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Effects of Occupational Exposure on Blood Cells of Radiographers Working in Diagnostic Radiology Department of Khuzestan Province

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ABSTRACT

Introduction: Because radiology technologists are exposed to protracted low-dose ionizing radiation and considering the possible effects of low-dose radiation on blood factors, we aimed to investigate the effects of occupational exposure on blood factors of radiographers working in radiology departments of Khuzestan Province, Iran.

Materials and Methods: This case-control study was conducted in Khuzestan Province, Iran, during 2015. Blood samples were obtained from 95 radiology technologists and 85 matched, nonradiated controls. The participants were chosen using the cluster sampling method. The data were collected by performing complete blood count (CBC) assay with a Sysmex cell counter. To analyze the data, t-test and Pearson correlation coefficient were run in SPSS, version 16.

Results: T-test demonstrated that the mean values of blood factors were not significantly different between the two groups (P>0.05), and there was no significant difference between the two groups (radiographer and non-radiographer) by gender.

Conclusion: In this study, occupational exposure did not have any deleterious effects on radiographers' blood factor levels, but with increasing age and work experience in radiographers, number of white blood cell decreased.

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Introduction

The use of ionizing radiation as one of the most important methods of disease diagnosis and treatment is widely increasing. The importance and benefits of medical radiology are evident, but if proper protective measures are not adopted, it can have adverse effects on people who are directly or indirectly exposed to radiation [1-4].

The harmful effects of ionizing radiation are divided into two categories of acute and chronic. Acute effects occur in a short while after irradiation and are usually the result of exposing a large part of the body to high-intensity radiation whereas the chronic effects are caused by exposure to relatively low doses of radiation over an extended period of time [5].

According to the reports from molecular biology studies, the risk of chromosomal damage and cancer is a simple function of radiation, that is, their risk increases even in response to low doses of radiation. Also, the damage does not have threshold doses and low doses can have carcinogenic effects (below 10 mSv) [6-12].

Due to the duration and level of radiation and the appropriate use of protective equipment, the occurrence of acute effects in diagnostic radiation exposure is rare. Therefore, the long-term effects associated with low-dose radiation are the main risk factors for diagnostic radiation [5, 10, 13, 14]. Radiation practitioners and professionals in these centers are always exposed to the potential damage caused by such radiation. Several studies have suggested that the risk of chromosomal damage in workers exposed to radiation doses lower than the limit was higher than that of their non-exposed peers [10, 13, 15-17].

Hematopoietic cells are considered to be the most sensitive cells to radiation [18], and among them, lymphocytes are known as the most sensitive cells that show the highest response to low-dose radiation [3]. Therefore, variation in the number of these cells

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can be considered a biologic index to assess radiation damage to the body [3, 19]. Myriad studies have emphasized on the importance of complete blood count (CBC) in the evaluation of radiation effects on the body, especially among radiographers, which can play an important role in the prognosis and diagnosis of complications such as chronic radiation injury [6, 12, 20]. In this regard, some studies have reported decreased numbers of white blood cells, lymphocytes, and monocytes in radiology technologists compared to controls while other studies have not shown any significant differences between these two groups [10].

Considering the necessity of evaluating the health status of radiology staff exposed to protracted low-dose radiation and the contradictory results of previous studies, we sought to assess the possibility and rate of changes in blood cells using CBC test in radiographers and compare them to those of non-radiographers in radiology departments of Khuzestan Province, Iran.

Materials and Methods

This cross-sectional case-control study was conducted in 2015 among 95 radiology staff in the radiology departments of Khuzestan Province. Based on the film badge dosimeter, the employees exposed to radiation doses less than 20 mSv/year were randomly selected.

Eighty-five persons from the normal population, who were matched in gender, age, nutritional status, occupation, and activity level with the case group, were selected as the control group. The exclusion criteria were conditions affecting blood factors and causing errors in the study like blood, diagnosis of hereditary and infectious diseases, consumption of drugs affecting blood cells, smoking, and pregnancy [3, 21].

