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The Impact of Exposure to Medical Radiation on Lead (Pb^{+2}) and Thyroid Function Test

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Abstract: Exposure to radiation has health impacts that extend to a long time and may deteriorate the biological functions of various organs. The objectives of the present study were to determine the levels of lead (Pb^{+2}) and thyroid function test among study participants. A total of 100 subjects were selected of whom 50 subjects were workers in Radiology Department at King Abdulla University hospitals and 50 control subjects. A blood sample was with drawn from each participant to assess the levels of lead (Pb^{+2}), T3, T4 and TSH. We analyzed the data using descriptive statistics to determine frequencies and percentages, means and standard deviations to present study variables. The differences in means were examined using independent t-test while Pearson correlation was used to test the correlation of study variables. Significance was considered at $p = 0.05$. Study findings showed that the mean lead (Pb^{+2}) in persons who were exposed to medical radiation was 7.89±3.73 µg/dL and this was significantly ($p = 0.000$) lower than that of control subjects (11.9±2.58 µg/dL). No significant variations in the difference of means for T3 and TSH were observed in study groups. A significant difference in means was observed for T4 ($p = 0.025$). A significantly negative correlation was observed between the lead level of study subjects and control subjects ($p = 0.000$). Other significantly positive correlations were observed between lead (Pb^{+2}) of patients and TSH-patients ($p = 0.008$), T3 of patients and TSH of patients (0.033), T4 of patients and TSH of patients ($p = 0.000$). Taken together, our data demonstrated for the first time that exposure to radiation decreases the levels of blood lead and impacts thyroid function tests.

Key words: Radiation, thyroid function test, lead (Pb^{+2}), T3, T4, TSH

INTRODUCTION

From a physical point of view, radiation is defined as the emission or transmission of energy in the form of waves or particles through space or through a material medium (Weisstein, 2014).

Radiation can be classified as either ionizing or non-ionizing according to the energy of the radiated particles (Desouky *et al*., 2015). Ionizing radiation carries more than 10 eV which is enough to ionize atoms and molecules and break chemical bonds (Hall and Giaccia, 2011). This is an important distinction due to the large difference in harmfulness to living organisms (Desouky *et al*., 2015). A common source of ionizing radiation is radioactive materials that emit α, β, γ, radiation, consisting of helium nuclei, electrons or positrons and photons, respectively (Howell *et al*., 2006). Other sources include X-rays from medical radiography examinations and muons, mesons, positrons, neutrons and other particles that constitute the secondary cosmic rays that are produced after primary cosmic rays interact with Earth's atmosphere (Hall and Giaccia, 2011).

Gamma rays, X-rays and the higher energy range of ultraviolet light constitute the ionizing part of the electromagnetic spectrum. The lower-energy, longer wavelength part of the spectrum including visible light, infrared light, microwaves and radio waves is non-ionizing; its main effect when interacting with tissue is heating. This type of radiation only damages cells if the intensity is high enough to cause excessive heating. Ultraviolet radiation has some features of both ionizing and non-ionizing radiation. While the part of the ultraviolet spectrum that penetrates the Earth's atmosphere is non-ionizing, this radiation does far more damage to many molecules in biological systems than can be accounted for by heating effects, sunburn being a

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well-known example. These properties derive from ultraviolet's power to alter chemical bonds even without having quite enough energy to ionize atoms.

The thyroid is one of endocrine glands and it is located in the neck and it produces and releases thyroid hormones. The thyroid hormones include Thyroxine (T4) and Triiodothyronine (T3) which have strong influences on energy metabolism, temperature regulation and body heat production. They also have important roles in skeletal muscle and cardiac contraction, memory and sleep. It has been shown that the synthesis of thyroid hormone depends on several factors including the nutritional availability of iodine and is predominantly regulated by thyrotropin (Thyroid Stimulating Hormone, TSH) which is secreted by the pituitary gland. It has been reported that both synthesis and secretion of TSH are under the control of hypothalamic TSH-Releasing Hormone (TRH) and it is inhibited by negative feedback by thyroid hormone itself (Peeters, 2005).

Lead (Pb) is a heavy metal that makes a risk to public health because of increased industrialization (Smith, 1984; Roper, 1991; Tong *et al*., 2000; Sahin *et al*., 2016). When it is introduced into the body, lead accumulates in various organs and tissues (Sahin *et al*., 2016). About 85-90% of Pb is bound to erythrocytes while the remaining proportion binds plasma proteins (Patrick, 2006). Lead poisoning can induce hematological, neurological, circulatory and immunological pathologies in addition to biochemical changes, liver and kidney dysfunctions and alteration of glucose metabolism (Al-Saleh, 1994; Iavicoli *et al*., 2003). The toxicity of lead impacts the functions of endocrine glands including thyroid hormones, reproductive hormones and stress hormones (Zacharewski, 1998; Sahin *et al*., 2016).

Study objectives: The main objectives of the present study were to evaluate the occupational exposure of radiation in a selected group of radiology technologist working at Radiology Department of King Abdulla University Hospital through examining changes in serum levels of T3, T4 and TSH and to evaluate the influence of radiation exposure on blood lead level.

