Original Research

Radiation exposure and immunity status of radiographers at government hospitals

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Received June 14, 2016. Accepted August 1, 2016

Abstract

Background: Long-term exposure to low doses of ionizing radiation may affect cells, tissues, and body systems and result in various adverse health effects. Immunity system is known to be highly radiosensitive; therefore it is susceptible to radiation. Medical radiographers are occupationally exposed to chronic levels of ionizing radiation that may affect their immune response.

Objective: To investigate the effects of exposure to radiation on health and well-being, including tests of immune function of medical radiographers (MRs) at government hospitals-Gaza governorates.

Materials and Methods: A cohort study was conducted at six main government hospitals- Gaza governorates, Palestine. The immunity status of 92 medical radiographers who exposed to chronic ionizing radiation compared with control group of 97 medical laboratories who not exposed to chronic radiation.

Result: The result revealed that several health complains such as headache were higher among medical radiographers (46.7%) compared to medical laboratories (10.3%) with highly statistically significant level (p=0.000). Regarding immunity systems, the study showed that clinical symptoms such as gastritis, sore throat, and repeated infections were prevailing among exposed group compared with non-exposed group. Other clinical symptoms such as skin diseases, fever, and pallor did not reached the statistically significant levels (p>0.05). About venous blood samples, the results exhibited that the mean of immunoglobulin G and A were higher among medical radiographers (1279±359), (215±108) compared with the control group (1225±209) and (1202±89) with no statistically significant level (p=0.324 and 0.498), respectively. Significant health complaints and clinical symptoms were recorded among medical radiographers compared with the matched control group.

Conclusion: Personal monitoring for ionizing radiation, periodic medical examination, and increasing level of protection for MRs is of utmost importance.

KEYWORDS: Immunity status, medical radiographers, ionizing radiation, X-ray

Introduction

It is known that ionizing radiation has negative biological effects on living organisms. Ionizing radiation can damage all living cells either destroy them or make them functionally abnormal.[1] Some parts of the body are more sensitive to radiation-induced damage than others. Radiation damage to the cells of the body depends on how sensitive the cells are to ionizing radiation (IR). Exposure to ionizing radiation may induce adverse effects on the human health and can cause many diseases such as cancer, cataract, congenital anomalies, and skin burns.[2–5] Exposure to acute large doses of IR can cause death within few days or months, while exposure to small doses over time may affects the body systems and increase the risk of cancer and genetic mutations.[3,4,6]

Generally, the most sensitive cells are those that divide rapidly or those that are in the process of dividing. These cells are most vulnerable to IR because it is difficult or impossible for them to repair any damage that may occur during cell division. Immunity system is considered as highly radiosensitive; therefore it is susceptible to radiation. Medical radiographers are known to be exposed to chronic and long term low levels

Access this article online	
Website: http://www.ijmsph.com	Quick Response Code:
DOI: 10.5455/ijmsph.2017.14062016583	

of ionizing radiation that have been shown to have immuno-compromising effects due to occupation.[2–11]. However, no previous studies conducted in Palestine have examined the effects of long term low doses ionizing radiation exposure on the immune status of radiology workers. The aim of this study was to investigate the effects of exposure to radiation on health and well-being, including tests of immune function.

Materials and Methods

A cohort study was conducted at six main government hospitals- Gaza governorates started from February 2015 to November 2015. Cases were all medical radiographers who are exposed to chronic doses of ionizing radiation due to occupation while controls were all medical laboratories (ML) workers who are not exposed to radiation. All current participants working at government hospitals were included if they have at least 5 years experience (5 days/week for 11 months). A total of 92 exposed participants (76 males, 16 females aged 28–55 yeas) compared with control group of 97 participants (76 males and 21 females aged 27–55 years).

Ten of cases were assigned for the piloting stage of the current study. The 10 cases were included in the study sample because the entire population of cases is relatively small. The participants in the pilot have at least 5 year experience and more in employment and don't have had chronic diseases. For the pilot test, Cronbach's alpha reliability for the total of the 10 items was 0.85. There is general agreement that 0.75 or above indicates appropriate instrument internal consistency.