After explaining the study objectives and obtaining written informed consent from the volunteers, demographic data including age, gender, and work experience were entered into the respective forms for each person. From both groups, 2.5 cc of venous blood was taken and the anticoagulant drug K2EDTA was added to it to carry out the CBC test. Afterward, the number of cells was counted by Sysmex. Finally, to analyze the data, t-test and Pearson correlation coefficient were performed in SPSS, version 16. P-value less than 0.05 was considered statistically significant.

Results

In this study, 180 persons, including 95 radiology technologists as the case group and 85 non-radiated persons as the control group, were examined. The mean work experience was 11.95±6.89 years (range: 1-30 years).

The mean ages of the case and control groups were 36.98±8.50 and 36.49 ± 10.90 years, respectively. In general, 57 and 52 of the subjects in the case and control groups were female, respectively. There was no significant difference between the two groups with respect to mean age and gender distribution. Table 1 presents the mean and standard deviations of blood factors in the radiology technologists and controls. According to this table, there was no significant difference in the mean values of blood factors between the two groups (P>0.05).

Table 1. Comparison of the mean values of blood factors between the radiology technologists and controls

Blood factors	Mean and standard deviation in the radiology technologists	Mean and standard deviation in the control group	Significance level
Red blood cell (10^6/ml)	4.71±0.66	4.87±0.58	0.08
White blood cell (1000/ml)	7.34±2.22	7.49±1.76	0.60
Platelet (1000/ml)	239.11±51.24	247.19±53.51	0.30
Hemoglobin (g/dl)	13.24±3.10	13.02±2.1	0.59
Hematocrit (g/dl)	39.37±5.56	40.27±3.34	0.20
Neutrophil (%)	60.29±9.03	60.62±8.23	0.80
Lymphocyte (%)	36.56±8.91	36.63±7.70	0.12
Monocyte (%)	1.94±1.58	1.62±1.22	0.86
Eosinophil (%)	1.69±1.37	1.61±1.56	0.33

Table 2 demonstrates the mean and standard deviations of blood factors in the radiology technologists and the non-radiated persons with respect to gender. According to this table, there were not any significant differences in blood factors between the two groups based on gender (P>0.05).

Table 2. Comparison of the mean values of blood factors between the radiology technologists and controls by gender

Blood factors	Gender	Mean and standard deviation in radiology technologists	Mean and standard deviation in the control group	Significance level
Red blood cell (10^6/ml)	Male	5.08±0.58	5.34±0.56	0.06
	Female	4.46±0.58	4.57±0.35	0.21
White blood cell (1000/ml)	Male	7.31±1.77	7.12±1.64	0.65
	Female	7.36±2.49	7.73±1.80	0.38
Platelet (1000/ml)	Male	235.63±43.48	239.45±48.10	0.72
	Female	241.46±56.16	252.10±56.58	0.33
Hemoglobin (g/dl)	Male	14.94±4.15	14.80±1.28	0.86
	Female	12.10±1.22	11.99 ±1.26	0.71
Hematocrit (g/dl)	Male	42.01±8.72	43.12±2.68	0.30
	Female	37.62±4.92	38.45±2.29	0.27
Neutrophil (%)	Male	61.45±9.72	60.00±7.61	0.49
	Female	59.48±8.50	61.01±8.65	0.35
Lymphocyte (%)	Male	35.58±8.92	35.27±6.55	0.86
	Female	37.25±8.93	34.23±8.34	0.07
Monocyte (%)	Male	1.97±1.45	1.75±1.29	0.46
	Female	1.94±1.66	1.53±1.17	0.68
Eosinophil (%)	Male	1.66±1.32	1.48±1.34	0.66
	Female	1.72±1.40	1.69±1.69	0.39

Pearson correlation coefficient reflected a significant correlation between age and work experience in technologists and reduced white blood cell count while no significant relationship was found among the other blood factors investigated in this study. More information on the influence of age and work experience on the blood factors is provided in Table 3.

