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HEMATOLOGICAL PROFILE OF HEALTHY WORKERS EXPOSED TO LOW DOSE RADIATION

Khorrami, M.B.[1,2]; Riahi-Zanjani, B.[3*]

[1]Department of New Sciences and Technology, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.
[2]Social Security Organization, 17th Shahrivar Hospital, Mashhad, Iran.
[3]Medical Toxicology Research Center, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

*riahib@mums.ac.ir

Abstract

Free radicals and reactive oxygen species play an essential role in the occurrence of more than hundred disorders. Human cells through radiation produce free radicals and they can ruin macromolecules such as DNA, lipid, proteins and carbohydrate. The present study was aimed at evaluating hematological findings in healthy workers of Radiology Department of a hospital of Mashhad, Iran. The study was carried out on 55 subjects including 25 individuals working with X-ray machines as the examined group and 30 healthy volunteers as the controls. Radiation dose of radiology staff taking part in the study was less than the maximum permissible annual level, 50 millisievert. All parameters except PDW and P-LCR did not show any significant difference between the two groups. However, a significant increase in the percentage of X-ray technicians' PDW (platelet distribution width, 14.50 ± 0.39; $p<0.01$) and PLCR (platelet large cell ratio, 28.20 ± 1.11; $p<0.05$) were observed in comparison to controls. As a result, our study showed that long-term low dose ionizing radiation might have toxic effects on thrombocytosis and coagulation function. Finally, usage of appropriate personal protective equipments at work and getting periodic medical surveillance and performing of the research projects on radiation protection and hazards to prevent irreversible damages is highly recommended.

Keywords: Free radical, Radiology, PDW, PLCR

Introduction

Electromagnetic waves is a form of energy that includes radio waves, infrared and visible light as well as high energy rays such as ultraviolet, x ray, and gamma ray. The toxic effects of high energy rays are mediated by transferring energy to atoms/molecules, leading to their excitation and ionization. This leads to free radicals and reactive oxygen species (ROS) formation and subsequently results in the oxidation of essential macromolecules (protein, DNA, unsaturated fatty acid), cellular oxidative stress, which plays a pathogenic role in many diseases such as malignancies [1-3]. Although human being has lived with natural radiation since the beginning of life, nowadays there is an elevation in artificial radiation, mainly from the medical sources. All of the ionizing radiations are seriously harmful and thus radiation protection products are required. However, the human body neutralizes free radicals via a comprehensive control of the body's antioxidant systems. They prevent free radical or ROS by inhibiting the formation of radicals, scavenging them, or by elevating their catalysis [2,4]. On the other hand, if ROS is over-produced, or the antioxidant content is low, the cells damage. Exposure to long-term low doses of ionizing radiation among workers operating X-ray apparatuses might lead to the toxic effects on rapidly proliferating tissues such as bone marrow. Workers who are over-exposed to ionizing radiations are prone to develop life threatening diseases often related with hematopoietic system [5-8]. The provision of medical surveillance for radiation field workers has become a standard practice in many countries due to the widespread use of ionizing radiation and their well recognized adverse effects on health. Ideally, this should be incorporated into the occupational health service and performed by an occupational health physician with good knowledge of ionizing radiation and its health effects, and the familiarity with the work processes that involve irradiation apparatus and radioisotopes in the workplace [9]. Considering the hematopoietic system is highly sensitive to radiation, the peripheral blood count may well serve as a biological indicator of such damage. Therefore, we aimed at evaluating the influence of low doses of ionizing radiation on hematological findings in a group of healthy workers operating X-ray machinery.

Materials and methods

Study design

A total of fifty five subjects including 25 X-ray technicians of a hospital (Mashhad, Iran) with a work experience higher than 8 years as the case group and 30 healthy volunteers with no past history of exposure to ionizing radiation of workplace as the control group were recruited for the study. Two groups were matched in terms of the age and sexuality. Radiation dose of radiology staff participating in the study was less than the maximum permissible annual level, 50 millisievert. The case group included the healthy radiology staff of a hospital, Mashhad, Iran. Control subjects who had been recently exposed to medical or diagnostic radiation were excluded from the study. In addition, subjects with gross anemia, known history of diabetes mellitus, cardiopulmonary disease, acute and / or chronic infection, autoimmune disease and malignancy, subjects with current or previous history of smoking or addictions were excluded from the study. After obtaining the medical research ethics committee approval, and following a through explanation of the objectives and methods of the study for the subjects, individual written informed consent was obtained.

Blood sampling

After an overnight fasting period, 2 ml of peripheral blood sample was taken via venipuncture from the case and control subjects. Blood samples for evaluation of hematological parameters were collected into sterile tubes with anticoagulant (EDTA).

