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Evaluation the Effect of Low Dose Ionizing Radiation on the Hematological Parameters of Medical Radiographers at Governmental Hospitals, Gaza Strip

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Abstract:

Background: *Medical Radiographers are occupationally exposed to chronic low doses of ionizing radiation that may affect their health. The hazards on human health of chronic low-doses radiation are complex and have not been well established.*

Objective: *To evaluate the effect of low ionizing radiation on the hematological parameters of medical radiographers at governmental hospitals-Gaza Governorates, Palestine.*

Materials and Methods: *The hematological status of 54 healthy Medical Radiographers were evaluated and compared with other 59 Medical Laboratory Technicians as a control group. The studied group matched in their sociodemographic and work experience. ABX Micros 60 analyzer checked hematological profile and data analysis. The statistical analysis was done by using Student's t test and one way ANOVA test.*

Results: *Concerning red blood cells, white blood cells, and platelets level, the study reported that no statistical significant differences were recorded between compared groups. There was observable disturbance in the mean values of hematocrit and corpuscular hemoglobin in some medical radiographers, but their means did not reach the statistical significant levels. Finally, comparing the duration of radiation exposure and*

hematological parameters of medical radiographers showed no statistical significant differences.

Conclusion: *the current study illustrated the importance of providing protective tools in all radiology departments. Furthermore, the study revealed that hematology status of medical radiographer showed stability in most of studied group. The chronic effect of low ionizing radiation already has been proved from previous studies, consequently, periodic medical surveillance including the hematological parameters should be done.*

Keywords: hematological parameters, medical radiographers, ionizing radiation, X-ray.

Introduction:

Ionizing radiation has the ability to produce biological effect, mutation, and cancer. There are different types of ionizing radiation; X-ray is one of the most common in medical issue utilizations [1]. Previous studies proved the damage in the molecular structure as a result of dysfunction (somatic effect) or mutations (genetic damage) [2].

The chronic exposing to low ionizing radiation that occurs in case of Medical Radiographers (MRs). This type of exposing is characterized as occupational dose. Consequently, these employees are prone to develop life-threatening diseases, especially related to hematopoietic system. In addition, hematopoietic system is highly sensitive to radiation, and therefore peripheral blood examination may serve as a biological indicator of such damage [3].

Over the last decades, there was a trend to investigate the biological effects of the radiation using hematological, biochemical, and cytogenetic parameters [4]. These investigations have reported that stochastic effects may appear after the exposure to low level of ionizing radiation [5]. Deterministic effects are well-known and often need higher radiation doses than received by MRs. [6]. Therefore, the concern and unawareness of MRs are related to the stochastic effects of long-term exposure to low-dose radiation. The risk of stochastic effects such as cancer increases by dose without threshold [7].

Routine medical checkup is highly recommended particularly for chronic exposure. Peripheral blood examination may serve as a screening test for various hematological as well as non-hematological disease states. Being a simple, inexpensive, and point-of-care test, the blood cell count (CBC) is especially valuable for diagnostic purposes in the subclinical stage of many diseases. In addition, blood cell examination allows the clinicians to achieve broad differential diagnostic impressions [8].

There are few studies that investigated the effects of low doses of ionizing radiation (LDIR) on the immune status of radiology workers. A study conducted by Godekmerdan et al, found lower concentrations of immunoglobulin serum among radiology workers compared to controls [9]. Similarly, Oskouii et al. showed that the mean serum IgA and IgM levels were lower among radiology worker than those of control group [10]. On the other hand, Moghaddam et al, and Daoud et al, found no statistically significant difference between exposed group and control group regarding serum immunoglobulin [11,12].

TLD are the most common for radiation monitoring among RTs and other health providers. The badge is comprised of a TLD card, which is placed in a holder that incorporates a filter system. This allows the radiation type and energy to be determined. It is used to determine the whole-body exposure of people who may be exposed to radiation (i.e. X-rays or gamma). It can be hold for 4 to 12 week wearing period depending on the work carried out and the risk to the operator. TLD is used by anyone who may be exposed to significant doses [13].

The monitor consists of a small plastic sachet containing a TLD, which can be chemically disinfected if necessary. The doses are determined by the measurement of the light output from the TLD card. Thermoluminescent materials store energy inside their structure when they are irradiated, as electrons and holes are trapped in trapping centers due to crystalline defects. When that material is heated, electrons and the positive atom recombine, at luminescence centers, and thus light is emitted. The light is measured using a photomultiplier

tube inside the reader device. The photons, which emitted are in the visible region and they comprise the TLD signal [14].