Table 3. The relationship of age and work experience with blood factors in the case group

	Red blood cell	White blood cell	Hemoglobin	Platelet	Hematocrit
Age	P=0.10	P=0.02	P=0.40	P=0.06	P=0.65
Work experience	P=0.30	P=0.03	P=0.14	P=0.65	P=0.28

Discussion

Radiology technologists working in radiology departments are always at high risk for protracted low-dose radiation exposure, therefore; evaluation of the associated risks seems to be mandatory. The present study was implemented to appraise the possibility of changes in blood cells in radiographers using CBC test and compare the results with those of non-radiographers in diagnostic radiology departments of Khuzestan Province, Iran.

We found no significant difference in the mean values of blood factors between radiation workers and non-radiated persons, which is in compliance with the results of studies by Sayed [17] and Salek Moqaddam [21]. Due to the long-term low-dose radiation exposure, it can be argued that the body organs have sufficient time to reconstruct and restore the damaged cells, and thus, they are not affected by low-dose exposure in radiation workers.

White blood cells are a group of blood cells that play an important role in the immune system. According to Table 1 and in accordance with the studies by Forslund [22], Zargan [4], Heydar Heydari [23], and Salek Moghadam [21], there is no significant difference in the mean number of white blood cells between the radiographers and controls.

Although lymphocytes are known to be the most sensitive cells to radiation, studies show that these cells are not sensitive to radiation doses of about 200-300 mSv [24]. Since the annual exposure of radiology staff (0.2 mSv) is negligible compared to background radiation (3.5 mSv/year) in ordinary people, there is no significant difference in the mean number of white blood cells in them. Accordingly, low radiation doses diminish the effects of high-intensity exposure through a phenomenon called adaptive responses. In this condition, exposing the body to low-dose radiation increases the levels of cell cytoprotective genes , consequently, in subsequent exposures, the amount of radiation is estimated to be lower than the actual value, and to some extent, the body becomes resistant to radiation [6, 21, 25, 26].

Meanwhile, in the study by Tavakoli, the mean number of white blood cells in the case group was reported to be lower than that in the control group. In this study, we examined different types of white blood cells, including neutrophils, lymphocytes, monocytes, and eosinophils; we found a significant difference in the mean number of monocytes between the two groups [3]. This discrepancy in results could be attributed to differences in the tested samples, such that in this study, only radiology personnel were recruited, while Tavakoli et al. investigated the personnel of CT scan and nuclear medicine departments who had received higher doses of ionizing radiation. Another factor can be the difference between the control groups that consisted of normal individuals in the present study while in the study by Tavakoli, staff of other divisions were assigned as the control group. These staff were exposed to a variety of hospital infections, and as a result, had a stronger immune system relative to their peers.

Regarding the mean number of red blood cells, we did not observe a significant difference between the radiology technologists and controls, which is consistent with the findings of Heydar Heydari [23], Tavakoli [3], Zargan [4], and Khedr [27]. Sayed [17], Heydar Heydari [23], Tavakoli [3], and Zargan [4] also did not report any significant differences between the case and control groups in the number of platelets.

In the same vein, the unchanged mean numbers of hematocrit and hemoglobin were reported by Hauck et al. [28]. Zargan et al. also showed no significant difference in the hemoglobin and hematocrit values between the case and control groups. The reasons for these results can be the adaptive effects of radiation [6, 21, 26], exposure less than the required level for effect on blood cells,

Based on the results reported in Table 2, there is no significant difference between the two genders in the levels of blood factors, but according to Table 3, with increasing age and work experience, the average number of white blood cells decreases**.** However, there is not any significant relationship between other blood factors and demographic characteristics. In line with this study, Tavakoli et al. reported no significant correlation between the number of blood factors and work experience, gender, education level, and work area. Zargan et al. also stated that the levels of blood cells in three groups with work experience of more than 10 years, 10 years, and less than 10 years were not significantly different [4], while Salek Moghadam et al. reported some changes in the number of white blood cells, such as increased CD4 and decreased CD8, in participants with work experience of more than 10 years [21]. A significant difference based on age was also found in the studies by Burton [29], Tuschl [30], Kusunoki [31], and Fugiwara [32]. Accordingly, the increase in the CD4/CD8 ratio is dependent on the subject's age and is not related to the level of exposure [21].