The cases and controls were matched in age, gender, years of experience, and smoking status. 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 than 5 years employment were excluded from the study. Length of working period among study participants varied from 5 to 30 years. Furthermore, data collected by two tools; close ended questionnaires and blood tests. The questionnaire was completed by face to face interview. The data collected in the questionnaire included socio-demographic data as age, gender, marital status, years of employment, demographic location, and smoking status. The second part of the questionnaire included the general health status of the participants and any health complaints, symptoms or any medical illness associated with the work. The third part included evaluation of the immunity system of the participants and any clinical symptoms that may appeared. The last part of the questionnaire included items for medical radiographers.

Three milliliters of venous blood samples was obtained from each participants from both groups (exposed and non-exposed) to determine IgA and IgG, levels. Serum of blood samples was obtained by centrifuging at 5,000 rpm for 10 min under ambient temperature. Serum analyses were performed by immunoturbimetric methods on the Response 910 instrument manufactured by DiaSys – Germany and using commercial kit made by the same company. Simultaneously, 2 ml of venous blood samples was collected into sterile tubes containing ethylenediaminetetra acetic acid (EDTA) from both groups for complete blood count (CBC) to determine white blood cells (WBCs) and its differentials. The analysis of the CBC parameters was carried out using ABX Micros 60.

Ethical approval: Data and blood sample were collected from the participants after obtaining ethical approval from Helsinki committee.

Statistical analysis: All statistics were performed in SPSS version 20 software. Parameters among exposed and control group were compared using chi square test and independent sample t-test. A significant *p*-value was considered when it less than 0.05.

Result

The respondent participants (189) were classified according to their profession into two groups: case group (92 MRs) and control group (97 MLs). The general characteristics of the overall participants, MRs and MLs are mentioned in Table 1. The mean age of the overall participants was 36.24± 6.65 years, while for the case and control groups it was 35.39±6.38 and 37.05±6.85 years, respectively. In addition, 82% of the participants are in age group from 27–33 years, followed by 78% in age group from 34–44. A number of 29 participants are in the age group (45–55 years).

The majority of the current participants (cases and controls) are male, which count 152 out of 189 (80.4%). Furthermore, total years of experience are recorded from 5 to 30 years in employment. 35% of participant had experience from 10 to 14 years, while participant who have 5–9 years' of experience are 33.9%, and relatively 17% of them had experience of 15–19 years. The participants with experience more than 20 years are 13.2%.

Moreover, 17.3% of the cases were females and were 83.7% were males corresponding to 21.7% were female and 77.3% were males for control group. About smoking status of the cases (MRs), there were 35 (38%) out of 92 smoker participant. The control group consists of 36 smokers and 36 non-smokers were participated to match those in the exposed group.

The study results revealed that health problems related work were greater among medical radiographers compared to those in control group with highly statistically significant level ($p<0.05$). Table 1 revealed the significant health complains appeared among MRs compared to MLs. Headache symptoms were prevailing among exposed group (46.7 %) compared with control group (10.3%) with statistically significant level ($p<0.001$). The same finding was reported in intermittent sleep ($p=0.001$). In addition, the present study results found that exposed participants suffering more from skin diseases

Table 1: Descriptive characteristics of the study participants

Items	(92) MRs		(97) MLTs		Chi- square test		
	N	%	*N*	%	OR	CI 95%	*p*-value
Previous health problems							
Yes	37	40.2	16	16.2	3.403	1.72 –6.71	<0.001
No	55	59.8	81	83.8			
Current health problems							
Yes	35	38.0	13	13.4	3.967	1.93 – 8.151	<0.001
No	57	62.0	84	86.6			
Problems reduce in holidays							
Yes	27	77.5	8	61.4	2.011	1.32 – 7.221	0.01
No	8	22.5	5	38.6			
Having skin symptoms							
Yes	14	15.2	7	7.2	2.308	.887–6.007	0.07
No	78	84.8	90	92.8			
Having eye symptoms							
Yes	31	33.7	9	9.3	3.201	1.80–6.214	<0.001
No	61	66.3	88	90.7			
Having headache							
Yes	43	46.7	10	10.3	3.725	2.02 – 9.02	<0.001
No	49	53.3	87	89.7			
Having intermittent sleep							
Yes	34	37.0	7	7.2	3.124	1.812–6.925	<0.001
No	58	63.0	90	92.8			

