Iranian Journal of Medical Physics

ijmp.mums.ac.ir

Evaluation of Blood Parameters of the Medical Radiation Workers

Mahshid Sabagh[1], Ali Chaparian[2*]

1. Student Research Committee, Faculty of Paramedical Sciences, Isfahan University of Medical Sciences, Isfahan, Iran
2. Technology of Radiology Department, Isfahan University of Medical Sciences, Isfahan, Iran

ARTICLE INFO

Article type:
Original Article

Article history:
Received: Mar 13, 2019
Accepted: May 14, 2019

Keywords:
Complete Blood Count
Radiation Effects
Workers

ABSTRACT

Introduction: Medical workers in the departments of radiology, computed tomography, nuclear medicine, and radiotherapy are always exposed to ionizing radiations. Complete blood count (CBC) test is commonly used to monitor the health of radiation workers. The aim of this study was to evaluate the hematological parameters of radiation workers of Isfahan, Iran, and reveal the effectiveness of the CBC tests in the prediction of the radiation effects on the health of such workers.

Material and Methods: The current study was conducted on 160 radiation workers and 103 healthy people using CBC tests. To obtain the main aim of the study the obtained results of the two groups were compared in terms of blood parameters.

Results: The hematocrit in the male radiation workers was estimated at 45.98±3.00, which was significantly higher than that of the control group (44.33±2.41%, $P<0.05$). However, mean corpuscular hemoglobin concentration and platelets counts were of lower levels in radiation workers, compared to the control group ($P<0.05$). The lymphocyte percentage of female radiation workers was 33.78±7.47%, which was significantly lower than that of the controls (37.84±8.97%, $P<0.05$).

Conclusion: The CBC test can be used to follow up on the overall health status of radiation workers. However, it is essential to perform complementary methods, such as chromosomal changes, cytokines, and interleukins evaluation, for the early detection of radiation effects.

►*Please cite this article as:*
Sabagh M, Chaparian A. Evaluation of Blood Parameters of the Medical Radiation Workers. Iran J Med Phys 2019; 16: 439-443. 10.22038/ijmp.2019.37427.1477.

Introduction

Ionizing radiations are widely used in the diagnosis and treatment of patients. Radiation workers have the direct responsibility of performing the tests in the radiology, computed tomography, nuclear medicine, and radiotherapy departments since they are frequently exposed to radiation [1, 2]. Ionizing radiations influence human health through producing free radicals, breaking down chemical and DNA molecules, inducing apoptosis in proliferating cells [3], and therefore leading to cancers [4]. The hematopoietic system is one of the most sensitive systems for radiation [5]. In a study conducted on the incidence of malignancies in radiation workers in the United States, it was concluded that there was an increased risk for leukemia among such staff decades after initial radiation exposure [6]. A multinational retrospective cohort investigation organized by the International Agency for Research on Cancer was conducted on a population of over 400000 radiation workers in the nuclear industry. The obtained results showed that there was a small increase in cancer risk even in case of low doses and received doses by these workers [7]. Therefore, it is important to pay attention to the health of radiation workers employed in various diagnostic and therapeutic departments of hospitals.

One of the methods that is commonly used to monitor the health status of radiation workers is to perform a complete blood count (CBC) test. According to the law of radiation protection agencies, radiation workers should undergo CBC tests every 6 months. In case of significant changes in their blood parameters, further measures should be taken. However, studies conducted in recent years on the blood tests of radiation workers had different results. A large number of studies [8-10] have indicated that there is no significant difference between the blood parameters of radiation workers and control group. On the other hand, other studies reported an increase or decrease in various blood parameters [11-16]. Therefore, it is important to realize that these discrepancies among the findings of the different researchers. Recently, Jang *et al.* [17] conducted a study to ascertain the clinical usefulness of CBC results for the radiation workers of South Korea.

Few studies have investigated the follow up of the blood tests of the Iranian radiation workers.