Finally, according to the results of this study, the presence of small doses of radiation in the radiology departments and consideration of protective issues prevent the deleterious effects of ionizing radiation on cells and blood factors of radiology technologists. Few studies have been conducted in this regard in Iran, some of which yielded contradictory results. Therefore, further studies are needed to monitor the radiology staff in diagnostic and therapeutic departments of hospitals.

Conclusion

The findings of this study showed that low doses of ionizing radiation do not adversely affect the levels of blood factors in radiology workers, but the effects of this type of radiation have not been thoroughly identified and further studies are required. Therefore, more accurate monitoring of radiology staff in shorter intervals and the use of more precise and updated personalized dosimeters are recommended.

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References

1. Baker N, Bromilow L, Costigan J. Exposure to ionising-radiation from x-rays in the intensive therapy unit-St Vincent's Hospital. Australian Critical Care. 1992;5(1):24.
2. Davoudian Talab A, Badiee Nejad A, Beit Abdollah M, Mahmoudi F, Barafrashtehpour M, Akbari G. Assessment of awareness, performance, and attitudes of radiographers toward radiological protective principles in Khuzestan. Iran J Health Res Community. 2015;1(3):15-23
3. Tavakoli Mahmood Reza MAZM, Anani Sarab Gholamreza, Hosseini Seyed Mohammad. Evaluation of blood cell count in the radiology staff of Birjand Hospitals in 2011 new care. 2012;9(2):80-6.
4. Zargan S SS, Emami H, Attarchi M, Yazdanparast T, hamidi H. Comparison of blood cells in radiology workers and non-radiation workers staff of a governmental hospital in Tehran. ioh. 2016;13(4):31-8.

