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Investigation of Blood Indices (Red Blood Cells, White Blood Cells, Platelets) in Radiology Workers in Shahrud County in 2024-2025

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Abstract

Introduction: Ionizing radiation is extensively used in medical, industrial, and military applications, playing a pivotal role in technological advancements. However, prolonged exposure to radiation, even at low doses, can adversely impact the hematological system and health of radiation workers. This study aimed to assess the effects of ionizing radiation on the hematological indices of radiology staff in Shahroud hospitals.

Methods: This cross-sectional study was conducted on 57 radiation workers. Demographic, dosimetry (including HP(10), beta dose, 6-month and 30-month cumulative doses), and hematological index (RBC, WBC, PLT) data were collected and analyzed using descriptive and analytical statistical tests (including t-test, ANOVA, and correlation) with SPSS 26.

Results: The mean Red Blood Cell (RBC) count significantly decreased at doses exceeding 0.2 mSv ($P<0.001$). A significant correlation was observed between cumulative radiation doses and alterations in hematological indices, with the most substantial changes seen in RBC. No significant correlation was found between hematological indices and demographic variables such as age, work experience, or number of shifts.

Conclusion: Ionizing radiation, even at low doses, can adversely affect the hematological system, with pronounced effects on RBC. Comprehensive monitoring of radiation workers and advanced assessment methods, such as cytogenetic assays, are crucial for evaluating radiation-induced biological damage. Developing effective protective protocols is recommended to mitigate radiation-associated risks.

Keywords: Ionizing Radiation - Radiation Workers - Hematological Indices - Cumulative Dose - Radiation.

Introduction

There is global concern about ionizing radiation in the medical field as X-rays, gamma rays and beta particles, the use of ionizing radiation as one of the most important methods of diagnosing and treating diseases is widely increasing. The necessity, importance and benefits of radiology are obvious, but if appropriate protective measures are not taken, it can have adverse effects on people who are directly or indirectly exposed to radiation. X-rays cause dangerous biological effects, as they can have an ionizing effect when penetrating living tissue, destroy living cells, cause chromosomal aberrations and cause carcinogenic effects (1-4). The harmful effects of ionizing radiation are categorized into acute and chronic. Acute effects occur shortly after exposure and typically result from high-intensity radiation, while chronic effects arise from prolonged exposure to relatively low radiation doses over time (5).

Typically, acute effects are rare in diagnostic radiation exposure due to controlled duration, dose levels, and proper use of protective equipment. Long-term effects associated with chronic low-dose exposure remain the primary risk factor for diagnostic radiation workers. Radiologists and radiology technicians in diagnostic imaging centers are

consistently at risk of potential harm from such exposure (6-7).
Abnormal annual trends in red blood cell (RBC) or hemoglobin levels have been observed in some radiation workers. Thus, RBC monitoring should be prioritized for workers exposed to radiation (8).
Given the lack of similar studies in the country on blood cell changes among medical imaging professionals exposed to radiation, this study investigates blood indices (RBC, WBC, platelets) in radiology workers in Shahroud County in 2024-2025.

Methodology

Design and Method

This study was designed and implemented using a cross-sectional and descriptive-analytical method to investigate the effects of ionizing radiation on blood parameters and its relationship with various variables. The study was conducted in three hospitals in Shahroud, including Khatam, Bahar, and Imam Hossein hospitals, and the statistical population included 57 radiation workers working in these centers. Ethical approval for the study was obtained from the relevant institutional review board, with the ethics identification number IR.IAU.SARI.REC.1403.363.
Study Design and Population: This descriptive-cross-sectional study was conducted in 2024 on all radiation workers (n=57) from the three main radiology centers in Shahroud County (Khatam Al-Anbiya, Bahar, and Imam Hossein hospitals).