Determination of the hematological parameters

*H*ematology analysis was performed with a hematology cell counter (Sysmex KX 21, Japan). Routine hematological indices involving hemoglobin content (Hb), hematocrit (Hct%), red blood cell (RBC) count, white blood cell (WBC) count and platelet (Plt) count were assessed. Other indices such as MCH (Mean corpuscular hemoglobin), MCHC (Mean corpuscular hemoglobin concentration), MCV (Mean corpuscular volume), MPV (Mean platelet volume), RDW (RBC distribution width), PDW (platelet distribution width), and P-LCR (platelet large cell ratio) were also reported. A blood smear was stained with Gimsa for each sample, slides were observed under light microscope. At least 100 cells were seen for differential analysis.

Statistical analysis

Data were statistically analyzed using Student's *t*-test to determine significant differences in the data of two groups. Statistical tests were conducted using INSTAT software (GraphPad, Inc., San Diego, CA). P values of less than 0.05 were considered significant. The values were expressed as means ± SEM.

Results

The hematological parameters of workers and controls are described in Table 1. All indices except PDW and P-LCR did not show any significant difference between the two groups. However, a significant increase in the percentage of case group on PDW (*p<0.01*) and P-LCR (*p<0.05*) was observed as compared to controls.

Discussion

Radiation has potential effects on living cell and lead to cytotoxicity via free radical mechanism [9]. In physiological conditions, there is a balance between free radical formation and anti-oxidant capacity. For example, when this balance is disrupted as a result of exposure to ionizing radiation it can lead to oxidative stress [10-12]. Thus, the balance between pro-oxidant production and antioxidant defense is very important in terms of maintaining cellular homeostasis [13]. Long-term exposure to ionizing radiation would be able to shift the oxidant/antioxidant equilibrium toward oxidant and results in various adverse health effects. One of the most vulnerable tissues to ionizing radiation is bone marrow because of the marrow's proliferative activity and lack of relative DNA repair capacity [14]. Among the hematological findings of our study, the mean percentages of PDW and P-LCR of case subjects were found statistically to be higher than values of control group. P-LCR, a platelet large ratio, reflects changes in either the level of platelet stimulation or the rate of platelet production [15]. Platelet distribution width (PDW) is a measure of heterogeneity in circulating platelet volume and reflects platelet turnover or activation [16]. Regarding to the vulnerability of bone marrow to ionizing radiation, the high level of PDW and PLCR of radiology staffs may be related to adverse effects of radiation on platelet progenitor cells. However, more research is needed to prove this hypothesis.

CBC analysis is a useful screening test in routine medical check-up. A high or low blood cells count even in a healthy-looking subject lead to the suspicion of disease and it should prompt further investigations [17,18]. Several studies have addressed the effects of partial or total body irradiation on peripheral blood count. In a research conducted by Meo and colleagues performed on radiation field workers, the platelet count was decreased among workers compared to controls, whereas no significant changes was shown in another hematological indices between two groups [18]. Rozgaj et al showed that, although occupational exposure to radiation has remained close to the natural background for the majority of the employed, but the exposed population has shown an increase in chromosome aberration frequency [19]. In another study performed *invitro* by Wagner and colleagues, ionizing radiation showed a toxic effect on mature leukocyte in case of their phosphatase activity [20]. However, the harmful effect of high dose ionizing radiation is well established [21,22].

In conclusion, as for PDW and P-LCR of the radiation workers were significantly higher than controls, carrying out a series of studies with focus on platelet function and production is highly recommended. In addition, according to the development of the multislice Serial CT Scanners and Digital Fluoroscopy applications which produce high doses of radiation, performing of research projects on radiation protection and hazards should be also encouraged to prevent irreversible damages.

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Table 1. Comparison of hematological profile of the X-ray technicians and the controls.

Parameter	Case group	Control group	P value
WBC (count ×10^3/µl)	6.88 ± 0.44	7.32 ± 039	0.465
RBC (count ×10^6/µl)	4.86 ± 0.14	4.89 ± 0.11	0.858
Hct (%)	39.48 ± 1.02	41.06 ± 0.80	0.214
Hb (g/dl)	13.21 ± 0.40	13.77 ± 0.29	0.254
Plt (count × 10^5/µl)	220 ± 12	231 ± 11	0.495
MCH (pg)	27.22 ± 0.50	27.86 ± 0.58	0.433
MCHC (g/dl)	33.41 ± 0.33	32.72 ± 0.83	0.512
MCV (fl)	81.67 ± 0.87	84.30 ± 1.09	0.111
MPV (fl)	9.90 ± 0.16	9.58 ± 0.15	0.157
Neutrophil (count × 10^3/µl)	3.84 ± 0.34	3.69 ± 0.25	0.720
Lymphocyte (count × 10^3/µl)	2.32 ± 0.17	2.85 ± 0.23	0.097
Mix (count × 10^3/µl)	0.70 ± 0.05	0.78 ± 0.06	0.333
RDW (%)	13.45 ± 0.12	13.52 ± 0.25	0.816
PDW (%)	14.50 ± 0.39	11.95 ± 0.27	0.009**
PLC-R (%)	28.20 ± 1.11	22.41 ± 1.14	0.011*