5. Fang S-P, Tago F, Tanaka T, Simura N, Muto Y, Goto R, et al. Repeated irradiations with γ-rays at a dose of 0.5 Gy may exacerbate asthma. Journal of radiation research. 2005;46(2):151-6.
6. Schimmöller L, Lanzman R, Dietrich S, Boos J, Heusch P, Miese F, et al. Evaluation of automated attenuation-based tube potential selection in combination with organ-specific dose reduction for contrast-enhanced chest CT examinations. Clinical radiology. 2014;69(7):721-6.
7. Paolicchi F, Faggioni L, Bastiani L, Molinaro S, Caramella D, Bartolozzi C. Real practice radiation dose and dosimetric impact of radiological staff training in body CT examinations. Insights into imaging. 2013;4(2):239-44.
8. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. New England Journal of Medicine. 2007;357(22):2277-84.
9. Barquinero J, Barrios L, Caballin M, Miro R, Ribas M, Subias A, et al. Cytogenetic analysis of lymphocytes from hospital workers occupationally exposed to low levels of ionizing radiation. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis. 1993;286(2):275-9.
10. Cengiz M, Gurkaynak M, Vural H, Aksoy N, Cengiz B, Yildiz F, et al. Tissue trace element change after total body irradiation. Nephron Experimental Nephrology. 2003;94(1): 12-6.
11. Nowak B, Jankowski J. Occupational exposure in operational radiology. International Journal of Occupational Medicine and Environmental Health. 1991;4(2):169-74.
12. Puthran SS, Sudha K, Rao GM, Shetty BV. Oxidative stress and low dose ionizing radiation. 2009.
13. Hashim S, Karim M, Bakar K, Sabarudin A, Chin A, Saripan M, et al. Evaluation of organ doses and specific k effective dose of 64-slice CT thorax examination using an adult anthropomorphic phantom. Radiation Physics and Chemistry. 2016;126:14-20.
14. Protasova O, Maksimov I, Nikiforor A. Altered balance of trace element in blood serum after exposure to low doses of Ionization Radiation. Biol Bull Russ Acad Sci. 2001;28(4):344-9.
15. Ebrahiminia A S-GD, Karegar A, Farzan A. Relationship between occupational exposure and concentration of some trace elements in radiology and radiotherapy workers J Qazvin Univ Med Sci. 2008;12(3):52-7.
16. Persson L, editor Effects of low-dose ionizing radiation. Proceedings of the 10th International Congress of the International Radiation Protection Association, May; 2000.
17. Sayed D, Elwanis MEA, Elhameed SYA, Galal H. Does occupational exposure to low-dose ionizing radiation affect bone marrow thrombopoiesis? International archives of medicine. 2011;4(1):8.
18. Ward E, Hornung R, Morris J, Rinsky R, Wild D, Halperin W, et al. Risk of low red or white blood cell count related to estimated benzene exposure in a rubberworker cohort (1940–1975). American journal of industrial medicine. 1996;29(3):247-57.
19. Rozgaj R, Kašuba V, Šentija K, Prlić I. Radiation-induced chromosomal aberrations and haematological alterations in hospital workers. Occupational medicine. 1999;49(6):353-60.
20. Perkins SL. Examination of the blood and bone marrow. Wintrobe's clinical hematology. 1999:9-35.
21. Salek Moghaddam A SA, Osati Ashtiani F, Jalali Galousang F. COMPARATIVE EVALUATION OF CELLULAR AND HUMORAL IMMUNITY PARAMETERS IN RADIOGRAPHERS AND NON RADIOGRAPHERS. RJMS. 2004;10(37):727-33.
22. Forslund T, Welin M-G, Laasonen L, Weber T, Edgren J. Peripheral blood lymphocyte subsets in radiologists exposed to ionizing radiation. Acta Radiologica: Oncology. 1985;24(5):415-7.
23. Heydarheydari S, Shookoh S, Almasi A, Sohrabi N. Evaluation of the Effects of Ionizing Radiation on Radiation Worker's Blood Parameters of Kermanshah hospitals. Journal of Clinical Research in Paramedical Sciences Autumn. 2012;1(3).
24. Kalamzadeh A, Keihani A, Hajati J, Nooraei M, Latifinia A, Zaker F, et al. Total plasma level of antioxidant and immune system function in radiology and nuclear medicine staff. Tehran University Medical Journal TUMS Publications. 2007;65(9):13-9.
25. Feinendegen LE, Pollycove M, Sondhaus CA. Responses to low doses of ionizing radiation in biological systems. Nonlinearity in biology, toxicology, medicine. 2004;2(3):15401420490507431.
26. Tucker JD. Low-dose ionizing radiation and chromosome translocations: a review of the major considerations for human biological dosimetry. Mutation Research/Reviews in Mutation Research. 2008;659(3):211-20.
27. Khedr M. Evaluation the Effect of Low Dose Ionizing Radiation on Radiological Staff. 2017.
28. Hauck B, Oremek D, Zimmermann R, Ruppel R, Troester B, Eckstein R. Influence of irradiation on in vitro red-blood-cell (RBC) storage variables of leucoreduced RBCs in additive solution PAGGS-M. Vox sanguinis. 2011;101(1):21-7.
29. Burton R, Ferguson P, Gray M, Hall J, Hayes M, Smart Y. Effects of age, gender, and cigarette smoking on human immunoregulatory T-cell subsets: establishment of normal ranges and comparison with patients with colorectal cancer and multiple sclerosis. Diagnostic immunology. 1983;1(3):216-23.
30. Tuschl H, Kovac R, Wottawa A. T-lymphocyte subsets in occupationally exposed persons. International journal of radiation biology. 1990;58(4):651-9.
31. Kusunoki Y, Akiyama M, Kyoizumi S, Bloom ET, Makinodan T. Age-related alteration in the composition of immunocompetent blood cells in atomic bomb survivors. International Journal of Radiation Biology. 1988;53(1):189-98.
32. Fujiwara S, Akiyama M, Kobuke K, Hakoda M, Kyoizumi S, Olson GB, et al. Analysis of peripheral blood lymphocytes of atomic bomb survivors using monoclonal antibodies. Journal of radiation research. 1986;27(3):255-66.