Demographic Data

Basic demographic data (age, gender, work shifts, and average work experience) were collected via standardized questionnaires. Questionnaires were distributed in person to radiation workers and collected after completion. Data accuracy was verified by hospital safety officers.
Radiation Dosimetry Data
Data on HP(10), beta dose, 6-month cumulative dose, and 30-month cumulative dose were extracted from personal dosimetry monitoring systems and hospital dosimetry reports. Reported doses were measured using film dosimeters and electronic systems. This information was periodically recorded at the treatment centers and used for analysis in the study.
Blood Sample Collection
Blood samples were collected from participants under standard conditions at three hospital laboratories. Analyzed parameters included RBC, WBC, platelets, and related indices. Tests were conducted using advanced equipment under laboratory supervision, with two sampling periods (6 months apart).

Data Collection

Demographic and occupational data were collected via a questionnaire.
Dosimetry data (HP(10), beta dose, 6-month and 30-month cumulative doses) were extracted from personal dosimetry records. Blood samples for CBC analysis were taken twice, six months apart.
Statistical Analysis: Data were analyzed using SPSS software (version 26) with descriptive statistics, independent t-test, ANOVA, and correlation tests. A significance level of $P<0.05$ was considered.

Data Recording and Monitoring

All demographic, diametric, and hematological data were entered into a centralized database for precise analysis and integrity. Access was restricted to researchers and authorized personnel.

Research Tools

1) A researcher-designed checklist was used to collect demographic data (age, gender, shifts, work experience). Checklist were simplified for clarity and reviewed to ensure accuracy.
2) Dosimetry Systems
   Film dosimeters measured cumulative radiation doses, including HP (10), beta doses, and 6-month/30-month cumulative doses.
3) Laboratory Equipment
   Blood samples were analyzed using automated hematology analyzers for RBC, WBC, and platelet counts.
4) Statistical Software

SPSS and generalized linear models were used for correlation analysis, mean comparisons, and examining relationships between radiation variables and blood parameters.

Result

In this study, the demographic and occupational characteristics of radiation workers, including the number of work shifts, work experience, age, and gender, were examined. The total number of subjects studied was 52, whose information was fully collected and analyzed. The results showed that the average number of work shifts among radiation workers was 21/21 shifts per month, with a minimum of 4 shifts and a maximum of 35 shifts. The work experience of the radiation workers was also examined in detail. The demographic characteristics of participants of study and hematological characteristics is listed in Table 1 and Table 2, respectively.

Table1: Demographic characteristics of participants (n=57)

Variable	Number	Minimum	Maximum	Mean
Shift/month	57	4	35	21.3
Work experience (years)	57	1.5	35	16.97
Age (years)	57	25	70	48.7

Table 2: Hematologic characteristics of participants (n=57)

Parameter	Number	Unit	Minimum	Maximum	Mean	SD
WBC	57	cells/mm^3	2951	8902	5647	633.89
RBC	57	million / mm^3	1.89	4.95	4.48	0.50
PLT	57	cells/mm^3	88514	296185	204136.77	53332.72

Of the 57 radiation workers surveyed, 26.5 percent (55 people) were within the normal dose range (11 millisieverts). Only 3.5 percent of people received doses of 1.15 and 1.2 millisieverts.

These data indicate that most radiation workers were adequately protected and their HP (10) radiation levels were within safe limits.

All 57 radiation workers were 100% within the normal beta dose range (below 0.05 mSv). These results confirm that beta radiation in workplaces is well controlled and the risks associated with this type of radiation are minimized.

The results showed that 93% of the subjects (53 subjects) had a 6-month cumulative dose below 0.05 mSv. Only 7% of the subjects (4 subjects) had received doses above 0.05, with values ranging from 0.05 mSv to 0.2 mSv. These data suggest that although most radiation workers were exposed to safe doses, there is a need for more careful monitoring for a small number of subjects. For the 30-month cumulative dose, 63.2% of subjects (36 people) were below 0.05 mSv. 36.8% of subjects (21 people) had higher doses, with cumulative dose values ranging from 0.05 to 13.65 mSv. Higher-than-normal values included doses of 3.55, 11.34, and 13.65 mSv, which require further protective consideration.

