SHORT REPORT

Comparison of Hematological Parameters between Diagnostic Radiation Workers and Non-Radiation Workers

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Abstract

Purpose: Radiation workers are exposed to chronic effects due to long-term exposure to low levels of ionizing radiation. One of the biological indicators to evaluate these chronic radiation effects is the study of the hematopoietic system. The purpose of this study is to compare the changes in blood parameters of radiology staff and staff of other wards of the hospital.

Materials and Methods: In this study, 47 radiology staff working in the radiology department of the hospital as the study group and 94 personnel in other departments as the control group were included. Demographic data including age, gender, and work experience were obtained. Hematological parameters were extracted from the complete blood count tests of participants.

Results: The results of this study showed that the Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) parameters significantly decreased in the male study group, whereas no significant differences were observed in the blood parameters of the female study group in comparison to those of the control group. There was a significant positive correlation between the parameters of Hemoglobin and age. There was a significant negative correlation between work experience and white blood cells, while there was a significant positive correlation between work experience and Hemoglobin.

Conclusion: Correlation between collective absorbed dose and changes in blood parameters is suggested for future studies. Based on the results of this study and other studies, it can be concluded that long-term exposure to low levels of radiation may change blood parameters. Therefore, regular and periodic complete blood count tests along with absorbed dose monitoring of radiation workers are recommended.

Keywords: Blood Parameters; Low Dose; X-Ray; Radiation Effect.

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1. Introduction

One of the most important sources of ionizing radiation is man-made sources such as diagnostic X-rays, nuclear medicine, and radiation therapy [1]. Nowadays, the use of imaging methods such as radiology can play an important role in early diagnosis, treatment design, staging, and monitoring of patients during treatment [2]. The initial diagnosis of some diseases depends entirely on X-ray tests, as the use of imaging information along with the patient's clinical information can complement the more accurate diagnosis of the disease [3]. At the same time, one of the harmful factors in the workplace is ionizing radiation, which can cause serious and irreversible damage to people who are in some way in contact with radiation or people who refer to diagnosis and treatment [4].

Ionizing radiation affects human health by producing free radicals, breaking down chemicals and Deoxyribonucleic Acid (DNA) molecules, causing apoptosis in proliferating cells, and thus leading to cancer [5, 6].

According to the results of various studies, the frequency of chromosomal damage in radiology staff, even those with low levels of radiation, has been reported more in normal people [7]. The United State (US) National Cancer Institute has added ionizing radiation to the list of carcinogens in humans due to the medical side effects of X-rays [8]. Molecular researches have now provided new information on the danger of small amounts of ionizing radiation. According to these studies, the risk of malignancy in cancers for ionizing radiation is a simple function of the amount of radiation and has no threshold [9].

A study on the incidence of malignancies in US radiology workers concluded that there was an increased risk of leukemia among radiologists, decades after the primary exposure to radiation [10].

A multinational retrospective cohort study was conducted by the International Institute for Cancer Research on a population of over 400,000 radiology staff in the nuclear industry. The results showed that there was a slightly increased risk of cancer even at low-received radiation doses [11]. Therefore, it is important to pay attention to the health of radiology staff working in different diagnostic and therapeutic departments of the hospital.

In the human body, the radiosensitivity of cells and tissues are different [12]. Hematopoietic cells are considered to be the most sensitive cells to radiation [13]. Among them, lymphocytes are known as the most sensitive cells that show the highest response to low-dose radiation [14]. Therefore, the difference in the number of these cells can be considered a biological indicator to evaluate the effects of radiation on the body.

Myriad studies have emphasized the importance of complete blood counts in assessing the effects of radiation on the body, especially among radiology staff, which can play an important role in the prognosis and diagnosis of complications such as chronic radiation injury [15, 16].

But a review of studies in this area reveals contradictory results. For example, some studies have reported that long-term ionizing radiation has no effect on blood parameters [14, 17], and some other studies have reported an increase or decrease in various blood parameters [18, 19].

Therefore, according to the contradictory results of previous studies, the purpose of this study is to compare the changes in blood parameters of radiology staff and staff of other wards of the hospital.

2. Materials and Methods

In this study, 47 radiology staff working in the radiology department of the hospital as the study group and 98 personnel in other departments as the control group were included.