*Corresponding Author: Tel: +989131091735; Fax: +983137928089; Email: ali_chaparian@yahoo.com

Therefore, the aim of this study was to evaluate the blood parameters of radiation workers of the radiology, computed tomography (CT) scan, nuclear medicine, and radiotherapy departments of Isfahan, Iran. In fact, the present study was carried out to determine the difference between the radiation workers in terms of hematological parameters. Moreover, the study moved further to reveal the effectiveness of the CBC tests in the prediction of the radiation effects on the health of radiation workers.

Materials and Methods

This descriptive-analytical study aimed to collect the information of the CBC tests of radiation workers of the radiology, CT scan, nuclear medicine, and radiotherapy departments of Isfahan. This study was carried out with the consent of radiation workers and in collaboration with the health authorities responsible for each center.

As a result, the study samples included the information of the CBC tests of 160 apparently healthy radiation workers (67 males and 93 females). Moreover, the demographic information of each radiation worker, including age, sex, years of work experience, and type of occupational category (radiology, CT scan, radiotherapy, and nuclear medicine) were also collected for further analysis. The CBC tests of smokers and pregnant women were excluded from the study. The control group in the present study encompasses 103 healthy individuals (47 males and 56 females) that their blood tests were collected under the supervision of a hematologist and an epidemiologist.

The investigated parameters in the CBC assay included white blood cells (WBC), red blood cells (RBC), hematocrit (Hct), hemoglobin (Hgb), mean volume of red blood cells (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), lymphocytes (LYM), and platelets (PLT). The CBC tests were performed by a cell counting device (Sysmex cell counter, model kx21).

The differences between the blood parameters of radiation workers and controls were explored in the present study. Moreover, there was a further investigation of the relationship between blood parameters and demographic information (i.e., age, sex, work experience, and employment departments). Quantitative and qualitative variables were analyzed using the Mann-Whitney U test, independent t-test, ANOVA, and Kruskal-Wallis tests. The relationship between quantitative variables was analyzed using the Pearson correlation coefficient. P-value less than 0.05 was considered statistically significant. Statistical analysis was performed using SPSS software (version 21, SPSS, Chicago, IL, USA).

Results

The demographic information, employment department, and work experience of the study subjects are shown in Table 1. The comparison of the blood parameters of male radiation workers and male controls are shown in Table 2. As shown in Table 2, there was a significant difference between the two groups in terms of three blood parameters (out of nine). The hematocrit value of the male radiation workers was 45.98±3.00, which was significantly higher than that of the controls (44.33±2.41%, $P<0.05$). However, the obtained results of MCHC and platelets were significantly lower than those of the control group ($P<0.05$).

Table 1. Demographic information of the investigated subjects

Study subjects	n	Age (y) (mean±SD)	Work experience (y) (mean±SD)	Employment Department			
				Radiology	Computed tomography	Nuclear medicine	Radiotherapy
Male radiation workers	67	43.51±8.87	16.94±8.79	38	8	11	10
Male control	47	41.2±5.35	-	-	-	-	-
Female radiation workers	93	36.34±7.50	10.96±6.94	53	8	23	9
Female control	56	34.67±6.23	-	-	-	-	-

Table 2. Comparisons of male radiation workers and male controls in terms of blood parameters

		WBC (K/μL)	RBC (M/ μL)	Hgb (gm/dL)	Hct (%)	MCV (fL)	MCH (pg)	MCHC (gm/dL)	PLT (K/ μL)	LYM (%)
Male radiation workers	Average	6.8	5.29	15.37	45.98	87.68	29.64	33.44	220.55	36.42
	STDEV	1.4	0.56	1.23	3.00	6.63	2.52	1.98	43.95	7.97
	min	4.1	4.16	12.7	39.9	55.3	18.9	21.6	129	13.3
	max	9.5	7.14	18.3	51.9	101	37.75	36.7	322	55.5
Male controls	Average	7.28	5.15	15.13	44.33	86.22	29.53	34.13	239.48	36.65
	STDEV	1.82	0.41	0.93	2.41	4.77	2.23	1.26	50.59	9.03
	min	4.9	4.41	13.1	39.6	75.3	24.6	31.2	142	20.1
	max	10.9	6.47	16.7	48.9	97.3	35	38.6	374	54.6
p-value		0.1175	0.1502	0.2647	0.0024	0.2024	0.8118	0.0389	0.0367	0.8868