than the control group (15.2% and 7.2%, respectively) with no statistically significant level (p=0.06).

Regarding the immunity system symptoms, the study results showed repeated infections among exposed participants was higher than control group with highly statistically significant level (p<0.001). The same results were found in other clinical symptoms such as gastritis, sore throat, and nausea and anorexia (p<0.05). Other symptoms such as bronchitis, fever, and pallor showed some variations among the two groups but did not reach the statistically significant level. Table 2 summarizes the clinical symptoms that reported among immunity system of study participants.

Regarding blood samples analysis, the current study explored that the mean of serum immunoglobulin G (IgG) among exposed group was higher than non-exposed (mean=129.21, standard deviation (SD) =359.30 and mean=1225.24, SD=209.42, respectively) with no statistically significant level (p=0.32). The same finding were found in immunoglobulin A (IgA) (p=0.4), as shown in Figure 1. Table 3 revealed the results of WBCs and its differentials showed some variations in the mean with no statistically significant levels.

The variables of the multiple linear regression model included in the current analysis increase F by at least 0.05 and we want to exclude them if the increase F by less than 0.1.

The age group is significant (p=0.04) with beta coefficient 0.004, which indicated that abnormal IgG levels is reported with aging and exposing to ionizing radiation. Regarding smoking status is not significant (p=0.83), and the coefficient is negative which would indicate that increasing smoking with radiation exposing is related to abnormal IgG levels (out of the range) which is expected.

The gender factor is significant (p=0.04) with negative beta coefficient, which indicated that abnormal IgA levels is reported with male more than female exposing to ionizing radiation. The age group is not significant (p=0.54) with beta coefficient -0.58, which indicated that abnormal IgA levels is reported with aging and exposing to ionizing radiation.

Discussion

The current results showed that some health complaints related to work, such as headache, were higher among exposed workers than control group with statistically significant level. This result was consistent with a study conducted in Egypt in 2013 which found that exposed group is suffering more during work from headache, tiredness, and dizziness compared to controls with statistically significant level.[9] These results matched with Prabhakara and Lakshman[9] and Daoud et al.[10] that found symptoms experienced by the radiographers were greater than control group. Regarding skin diseases, the study illustrated that skin problems were doubled

Table 2: General health status of the study participants (cases and controls)

Items	(92) MRs		(97) MLTs		Chi- square		
	N	%	*N*	%	OR	CI	*p*-value
Having sinusitis							
Yes	50	54.3	19	19.6	4.887	2.557– 9.342	<0.001
No	42	45.7	78	80.4			
Having sore throat							
Yes	70	76.1	42	43.3	4.167	2.220–7.785	<0.001
No	22	23.9	55	56.7			
Having bronchitis							
Yes	18	19.6	10	10.3	2.116	.920 – 4.867	0.07
No	74	80.4	83	89.7			
Having gastritis							
Yes	32	34.8	12	12.4	3.778	.800 – 5.928	0.09
No	60	65.2	85	87.6			
Having nausea, anorexia							
Yes	22	23.9	2	2.1	14.777	3.745 – 64.255	<0.001
No	70	76.1	95	97.9			
Getting ear infection							
Yes	8	8.7	4	4.1	1.025	.320 – 3.210	0.2
No	84	91.3	93	95.9			
Having urinary infection							
Yes	18	19.6	5	5.2	3.111	2.201 –7.235	0.001
No	74	80.4	92	94.8			
Having repeated infections							
Yes	24	26.1	6	6.8	2.425	1.598 – 6.25	0.001
No	68	73.9	91	93.2			
Suffering fever, pallor							
Yes	6	6.5	1	1.0	1.225	0.133– 4.255	0.13
No	86	93.6	96	99.0			