Blood indices including red blood cells (PLT) and platelets (RBC), white blood cells (WBC) were examined in two groups of men and women. The results showed differences in the mean and standard deviation of these indices between the two groups (Table 3).

Table 3: Descriptive analysis of blood indices in males and females.

Blood Index	Gender	Number	Mean	Std. Deviation	Std. Error
WBC	**Male**	32	5,303.8	642.71	113.61
	Female	25	5,905.9	631.99	126.39
RBC	**Male**	32	4.5234	0.31903	0.05640
	Female	25	4.4208	0.67223	0.13445
PLT	**Male**	32	194,352.34	54,809.14	9,688.97
	Female	25	216,660.84	49,655.08	9,931.02

The mean RBC count significantly decreased at doses exceeding 0.2 mSv (P<0.001), demonstrating more substantial changes compared to WBC and PLT. A significant correlation was observed between cumulative radiation doses and alterations in hematological indices.

The current study demonstrates that ionizing radiation, even at low doses, can cause significant changes in the blood system. These changes include reductions in red blood cells (RBC), white blood cells (WBC), and platelets, highlighting the high sensitivity of blood cells to radiation exposure. White blood cells, due to their key role in immune response and greater susceptibility to radiation damage, showed a significant decrease among radiation workers. These findings align with previous research indicating radiation-induced immune dysfunction and emphasize the need for rigorous monitoring of radiation workers' immune status (Table 4).

Table 4: Mean and Standard Deviation of Blood Indices in Two Levels of 30-Month Cumulative Dose

Blood index	Cumulative level (D30M)	Mean	SD
WBC	Normal	6203.7	599.87
	Above Normal	1068.00	141.42
	Dangerous	1590.00	1036.62
RBC	Normal	4.52	0.37
	Above Normal	4.68	0.03
	Dangerous	3.12	1.74
PLT	Normal	207096.09	53260.55
	Above Normal	130015.00	15535.13
	Dangerous	1999036.50	6849.73

One of the key findings of this study is the impact of cumulative radiation doses on blood indices. Specifically, doses exceeding 20 millisieverts over six-month and 30-month periods were associated with significant reductions in red and white blood cell counts. These results suggest that cumulative radiation can have harmful effects, even at low doses, which become evident over the long term. Additionally, no significant correlation was found between blood indices and variables such as work history or shift frequency, indicating that cumulative radiation dose may play a more dominant role than other factors.

Analytical Findings

- The decrease in the mean RBC count at doses higher than 0.2 mSv (in HP(10)) was statistically significant ($P < 0.001$).
- A significant correlation was observed between cumulative radiation doses (6 and 30 months) and a decrease in hematological indices (especially RBC) ($P < 0.05$).
- Based on ANOVA, a significant decrease in mean RBC was observed with increasing HP(10) dose level ($P = 0.004$). This decrease was not significant for WBC ($P = 0.094$) or PLT ($P = 0.469$).
- No significant correlation was found between hematological indices and demographic variables (age, gender, work experience, number of shifts) ($P > 0.05$ for all).

Discussion

These findings underscore the importance of developing and implementing effective protective protocols. The use of personal protective equipment and regular monitoring of radiation exposure can mitigate associated risks. Furthermore, advanced methods for assessing blood changes, such as cytogenetic testing, could replace conventional methods like CBC, providing greater accuracy in identifying radiation effects. Overall, this study strongly advocates for more precise monitoring of radiation workers' blood status and the design of more effective protective programs to prevent ionizing radiation damage.