Participants with a history of blood diseases such as thalassemia and hemophilia as well as smokers were excluded from the study. This study was conducted after the approval of the regional ethics committee and obtaining the consent of the participants. Demographic and blood factors information were included in the checklist. Demographic data included age, gender, and work experience. Hematological parameters included Neutrophils (Neut), White Blood Cells (WBC), Red Blood Cells (RBC), Hemoglobin (Hgb), Hematocrit (Hct), Mean Volume of red blood Cells (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Lymphocytes (LYM) and Platelet (PLT).

The data obtained from the study were plugged into SPSS software (Version 24). First, the data were described using descriptive statistics (mean and standard deviation or number and percentage). To compare quantitative data in two independent groups, t-test analysis was used, and if the data were not a normal distribution, the Mann-Whitney test was used. In all tests, a significance level of 0.05 was considered.

3. Results

The demographic data of participants are summarized in Table 1. Forty-seven radiology staff including 12 males and 35 females were enrolled in this study. Ninety-eight staff from other departments of the hospital, including 51 males and 47 females were enrolled in this study as the control group. The mean age of the study and control groups were 35.85 ± 7.7 and 38.25 ± 7.7, respectively. The mean working experience and the mean working hours per week were 12.3 ± 7.6 years and 30.6 ± 10.2 hours, respectively.

Table 1. Demographic data of study group and control group

	Study group	Control group
N	47	98
Age (mean ± SD)	35.85 ± 7.7	38.25 ± 7.7
Male	12	51
Female	35	47
Work experience (year)	12.3 ± 7.6	-
working hours per week	30.6 ± 10.2	-

Results of the correlation between blood parameters and age and working experience are summarized in Table 2. There is a significant positive correlation between parameters of Hgb and age ($P < 0.05$). There is a significant negative correlation between working experience and WBC, while there is a significant positive correlation between working experience and Hgb ($P < 0.05$). The rest of the blood parameters did not show a significant correlation between age and working experience.

The number of radiation workers in Computed Tomography (CT) scan and radiography was 6 (with working experience of 15.5 ± 8.5 years) and 13 (with working experience of 12.6 ± 7.1 years), respectively. The rest of the radiation workers stated that they work in both radiography and CT scan units.

Table 2. Results of correlation between blood parameters and different variables

	Age		Work experience	
	r	P-value	r	P-value
Neut	- 0.130	0.385	- 0.158	0.287
LYM	0.248	0.093	- 0.259	0.079
RBC	0.264	0.073	0.271	0.065
Hgb	0.269	0.043	0.290	0.048
Hct	0.276	0.060	0.274	0.063
MCV	0.016	0.917	- 0.001	0.997
MCH	0.042	0.781	0.029	0.848
MCHC	0.069	0.645	0.064	0.669
WBC	- 0.270	0.066	- 0.295	0.044
PLT	- 0.247	0.094	- 0.259	0.078

The mean blood parameters of the study and control group for males are summarized in Table 3. The mean values of MCH and MCHC significantly decreased in the study group ($P < 0.05$), whereas the rest of the parameters showed no significant differences. The mean blood parameters of the study and control group for females are summarized in Table 4. All blood parameters showed no significant differences ($P > 0.05$).

Table 3. Comparison of blood parameters of male study group and male control group

	Study group	Control group	P-value
Neut	3241.67 ± 561.58	3452.16 ± 829.72	0.408
LYM	2660.0 ± 436.01	2400.0 ± 584.08	0.098
RBC	5.32 ± 0.36	5.34 ± 0.36	0.841
Hgb	15.32 ± 0.48	15.90 ± 0.97	0.060
Hct	45.48 ± 2.24	46.35 ± 2.85	0.331
MCV	85.50 ± 3.46	86.83 ± 3.57	0.249
MCH	28.84 ± 1.01	29.86 ± 1.26	0.012
MCHC	33.72 ± 0.90	34.35 ± 0.98	0.049
WBC	6470.00 ± 985.47	6409.8 ± 1307.42	0.500
PLT	2403.33 ± 495.73	2460.2 ± 579.4	0.381

4. Discussion

Radiation workers are exposed to chronic effects due to long-term exposure to low levels of ionizing radiation. One of the biological indicators to evaluate these chronic radiation effects is the study of the hematopoietic system. Any change in blood parameters from the normal range should be examined [20]. This study aimed to compare the blood parameters of diagnostic X-ray department

Table 4. Comparison of blood parameters of female study group and female control group