This study aims to evaluate the effects of chronic ionizing radiation on the hematological parameters of MRs at governmental hospitals, Gaza governorates, Palestine.

Materials and Methods

The current study was conducted in the six main governmental hospitals between April and November 2015. A total of 54 (40 males and 14 females) MRs with age between 28-55 years old were occupationally exposed to long term low doses of ionizing radiation and having at least 5 years' experience in radiology. The selected cases were compared with another group of 59 (44 males and 15 females) healthy participants, who were never exposed to radiation as a control group. The exposed group was matched with controls in age, gender, years of experience, and smoking status. MRs worked on different types of imaging modalities and equipment, including conventional and computed tomography (CT), computed radiography, and magnetic resonance imaging (MRI). Also, they worked in different shifts for 7 hours a day for five days per week.

In the current study, the dose level was determined by checking previous recordings of MRs. In the Gaza Strip, TLD-100 (LiF:Mg,Ti) is the standard dosimeter for all personal monitoring in hospitals.

Exclusion Criteria: Participants who had any previous diseases such as gross anemia, known history of diabetes mellitus, cardiopulmonary disease, acute or chronic infection, autoimmune disease, and malignancy were excluded from the study. Also, participants with less than5 years employment were excluded from the study.

Hematological analysis: Blood samples of all participants were collected (2 ml of blood from each participants) by vein-puncture in a disposable syringe and blood was transferred to a tube containing ethylene diamine tetra acetic acid (EDTA) in a concentration of

1.5mg/ml. Hematological parameters (HPs) were measured by using s ABX Micros 60 analyzer at private and standard laboratory.

ABX Micros 60 analyzer is a fully automated hematology analyzer used for in-vitro diagnostics testing whole blood specimens, platelet Platelet-Rich Plasma (PRP) samples, and whole blood component concentrates. This analyzer uses impedance technology and photometry as measurement methods, as well as stepper motor technology which enables the system to operate without a compressor. Nine of the HPs were examined in this study including red blood cells (RBC), white blood cells (WBC), platelet count (PLT), hematocrit (HCT), hemoglobin (Hb), and mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV), and atypical lymphocytes. Blood samples were collected from all participants after obtaining an ethical approval from Helsinki committee.

Statistical analysis: All statistics were performed in SPSS version 20 software. The means of quantitative variables were compared using both independent sample t-test and one- way ANOVA. A significant P-value was considered when it is less than 0.05.

Results and Discussion

Long-term exposure to low doses of ionizing radiation may adversely affect cells and tissues. Hematopoietic system is known to be radiosensitive and can be affected by chronic exposure to low dose of ionizing radiation resulting in peripheral blood cells count [9]. The present study is the first study conducted in the Gaza Strip, Palestine. Thus, this study has recruited medical radiographers as they are continuously exposed to occupational ionizing radiation. The present study incorporated nine hematological parameters (HPs) for MRs compared with matched control group. The aim was to assess the effects on hematological parameters in medical radiographers exposed to radiation due to occupation.

Radiation Protection Organizations

In this section, a brief description about the important national and international organizations concerned with radiation protection of the public that develop recommendations on radiation protection. In addition to a general discussion of the role of each organization, protection of the public, the particular responsibilities for the development of standards for Technologically Enhanced Naturally Occurring Radioactive (TENORM) are emphasized.

The principal federal agencies with responsibilities for radiation protection of the public are the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission, and the Department of Energy (DOE). Of these, only EPA and DOE may develop guidance or regulations for TENORM. State governments also have important responsibilities for radiation protection of the public, including the development of regulations for TENORM. Finally, the National Council on Radiation Protection and Measurements (NCRP) and the Health Physics Society are important national organizations that have developed recommendations on radiation protection, including recommendations applicable to TENORM.

The International Commission on Radiological Protection (ICRP) is the principal international organization concerned with radiation protection. ICRP is an organization similar to NCRP and also develops recommendations on radiation protection. Other important international organizations are the International Atomic Energy Agency (IAEA) and the Commission of the European Communities (CEC).

Ionizing radiation sources and Maximum Permissible Dose (MPD)

Different sources of ionizing radiation can yield biological effect on human tissue. Large proportion of the average annual radiation dose received by people results from natural environmental sources (Figure

1). Accordingly, periodic measurement should be conducted on those people that may expose to ionizing radiation during their work (occupational dose). MPD is the maximum permissible dose equivalent that a body is permitted to receive in a specific period. Occupationally, exposed persons should not exceed 20 mSv/year (ICRP) averaged over defined periods of 5 years, with no single year exceeding 50 mSv, or simply 50 mSv/year based on NCRP [15].