In this context, our study focused on the effects of ionizing radiation on blood indices (CBC) and showed that radiation can lead to significant changes in red blood cells, white blood cells, and platelets. In contrast, another study examined skin wrinkles among healthcare workers (9). Their results indicated that ionizing radiation could increase wrinkles in various areas of the face and neck, demonstrating its structural and aesthetic impacts.

These two studies collectively demonstrate that the effects of ionizing radiation are not limited to internal systems like the hematopoietic system but also extend to external tissues such as the skin. This comparison highlights the importance of multidimensional perspectives in radiation-related studies, as only by considering all aspects of these effects can effective protective and monitoring measures be designed for Beyond the effects of ionizing radiation on the blood system and skin changes, broader and more comprehensive investigations into occupational radiation exposure's impact on workers' health are essential. The occupational health of radiation workers is not only affected by direct radiation but also significantly influenced by workplace conditions and ergonomic factors. Specifically, work-related musculoskeletal disorders (WMSDs) are a common issue among radiation workers, requiring special attention.

A study by Li Yan et al. (2024) examined the prevalence and risk factors of musculoskeletal disorders among 1,669 radiation workers in Guangdong Province,

China [10]. The research found that 15.3% of radiation workers suffered from these disorders, with factors such as gender, alcohol consumption, repetitive movements, overtime work, and prolonged static postures significantly increasing the risk. These results highlight the importance of ergonomic interventions, such as adjustable chairs and optimal environmental temperatures, in reducing these risks.
Compared to the current study and the research by Huriye Aybüke Koç, which focus on the blood system and skin changes due to radiation, Li Yan's study reveals another dimension of occupational health that indirectly affects workers' well-being and performance. This diversity in research outcomes demonstrates that radiation-related studies must consider not only the direct effects of radiation on tissues but also ergonomic and psychosocial workplace factors (9-10).
Moreover, the effects of ionizing radiation are not limited to specific tissues like blood or skin but can also impact other body systems. For example, a study by Galina et al. investigated the impact of long-term occupational exposure to ionizing radiation on non-cancerous respiratory diseases, such as chronic bronchitis and asthma, among workers at the "Mayak" nuclear facility [11]. The study found that exposure to gamma and alpha radiation was associated with an increased risk of chronic bronchitis. Notably, the excess relative risk (ERR/Gy) from internal alpha radiation exposure was significantly higher than that from gamma radiation. In contrast, no association was observed between occupational radiation exposure and the incidence or mortality of bronchial asthma.
This study, using an advanced dosimetry system (MWDS-2013) to estimate radiation doses accurately, demonstrated that the biological effects of radiation depend on the type of radiation (gamma or alpha), dose level, and intervening factors such as behavioral habits (e.g., smoking). For instance, among workers with a history of smoking or high smoking indices, the risk of mortality from chronic bronchitis increased significantly. Compared to studies like ours on blood indices or Huriye Aybüke Koç's research, this study emphasizes the effects of radiation on the respiratory system. This comparison underscores the need for comprehensive and extensive investigations into all body systems and potential effects at cellular and systemic levels to fully understand the consequences of ionizing radiation (9).
A study by Bahrami Asl et al, which examined the effects of long-term exposure to ionizing radiation on blood cells and interleukin-6 (IL-6) levels in radiation workers, shares significant similarities with the current research [12]. Both studies focus on hematological changes due to radiation and emphasize the importance of monitoring blood indices to understand its biological effects. In this study, in addition to traditional blood indices like CBC, IL-6 levels were evaluated as an inflammatory marker. The study found that even at radiation doses below the permissible limit (annual average of 1.18 millisieverts), IL-6 and eosinophil levels were significantly higher in the radiation worker group compared to the control group. These results suggest that occupational exposure to ionizing radiation, even at low doses, can cause biological changes that may lead to diseases like cancer in the long term.
Our advancements in this study represent an effective step in this direction, showing how new approaches can lead to a better understanding and improved protection of radiation workers' health.

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Conflict of Interest

The authors declare no conflicts of interest.

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