	Study group	Control group	P-value
Neut	3669.14 ± 863.49	3442.55 ± 784.08	0.226
LYM	2277.14 ± 722.25	2248.87 ± 560.89	0.333
RBC	4.71 ± 0.38	4.68 ± 0.30	0.235
Hgb	13.44 ± 1.06	13.51 ± 0.74	0.730
Hct	39.67 ± 3.0	40.40 ± 2.24	0.093
MCV	84.43 ± 5.67	86.43 ± 3.28	0.067
MCH	28.64 ± 2.24	28.95 ± 1.61	0.461
MCHC	33.91 ± 1.42	3.46 ± 1.05	0.105
WBC	6569.71 ± 1332.11	6235.10 ±1022.93	0.235
PLT	2602.28 ± 512.92	2611.06 ± 563.64	0.855

staff with other staff of the hospital. In this regard, the CBC test results of 98 non-radiation workers and 47 radiation workers were analyzed.

The sensitivity of cells to radiation is different, and in fact, hematopoietic cells are among the most sensitive cells to radiation. Most previous studies have shown that radiation has potential cytological effects, cell dysfunction, and changes in hematological factors in blood cells. Blood cell dysfunction can be seen in the study by Hrycek *et al.* [21], who concluded that changes in neutrophil metabolism are evident in radiation-employed individuals with more than 5 years of working experience, and neutrophil phagocytic power was reduced. In the study of Godekmerdan *et al.* [22], it was observed that long-term exposure to radiation in radiation workers is associated with a decrease in the level of CD4 and immunoglobulins, which leads to a decrease in the strength of the cellular and humoral immune systems.

The results of this study showed that the parameters of MCH and MCHC significantly decreased in the male study group, whereas no significant differences were observed in the blood parameters of the female study group. Decreased MCH and MCHC may be related to the destruction of red blood cells [20]. Inconsistent with our results, Shahid *et al.* [23] observed a significant decrease in MCHC in radiation workers compared to controls.

The results of this study are different from those of other similar studies. Davoudi *et al.* [20] and Shafiee *et al.* [24] reported that parameters of PLT and WBC decreased significantly in radiation workers compared to the control group. Also, Faraj and Mohammed [1] showed that parameters of PLT and WBC decreased significantly in male radiation workers, whereas parameter of MCV decreased significantly and parameter of MCHC increased significantly compared to the control group. Mohammed *et al.* [25] reported that only the percentage of atypical lymphocytes was significantly higher in X-ray technicians compared to controls. Ratini *et al.* [26] showed that only Hgb was significantly higher in radiation workers. Surniyantoro *et al.* [27] reported that parameters of RBC and monocyte increased significantly, whereas parameters of WBC, Hct, MCV, and lymphocytes decreased significantly in radiation workers compared to controls. Heydarheydari *et al.* [28] showed that parameters of Hgb and MCV decreased significantly in radiation workers with at least 10 years of working experience compared to controls. Sabagh and Chaparian [18] observed that Hct increased significantly, and PLT and MCHC decreased significantly in male radiation workers compared to the male controls, whereas LYM decreased in female radiation workers compared to the female controls. Significantly decreased MCHC in the male study group in our study is consistent with Sabagh and Chaparian's study.

DavudianTalab *et al.* [14] and Zargan *et al.* [29] reported no significant difference in blood parameters between radiation workers and non-radiation workers.

The results of this study showed a significant correlation between age and Hgb, which is consistent with Sabagh and Chaparian's study [18]. Moreover, there was a significant positive correlation between working experience and Hgb which is consistent with Sabagh and Chaparian's study [18].

The dissimilarity of the results of this study with others may be due to different absorbed radiation doses, different work load and working hours per week. The work schedule for radiation workers in this study was 30.6 ± 10.2 hours per week. Also, different results between males and females may be due to different work load per day and different individual radiosensitivity that emanate further investigations.

This study has two limitations. First, the study population is relatively small. Second, radiation absorbed dose data was not included in the study, but the absorbed dose of none of the radiation workers exceeded the dose limits provided by International Commission on Radiological Protection (ICRP).

5. Conclusion

The results of this study showed that the parameters of MCH and MCHC significantly decreased in the male study group, whereas no significant differences were observed in the blood parameters of the female study group. Correlation between collective absorbed dose and changes in blood parameters is suggested for future studies.

Based on the results of this study and other studies, it can be concluded that long-term exposure to low levels of radiation may change blood parameters. Therefore, regular and periodic complete blood count tests along with absorbed dose monitoring of radiation workers are recommended.

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