Table 3. Comparisons between blood parameters of female radiation workers and female controls

		WBC (K/μL)	RBC (M/ μL)	Hgb (gm/dL)	Hct (%)	MCV (fL)	MCH (pg)	MCHC (gm/dL)	PLT (K/ μL)	LYM (%)
Female radiation workers	Average	6.92	4.73	13.25	40.26	86.80	29.60	32.64	241.76	33.78
	STDEV	1.54	0.72	1.12	4.07	8.89	6.38	3.08	54.50	7.47
	min	4	3.85	8.2	13.2	40.3	18.7	12.8	102	2.67
	max	11.5	9.32	15.4	47.2	101.1	86.3	43.8	349	50
Female controls	Average	7.02	4.66	13.41	39.72	85.80	28.67	33.42	254.86	37.84
	STDEV	1.40	0.35	1.01	2.25	4.64	2.20	1.53	45.08	8.97
	min	4.1	3.88	10.4	32.5	73.9	22.6	26.8	153	17
	max	10.1	5.74	16.2	45.4	97.8	33.8	36	378	58.4
p-value		0.7209	0.4942	0.3798	0.3598	0.4334	0.2903	0.07706	0.1299	0.0034

Table 4. Correlation of different blood parameters with age and work experience of radiation workers

		WBC (K/μL)	RBC (M/ μL)	Hgb (gm/dL)	Hct (%)	MCV (fL)	MCH (pg)	MCHC (gm/dL)	PLT (K/ μL)	LYM (%)
Age	Pearson correlation coefficient	- 0.093	0.220	0.292	0.208	0.003	0.105	0.079	- 0.054	0.074
	P-value	0.241	0.005	0.001	0.008	0.972	0.186	0.323	0.499	0.351
Work experience	Pearson correlation coefficient	- 0.022	0.242	0.223	0.155	- 0.020	0.153	0.047	-0.067	- 0.002
	P-value	0.783	0.002	0.005	0.051	0.799	0.053	0.553	0.397	0.982

Table 5. Comparison of blood parameters of male and female radiation workers

		WBC (K/μL)	RBC (M/ μL)	Hgb (gm/dL)	Hct (%)	MCV (fL)	MCH (pg)	MCHC (gm/dL)	PLT (K/ μL)	LYM (%)
Male radiation workers	Average	6.8	5.29	15.37	45.98	87.68	29.64	33.44	220.55	36.42
	STDEV	1.4	0.56	1.23	3.00	6.63	2.52	1.98	43.95	7.97
Female radiation workers	Average	6.92	4.73	13.25	40.26	86.80	29.60	32.64	241.76	33.78
	STDEV	1.54	0.72	1.12	4.07	8.89	6.38	3.08	54.50	7.47
P-value		0.627	0.000	0.000	0.000	0.826	0.056	0.005	0.009	0.035

Comparisons between the blood parameters of female radiation workers and female controls are shown in Table 3. Out of nine blood parameters, only one parameter was significantly different between female radiation workers and female control group. The percentage of lymphocytes in female radiation workers was 33.78±7.47%, which was significantly lower than controls (37.84±8.97%, P<0.05).

The relationships between various blood parameters of radiation workers with their age, gender, work experience, and employment departments were also determined in this study. Table 4 shows the correlation of different blood parameters with the age and work experience of radiation workers. The results showed that the number of red blood cells, hemoglobin, and hematocrit had a positive poor correlation with age (P<0.01). In addition, the more experienced the radiation workers, the higher the red blood cells and hemoglobin (P<0.01). The remaining blood parameters did not have a significant relationship with age and work experience of radiation workers.