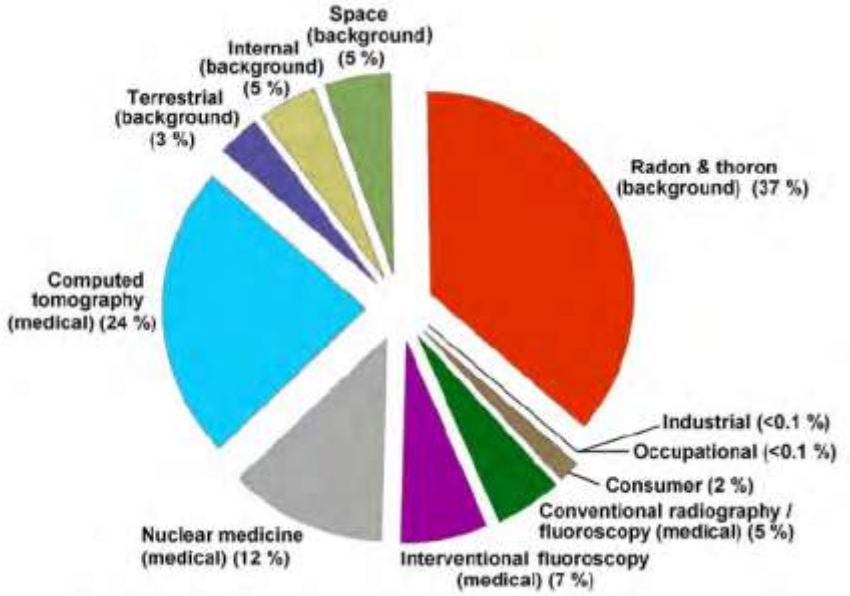

Figure 1. Percent contribution of various sources of exposure to ionizing radiation to the average annual effective dose (NCRP, 2009)

Blood cell count (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. Some studies have demonstrated the negative effect of low doses radiation on hematological parameters while others detect the change at genetic analysis level only [9-11].

The present study was focused on the hematological parameters (HPs) of medical radiographers (MRs) through cell blood count (CBC).Fifty

four participants (40 males and 14 females) of MRs were included in this study as exposed group and nine HPs were examined to assess the effects of ionizing radiation. The mean age for MRs was 35.39± 6.38 years, while it was37.05 ± 6.85 years for the control group. As shown in table (1), no statistically significant differences between MRs and the control group in all listed hematological parameters. It should be noted that there were four MRs participants found with lower levels of hematocrit and also 3 have higher values of corpuscular hemoglobin.

Table 1. Hematological parameters of MRs compared with the control group using independent t- test

Hematological Parameters(HPs)	MRs =54	Controls =59	Significance level P-value=0.05
	Mean ± SD	Mean ± SD	
WBC	6.82 ± 1.55	± 1.58 6.84	0.94
RBC	5.01 ± .49	5.05 ± .59	0.61
PLT	233.31 ± 50.98	245.20 ± 66.04	0.28
Hb	13.24 ± 1.28	13.26 ± 1.41	0.93
HCT	40.65 ± 6.62	41.47 ± 4.58	0.44
MCV	82.02 ± 4.44	82.56 ± 2.79	0.43
MCH	30.51 ± 1.35	26.41 ± 1.47	0.31
MCHC	32.04 ± 1.02	31.97 ± 1.34	0.74
Lymphocytes	2.87 ± 0.76	± 0.66 2.91	0.76

Table 2 showed the results of ANOVA test comparing the mean differences of HPs with different duration of exposure of MRs. The duration of exposure was divided into three groups, 20 out 54 MRs participants having duration of work from 5 to 10 years, 22 of them having 10 to 20 years, and finally 12 participants have> 20 years. The study results reported no statistically significant differences of HPs with the duration of work of MRs.

Table 2. Hematological parameters of MRs according to their duration of exposure using ANOVA test.