MATERIALS AND METHODS

Study design: A case control study design was conducted to collect data from study participants.

Study setting: The present study was conducted at Radiology Department in King Abdulla University Hospital. Control subjects were chosen from other departments who were not exposed to occupational radiation.

Study population: Study population represents all workers in Radiology Departments in Jordan who are exposed to occupational radiology.

Study sample: A study sample included 50 radiology technologist and 50 control subjects.

Sampling technique: A convenience samling technique was followed to collect data from participants who agreed to participate in the present study.

Assessment of thyroid function tests and blood lead level: Blood samples were withdrawn from all participants to examine the levels of the following hormones T3, T4, TSH as well as blood lead level.

All hormone analyses were carried out at medical laboratories at King Abdulla University Hospital using Enzyme Linked Immunosorbent Assay (ELISA). Blood lead level was measured using atomic absorption spectrophotometry.

Statistical analysis: A working sheet was created for each participant that includes study variables including gender, thyroid function tests and blood lead level. Data for all patients was entered into SPSS Version 20. An independent t-test was used to examine the relationship between study variables between study groups. The significance was considered at alpha level <0.05.

RESULTS AND DISCUSSION

As shown in Table 1, study participants included 100 participants of whom there were 50 patients and 50 control subjects. Patients included 37 (74%) males and control subjects included 36 (72%) males.

The levels of lead (Pb^{+2}) and thyroid function tests and their statistical significance: As seen in Table 2, the level of lead (Pb^{+2}) in patient group was 7.89±3.73 μg/dL and this was significantly ($p = 0.000$) less than that of control group 11.9±2.58 μg/dL. No significant differences were observed between the levels of T3 in patient group (2.11±1.11 pmol/L) and control group (4.95±22.68 pmol/L) ($p = 0.383$). The mean differences between the levels of T4 of patients (10.88±1.57 pmol/L) and controls (10.17±0.46 pmol/L) were statistically significant ($p = 0.025$). No statistically significant differences were observed for the levels of TSH in patients (5.04±0.46 mIU/L) and that of controls (4.917±0.52 mIU/L) ($p = 0.210$).

Correlation between study variables: The data of the present study showed a group of significant correlations. A significantly negative correlation was found between

Table 1: General characteristics of participants

Variables	Descriptions
Gender-patients (N, %)	
Males	37 (74%)
Females	13 (26%)
Gender-control (N, %)	
Males	36 (72%)
Females	14 (28%)

Table 2: The levels of lead (Pb) and thyroid function tests in study participants

Variables	M	SD	p-values
Lead_patient (μg/dL)	7.890	3.730	0.000
Lead_control	11.900	2.580	
T3_patient (pmol/L)	2.110	1.110	0.383
T3_control	4.950	22.680	
T4_patient	10.880	1.570	0.025
T4_control	10.170	0.460	
TSH_patient (mIU/L)	5.040	0.460	0.210
TSH_control	4.917	0.520	

the levels of lead (Pb^{+2}) for patients and control ($r = -0.0564$, $p = 0.000$). A significantly positive correlation was observed between the levels of lead (Pb^{+2}) of patients and that of TSH of patients ($r = 0.372$, $p = 0.008$). Anoher positively significant correlation was found between T3 of patients and TSH of patients ($r = 0.302$, $p = 0.033$). The last positively significant correlation was found between T4 of patients and TSH of patients ($r = 0.562$, $p = 0.000$) (Table 3).

The data of the present study showed that the exposure to radiation decreased the levels of lead (Pb^{+2}) significantly compared with control subjects ($p = 0.000$). Up to the best knowledge of the researcher, this result may the first in literature. Within the current information, it is not easy to explain this finding but we may think that exposure to radiation influence the metabolic pathways that mediate the metabolism of lead.

We found that there was significant difference in the means of T4 between exposed workers to radiation and control subjects ($p = 0.025$). Radiation exposed patients had higher levels of T4 than control subjects. This finding is consistent with other studies in which radiation exposure impacts thyroid function (Peeters, 2005).

The results of Pearson correlation showed that the levels of blood lead were negatively and significantly correlated ($p = 0.000$). The impact of exposure to radiation is obvious. Another important correlation was found between lead of patients and TSH of patients ($p = 0.008$). This emphasizes the role of lead (Pb^{+2}) in inducing alterations in thyroid function (Sahin *et al*., 2016).

We also found significant correlations between each of T3 and T4 of radiation exposed subjects with TSH of radiation exposed subjects ($p = 0.033$, $p = 0.000$, respectively). It seems that the exposure to radiation interferes or mediates the levels of thyroid function tests in a dependent manner. We think that this finding may be new and was not reported previously.

Table 3: Correlation between study variables (Pearson corrlation)

Variable 1	Variable 2	Pearson correlation	p-values
Lead-patients	Lead-control	-0.564	0.000
Lead-patients	TSH-patients	0.372	0.008
T3-patients	TSH-patients	0.302	0.033
T4-patients	TSH-patients	0.562	0.000

CONCLUSION

Our data demonstrated for the first time that exposure to radiation decreases the levels of blood lead and impacts thyroid function tests.

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