The relationships of different blood parameters with gender and employment departments were also investigated in the current study. There was no significant difference between the blood parameters of radiation workers and the departments they are working (radiology, CT scan, radiotherapy, and nuclear medicine). The relationship between gender and blood parameters of radiation workers is shown in Table 5. The amounts of red blood cells, hemoglobin, hematocrit, MCHC, and lymphocytes were significantly higher in male radiation workers, compared to female radiation workers (P<0.001). On the other hand, platelet count was higher in women than men (P<0.01).

Discussion

The obtained results of the current study showed that some blood parameters of the radiation workers differ significantly from those of the control group. Moreover, it was shown that some of the blood parameters had a significant relationship with the factors of age, work experience, and gender. One of the positive features of the present study was that blood tests were separately investigated for men and women, unlike many previous studies.

In general, the comparison of the results of the present study with those of other studies showed that

almost all of the studies conducted on the blood tests of radiation workers had different outcomes. In the present study, male radiation workers had higher hematocrit level and lower levels of MCHC and platelets than controls ($P<0.05$). However, lymphocyte was the only factor that was significantly lower in the blood of the female radiation workers than the control group ($P<0.05$). In studies performed by Taqi *et al.* [15], Faraj *et al.* [16], Shafie *et al.* [18], and Dainiak [11], the reduction of platelet counts were also reported in the blood of radiation workers. Heidari *et al.* [12] also reported a decrease in platelets and white blood cells in radiographers; however, indicated that ionizing radiation did not affect red blood cells, hematocrit, hemoglobin, MCH, and MCV. On the contrary, a study conducted by Sayed *et al.*[13] revealed an increase in the platelet count of radiation workers. The MCH of radiation workers was lower than the normal range in the study by Shahid *et al.*[14]. However, the amounts of red blood cells and lymphocytes were higher than those of the control group in the mentioned study.

A number of studies [8-10] concluded that there was no significant difference between the blood parameters of radiation workers and the controls. A number of researchers introduced other criteria, such as Treg cells [19], binucleated micronucleated cell rate (BMCR) [20], chromosomal aberrations in lymphocytes [21], cytokines and interleukins [12, 22], physiological function of neutrophils [9] for the detection and measurement of the ionizing radiation effects in radiation workers.

One limitation of this study was inaccessibility to the blood tests of all radiation workers. In addition, some of the radiation workers employed in private clinics did not have blood tests. Although the current study investigated the blood tests of 160 radiation workers, which was lower in number compared to the study by Jang *et al.* [17] in South Korea with 8052 blood tests, the obtained results were better compared to previous studies with 14-92 blood tests.

Conclusion

The obtained results of the present study and its comparison with other studies, it can be concluded that although some of the parameters of CBC tests of radiation workers were significantly different in comparison to controls, there was no general agreement on specific parameters. The CBC test cannot exactly show the effects of ionizing radiation in low doses and it is recommended to utilize this test only for the follow up of the overall health status of radiation workers. Therefore, the complementary methods, such as the evaluation of chromosomal changes, cytokines, and interleukins, should be used for the early detection of radiation effects in radiation workers.

Acknowledgment

The authors of this article would like to thank all radiation workers who collaborated in this research. This study was sponsored by the Student Research Committee of the Paramedical School of Isfahan University of Medical Sciences, Isfahan, Iran, with the approved project number of 196113.

