, MCHC, RDW, and TWBC in Radiographers based on Duration of Exposure (Mean±SD).

There were significant increases in the mean values of PCV in 3-10years of exposure (34.18±2.23)% , Haemoglobin (11.80±0.78)g/dl, and TWBC (7.03±2.36) x10^9/L when compared to 11-18 years of exposure (31.10±1.97)%, (10.79±0.81)g/dl, (4.83±1.38) x 10^9/L and >18years of exposure (30.14±1.86)%, (10.43±0.79) g/dl and (5.27±1.09) x10^9/L, respectively (t=111.09, p=0.000; t= 7.96, p=0.001 and t=6.20, p=0.005).

There were no significant increases in the mean values of RBC(3-10yrs) (4.01±0.47) x 10^{12}/L, MCV (80.82±4.69)fl, MCH (28.73±1.79)pg, RDW (40.55±5.36 when compared to 11-18 years of exposure (3.83±0.50) x 10^{12}/L, (78.80±7.53)fl ,(27.32±3.37)%, (37.07±5.96)%, (3.78±0.41) mmol/l. and 18years (3.56±0.56) x10^9/L, (76.29 x10^{12}/L8.28) x10^9/L, (27.00± 3.69)pg, (35.49±5.36)% and (3.69±0.54)mmol/l respectively (t=1.71, p=0.195; t=0.91, p=0.413; t=0.95, p=0.396; t=2.03, p=0.147; and t=1.97, p=0.154).

Key:
PCV: Packed cell volume
RBC: Red blood cell
MCV: Mean cell volume
MCH: Mean cell haemoglobin
MCHC: Mean cell haemoglobin concentration
RDW: Red cell distribution Width
TWBC: Total white blood count
*: Significant p value

Parameter	Male	Female	t-value	p-value
PCV (%)	32.23±2.34	30.00±3.54	4.01	0.069
Haemoglobin (g/dl)	11.77±3.63	10.24±01.23	1.51	0.360
RBC (x10^{12}/L)	3.91±0.46	3.48±0.68	2.37	0.070
MCV (fL)	79.11±6.92	73.20±5.81	1.43	0.197
MCH (pg/cell)	27.87±2.94	26.00±3.32	1.44	0.208
MCHC (g/dl)	33.31±2.79	35.00±2.35	0.44	0.126
RDW (%)	39.11±5.46	32.60±8.50	2.33	0.798
TWBC (x10^9/L)	5.37±1.92	5.60±1.77	1.45	0.542

Table 3: Comparison of PCV, Haemoglobin, RBC, MCV, MCH, MCHC, RDW, and TWBC in Radiographers based on Sex.

There was a non-significant increase in the mean values of PCV (32.23±2.34) %, haemoglobin (11.77±3.63)g/dl, RBC (3.91±0.46) x10^{12}/L, MCV (79.11±6.92) fL, MCH (27.87±2.94) pg/cell, RDW (39.11±5.46)%, in male radiographers when compared to female radiographers (30.00±3.54)%, (10.24±01.23)g/dl, (3.48±0.68) x10^{12}/L, (73.20±5.8)fl, (26.00±3.22) pg, (32.60±8.50) %, (t=4.01,p=0.069; t=1.51, p=0.360; t=2.37, p=0.070; t=1.43, p=0.197; t=1.44, p=0.208; t=2.33, p=0.798).

The mean values of MCHC (33.31±2.79) g/dl, and TWBC (5.37±1.92) x10^9/L in males were insignificantly lower when compared to females (35.00±2.35) g/dl, (5.60±1.77) x10^9/L, (t=0.44, p=0.126; t=1.45, p=0.542).
Key:
PCV**:** Packed cell volume
RBC: Red blood cell
MCV: Mean cell volume
MCH: Mean cell haemoglobin
MCHC: Mean cell haemoglobin concentration
RDW: Ratio density weight
TWBC: Total white blood cell

Parameter	(35-50)yrs n=27	>50 yrs n=13	t-value	p-value
PCV (%)	32.93±2.41	30.00±1.47	1.87	0.071
Haemoglobin (g/dl)	12.14±4.08	10.41±0.64	0.93	0.140

RBC (x10^{12}/L)	3.96±0.43	3.57±0.58	1.86	0.123
MCV (fL)	79.51±6.42	76.23±7.63	1.82	0.162
MCH (pg/cell)	28.13±2.77	26.69±3.30	1.31	0.158
MCHC (g/dl)	33.35±2.51	33.76±3.35	1.28	0.660
RDW (%)	39.78±6.03	35.13±5.43	2.33	0.224
TWBC (x10^{9}/L)	5.70±1.97	4.80±1.54	0.26	0.155

Table 4: Comparison of the PCV, Haemoglobin, RBC, MCV, MCH, MCHC, RDW, and TWBC based on Age.