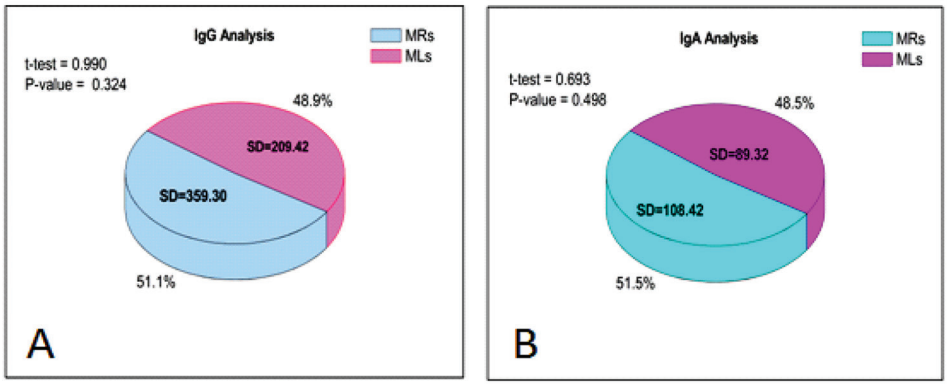

Figure 1: The mean of serum immunoglobulin G (A) and A (B) IgG among exposed and non-exposed group

among exposed group compared to controls with no statistically significant level. These findings were consistent with the results reported by Rezvani et al.[11] found that exposure to low doses of radiation did not show a significant increase in the prevalence of skin lesions. The result was consistent with a study conducted in Egypt found that no signs of eczema among exposed workers compared to controls.[9] On the other hand, Peter[12] reported early skin lesions in workers exposed to X-ray.

Table 3: Clinical symptoms of immunity system among the study participants. t-test comparing the mean of WBCs and it differentials among participants

Variables / Participant	No.	Mean	SD	t-test	*p*-value
WBCs levels					
MRs (Cases)	54	6835.19	1552.38	0.42	0.67
MLs (Controls)	57	6713.07	1513.55		
Lymphocytes levels					
MRs (Cases)	54	2846.30	837.36	1.52	0.39
MLs (Controls)	57	202.90	89.32		
Monocytes levels					
MRs (Cases)	54	303.70	837.25	-1.22	0.27
MLs (Controls)	57	2700.00	622.35		
Granulocytes levels					
MRs (Cases)	54	3636.19	1077.14	0.77	0.35
MLs (Controls)	57	3475.12	1140.22		

Regarding the immune system symptoms, the study results reported significant higher percentage in repeated infections among medical radiographers compared to control group (26.1% and 6.8%, respectively) and (p=0.001), this was matched with Saleh et al.[8] which found that repeated infections among exposed workers were higher 35.5% compared to 15.2% to the control group with statistically significant level (p=0.02). The current results was similar to a study conducted in 2002 by Ben and Emelia[13] to test the effect of radiation on the human immune system and they found higher infection rates in people exposed to radiation for long time at low doses. Another matched study found an increase in the prevalence of respiratory tract infections among children living around Chernobyl and they explained this findings by long term low dose exposure of the whole body to radiation.[15] Other clinical symptoms such as gastritis, pallor, and anorexia that reported among exposed group were higher than controls with statistically significant level, this is consistent with the study conducted by Saleh et al.[8] that found higher percentages of gastritis among exposed than non-exposed group.