References

1. Jabeen A, Munir M, Khalil A, Masood M, Akhter P. Occupational exposure from external radiation used in medical practices in Pakistan by film badge dosimetry. Radiation protection dosimetry. 2010; 140(4):396-401.
2. Masood K, Zafar J, Zafar T, Zafar H. Assessment of the occupational radiation exposure doses to workers at INMOL Pakistan (2007‑11). Radiation protection dosimetry. 2012;155(1):110-4.
3. Vakifahmetoglu H, Olsson M, Zhivotovsky B. Death through a tragedy: mitotic catastrophe. Cell death and differentiation. 2008;15(7):1153.
4. Chaparian A, Tavakoli I, Karimi V. Organ doses, effective dose, and radiation risk assessment in radiography of pediatric paranasal sinuses (Waters view). Asian Biomedicine. 2013; 7(5): 695-8.
5. Smirnova OA. Environmental radiation effects on mammals: a dynamical modeling approach. Springer; 2016 Oct 14.
6. Linet MS, Freedman DM, Mohan AK, Doody MM, Ron E, Mabuchi K, et al. Incidence of haematopoietic malignancies in US radiologic technologists. Occupational and environmental medicine. 2005; 62(12): 861-7.
7. Cardis E, Vrijheid M, Blettner M, Gilbert E, Hakama M, Hill C, et al. Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries. Bmj. 2005; 331(7508): 77.
8. Davoudian Talab A. Effects of Occupational Exposure on Blood Cells of Radiographers Working in Diagnostic Radiology Department of Khuzestan Province. Iranian Journal of Medical Physics. 2018; 15(2): 66-70.
9. Meo SA, Al Drees AM, Zadi SZ, Damgh SA, Al-Tuwaijri AS. Hazards of X-ray radiation on the quantitative and phagocytic functions of polymorphonuclear neutrophils in X-ray technicians. Journal of occupational health. 2006; 48(2):88-92.
10. Mohammed MR, Abdulateef SM, Dawood NA, Taher MG, Jabur SA, Alwain AH. Effects of Radiation on the Hematological Parameters in X-Ray Technicians: A Case-Control Study. Journal of Pioneering Medical Sciences. 2014; 4(2): 85-88.
11. Dainiak N. Hematologic consequences of exposure to ionizing radiation. Experimental hematology. 2002; 30(6): 513-28.
12. Heidari S, Taheri M, Ravan AP, Moghimbeigi A, Mojiri M, Naderi-Khojastehfar Y, et al. Assessment of some Immunological and Hematological Factors among Radiation Workers. Journal of Biology and Today's World. 2016; 5(7): 113-9.
13. Sayed D, Elwanis ME, Elhameed SY, Galal H. Does occupational exposure to low-dose ionizing radiation affect bone marrow thrombopoiesis?. International archives of medicine. 2011; 4(1): 8.
14. Shahid S, Mahmood N, Chaudhry MN, Sheikh S, Ahmad N. Assessment of impacts of hematological parameters of chronic ionizing radiation exposed workers in hospitals. FUUAST Journal of Biology. 2014; 4(2): 135.

15. Taqi AH, Faraj KA, Zaynal SA, Hameed AM, Mahmood AAA. Effects of occupational exposure of x-ray on hematological parameters of diagnostic technicians. Radiation Physics and Chemistry. 2018; 147: 45-52.
16. Faraj K, Mohammed S. Effects of chronic exposure of X-ray on hematological parameters in human blood. Comparative Clinical Pathology. 2018; 27(1): 31-6.
17. Jang S, Lee JK, Cho M, San Yang S, Kim SH, Kim WT. Consecutive results of blood cell count and retrospective biodosimetry: useful tools of health protection regulation for radiation workers. Occup Environ Med. 2016; 73(10):694-700.
18. Shafiee M, Rashidfar R, Borzoueisileh S, Ghorbani M, Vafapour H, Rahimi S. The Effect of Occupational Exposure on Blood Parameters of Radiology Staffs in Yasuj. Armaghane danesh. 2016; 21(4):410-9.
19. Torkabadi E, Kariminia A, Zakeri F. Alteration of peripheral blood T-reg cells and cytokines production in angiography personnel exposed to scattered X-rays. Iranian Journal of Allergy, Asthma and Immunology. 2007; 6(4):181-7.
20. Sari-Minodier I, Orsière T, Auquier P, Martin F, Botta A. Cytogenetic monitoring by use of the micronucleus assay among hospital workers exposed to low doses of ionizing radiation. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 2007; 629(2):111-21.
21. Mezhoud K, Sakly A, Ben Cheikh H, Saïdi M, Edery M. Radiobiology worker risk assessment using stress indicators and proteomics. International Journal of Low Radiation. 2014; 9(3):199-218.
22. Zakeri F, Hirobe T, Akbari Noghabi K. Biological effects of low-dose ionizing radiation exposure on interventional cardiologists. Occupational medicine. 2010; 60(6):464-9.