There was a non-significant increase in the mean values of PCV (32.93±2.41)%, haemoglobin (12.14±4.08)g/dl, RBC (3.96±0.43) x10^{12}/L, MCV (79.51±6.42) fL, MCH (28.13±2.77)pg/cell, RDW (39.78±6.03)%, TWBC (5.70±1.97) x10^{9}/L, in radiographers of ages (35-50)yrs when compared based on radiographers of ages >50 yrs (30.00±1.47)%, (10.41±0.64) g/dl, (3.57±0.58) x10^{12}/L, (76.23±7.63) Fl, (26.69±3.30) pg/cells, (35.13±5.43) %, (4.80±1.54) x10^{9}/L (t=1.87, p=0.071; t=0.93, p=0.140; t=1.86, p=0.123; t=1.82, p=0.162; t=1.31, p=0.158; t=2.33, p=0.224; t=0.26, p=0.155). There was a non-significant decrease in the mean value of MCHC (33.35±2.51) g/dl, in radiographers of ages (35-50) yrs when compared to radiographers of ages, >50yrs (33.76±3.35) g/dl (t=1.28; p=0.660).

KEY:
PCV: Packed cell volume
RBC: Red blood cell
MCV: Mean cell volume
MCH: Mean cell heamoglobin
MCHC: Mean cell heamoglobin concentration
RDW: Red cell distribution width
TWBC: Total white blood count

5 Discussion

Long-term exposure to low doses of ionizing radiation has been associated with adverse effects on human cells, particularly among radiation workers. These effects may contribute to various hematological disorders (Davoudi et al., 2022). In this study, the mean values of packed cell volume (PCV) and hemoglobin were significantly reduced in medical radiographers exposed to radiation compared to the control group. This finding aligns with the work of Fliedner and Graessle (2022), who reported no statistically significant changes in red blood cell (RBC) counts among radiation workers. Similarly, Dainiak and Sorba (2019) found no significant differences in RBC counts between exposed and non-exposed individuals. The lack of significance in RBC count variations in this study could be attributed to differences in sample sizes. Chronic exposure to low doses of ionizing radiation has been linked to lfe-threatening diseases, particularly those affecting the hematopoietic system, as radiation-induced damage to red blood cells leads to decreased PCV and hemoglobin levels (Alnahhal et al., 2021). Peripheral blood examination serves as a useful screening tool for detecting hematological and non-hematological disorders, as deviations in blood cell counts, even in asymptomatic individuals, may indicate underlying health issues requiring further investigation (Khorrami & Riahi-Zanjani, 2020).

This study also revealed no significant difference in RBC count among radiographers compared to controls. Additionally, significant reductions were observed in the mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH), while mean corpuscular hemoglobin concentration (MCHC) and red cell distribution width (RDW) showed no significant differences. These red cell indices are critical in diagnosing anemia and assessing red blood cell morphology. The findings are consistent with those of Alnahhal et al. (2021), who demonstrated the adverse effects of low-dose radiation on red cell indices. However, while some studies have identified these hematological changes, others have only detected radiation-induced effects at the genetic level. Shafiee et al. (2016) reported variations in red cell indices among radiographers that did not reach statistical significance, whereas recent research by Alnahhal et al. (2021) found significant differences between exposed and non-exposed groups.

Total white blood cell (TWBC) count was significantly lower in radiographers compared to controls. The decline in TWBC may be due to radiation-induced cellular damage, leading to degradation and reduced cell counts. Wagner et al. (2017) demonstrated the in vitro effects of ionizing radiation on mature leukocytes, identifying white blood cells as highly sensitive indicators of radiation exposure. The present findings align with those of Davoudi et al. (2022), who observed significant reductions in white blood cell and platelet counts among radiation-exposed workers, particularly those with more than five years of occupational exposure. Furthermore, Wagner et al. (2017) investigated the impact of low-dose radiation on differential leukocyte counts and found a significant decrease in neutrophil levels among radiographers compared to controls. These findings are further supported by Shahid et al. (2020), who also reported reduced neutrophil counts in radiographers.

When comparing hematological parameters based on years of radiation exposure, significant reductions were observed in PCV, hemoglobin, and TWBC. This suggests that prolonged exposure to radiation exacerbates these hematological changes (Alnahhal et al., 2021). However, no significant differences were found in RBC count, MCV, MCH, MCHC, and RDW across different exposure durations. These findings are in agreement with Yang et al. (2019), who reported no significant changes in MCV, MCH, MCHC, lymphocyte count, and platelet count among radiation workers.

6. Conclusion

In summary, this study found that PCV, hemoglobin, MCV, MCH, RDW, and TWBC were significantly reduced in radiographers exposed to radiation compared to controls, while RBC and MCHC showed no significant differences. These findings highlight the potential hematological risks associated with long-term occupational radiation exposure and underscore the importance of regular hematological monitoring in radiation workers.

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