HPs	Mean ± SD	Duration of exposure for MRs =54			P value 0.05
		5-10 years	10-20 years	>20 year	
WBC	Mean ±SD	7.03±1.63	6.61±1.44	6.91±1.66	0.62
RBC	Mean ±SD	4.98±.45	4.98±.53	5.30±0.49	0.12
PLT	Mean ±SD	242.22±61.3	228.2±36.33	212033±62.22	0.41
Hb	Mean ±SD	13.29±0.99	12.97±1.46	13.95±1.42	0.36
HCT	Mean ±SD	40.00±8.22	40.22±4.66	43.75±4.52	0.31
MCV	Mean ±SD	81.82±3.55	82.85±5.22	82.00±4.41	0.85
MCH	Mean ±SD	36.22±1.66	26.15±1.27	26.25±2.22	0.41
MCHC	Mean ±SD	32.25±1.25	32.65±1.96	31.95±1.8	0.54
Lymph.	Mean ±SD	2.27± 0.45	2.9± 0.16	2.22± 0.56	0.60

Table 3 describes the relationship between hematological parameters in relation with gender (male and female) of MRs by using t-test. As shown in table 3, high statistical significant level in the mean differences of both RBC and Hb values between males and females. In addition, despite the association between gender and lymphocytes value was weak, it reached the statistically significant level. The rest of HPs did not reach the statistically significant difference.

Table 3 shows the association between HP and gender of MRs using t-test

HPs	MRs= 54		Mean ± SD	P-value = 0.05
	Gender	NO.		
WBC	M	40	7.00 ± 1.64	0.12
	F	14	6.23 ± 0.98	
RBC	M	40	5.19 ± .44	0.001
	F	14	4.42 ± 0.21	
PLT	M	40	224.77 ± 53.32	0.09
	F	14	253.92 ± 47.28	
Hb	M	40	13.75 ± 1.00	0.000
	F	14	11.59 ± 0.74	
HCT	M	40	43.06 ± 4.58	0.92
	F	14	32.61 ± 9.04	
MCV	M	40	82.21 ± 4.37	0.52
	F	14	81.25 ± 4.59	
MCH	M	40	31.60 ± 1.47	0.59
	F	14	31.60 ± 1.47	
MCHC	M	40	31.97 ± 0.96	0.06
	F	14	32.60 ± 1.07	
Lymphocytes	M	40	± 0.77 2.98	0.05
	F	14	2.40 ± 0.46	

The results of the current study showed that the mean differences of the basic hematological parameters including WBC, RBC, and, PLT in MRs did not reach the statistically significant levels when compared with controls. Our results were in agreement with several recent studies conducted in Iran, Iraq, Egypt, and Sudan, which reported some variations in the basic HPs with no statistically significant [16-21]. However, recent studies conducted in Poland and Pakistan, Sudan, Saudi Arabia Kingdom found statistically significant difference between exposed and non-exposed subjects regarding to lymphocytes count [21-22]. These results and variations can be attributed to the performing and practices of protection standards and

experience years among exposed participants. The other HPs especially HCT and Hb found low and high in some medical radiographers but not reach the statistically significant levels. These results were matched with studies of Shaffie, 2016 and Korrami, 2015 [16,20].

Moreover, the HPs did not reach the statistically significant levels when they compared with the duration of work of MRs. Our findings were consistent to the study conducted in Iraq, they found no statistically significant differences between HPs and duration of work for exposed X–ray workers [20].

Several studies were conducted to determine the effect of X-ray on the blood contents. Study that done by Meo SA, exhibited that the mean value of platelet count was significantly decreased ($p<0.01$) in x-ray technicians when compared to controls. However, no significant difference was observed in RBC and WBC count between the groups. The study suggests that exposure to x-ray radiation causes decreased platelet count. Further, studies are needed to study the long-term effects of x-ray radiation on blood cell count in x-ray technicians [24].

Another fresh study was conducted by Nureddin et al., to determine hematological changes, in particular white blood cell count (WBC), red blood cell count (RBC) and platelets count for X-ray technicians. Significant correlation was found between increased duration of work. Radiation field worker (technicians) showed a statistically significant increased ($p<0.01$ and $p<0.05$) in the mean values of platelets count and white blood cells, respectively when in comparison to controls. However, no significant difference was observed in the rest of hematological parameters between the groups. Its concluded that long-term of work to low X-ray dose may cause a low degree of severity of diseases which is expressed in term of hematological changes [23].

Conclusion and Recommendation

Based on the current results, restrict auditing on personal protective tools for MRs is highly recommended. Additionally, to that protection and safety applied, and should undergo periodic medical surveillance

including hematological parameters. These measures will–help to decrease the effects of occupational hazards of radiation and detect the diseases in their initial stage.

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