The reported IgG and IgA showed no statistically significant differences among exposed and non-exposed group. The same results are achieved with studies conducted in Turkey, Iran, and Egypt that found no statistically significant differences between the two groups.[10,14,16]. On the other hand, studies performed in Turkey, 2004 and Iran, 2013 reported significant lower concentrations of IgA and IgG among radiology employees.[17,18]. Also, Klucinski et al.[16] reported decline in IgG levels among radiology team . A recent study conducted in Russia, 2014 stated elevated levels in IgA readings among radiology workers compared to controls.[19] Also, Zakeri et al.[17] in 2010 found significant increase in serum IgG of interventional cardiologists that occupationally exposed to radiation compared to non exposed group.

Regarding WBCs and its differentials the results did not show statistically significant differences in all parameters between exposed and control groups; this is consistent with the study conducted by Zakeri et al.[17] in 2010 which found no statistically significant differences between the two groups. Other studies conducted by Moghaddam et al.[15] in 2005 and Daoud et al.[10] in 2008 found some variations between WBCs and lymphocytes of the two groups with no statistically significant levels. On the other hand, a study performed by Shahid et al.[19] in 2014 showed significant increase in lymphocyte counts of exposed person compared to non-exposed group. Furthermore, significant diminution in the concentrations of WBCs and lymphocyte were reported among nuclear medicine workers compared to control group in the study carried out.[9]

Limitations of the study

- The time factor: because the blood reagent not available in MOH the researcher take a lot of time to find out a valid place to apply the blood tests.
- The researcher took a lot time to find the best laboratory and best method and technique in doing the immunity blood tests (Immunoglobulin). Also, there is a few laboratory centers doing the immunoglobulin tests and also it's not doing in the routine work like other blood tests such as CBC.
- Difficulties in convincing the volunteers to participate in the study, especially females, because of social considerations and blood samples.
- There were some difficulties in radiation studies in attempting to investigate effects due to radiation, particularly at the very low exposure levels. Thus any association of a particular biologic effect with an exposure to ionizing radiation must have with it a degree of uncertainty.
- Another problem that encounter in the study of low level radiation effects is the latent period, for example effects of low dose irradiation on genetic abnormalities, immune system functions and immune system cells (T and B cells).

Table 4: The effects of independent variables on IgG using multiple regression

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	1.109	.181		6.12	0.001
	Smoking status	-.018-	.082	-.022-	-0.22-	0.83
	Gender	.048	.083	0.060	0.58	0.56
	Age group	.002	.051	0.004	0.04	0.96

[a]Dependent Variable: IgG group

Table 5: The effects of independent variables on IgA using multiple regression

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.190	.138		8.62	0.001
	Smoking status	.056	.063	.089	0.89	0.37
	Gender	-.132-	.063	-.213-	-2.10-	0.04
	Age group	-.023-	.039	-.058-	-0.61-	0.54

[a]Dependent Variable: IgA group

Conclusion

The present study revealed that the continuous exposure to low doses of ionizing radiation causes many health complaints regarding the immunity system. Although the mean of immunological parameters (IgG, IgA) were increased among exposed participants than non-exposed group, these differences did not reach the statistically significant levels. The variations of statistical significant differences between clinical symptoms and blood tests may be attributed to the low response of medical radiographers for venous blood sampling compared to the high response obtained from questionnaire.

Finally, medical radiographers are exposed to low doses of radiation, yet significant affection of some basic blood parameters was evident. Thus, personnel monitoring for ionizing radiation and increasing the level of protection for MRs is of utmost importance.

Significant clinical symptoms related to the immunity troubles have been reported on medical radiographers and can be attributed to ionizing radiation exposure.

In the current study, a potential limitation was encountered due to the time between radiation exposure and the detection abnormalities is known as the latent period, for example effects of low dose irradiation on genetic abnormalities, immune system functions and immune system cells (T and B cells) may takes years to appear.

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How to cite this article: Alnahhal M, Alajerami YSM, Jaber S, Abushab K, Ahmed Najim A. Radiation exposure and immunity status of radiographers at government hospitals. Int J Med Sci Public Health 2017;6:232-238

Source of Support: Nil, **Conflict of Interest:** None declared.