ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230, **ISSN (online):** 2412-3986, **DOI:** **http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Cumulative effects of low X-ray doses on some liver function and proteins of diagnostic technicians working in conventional X-rays

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A B S T R A C T:
Today X-rays are widely used for diagnostic in medicine using different technics such as computed tomography (CT), fluoroscopy and conventional X-ray. During diagnostic procedures the technicians might expose to low X-ray doses especially those who omit radiation protection tools. The aim of the study was to assess liver function and proteins due to the cumulative effects of low X-ray doses on diagnostic technicians through measuring aspartate aminotransferase (AST), alanine aminotransferase (ALT), total proteins, albumin, globulin, serum ferritin (s.ferritin), malondialdehyde (MDA) and glutathione (GSH). Twenty four male diagnostic technicians at Kirkuk hospitals participated, they classified into two groups depending on their working experiences, each group with 12 technicians. Twelve male healthy controls participated to show any alteration of the parameters. The results showed that ALT, AST and s.ferritin increased significantly ($p<0.05$) for the first group compared to the control while high significant ($p<0.001$) increasing was recorded for the second group. Total proteins decreased significantly ($p<0.05$) in the first group and high significant ($p<0.001$) decreasing in the second group compared with the control group. High significant ($p<0.001$) decreasing for albumin was recorded in both groups while globulin decreased insignificantly ($p>0.05$) in the first group and significant ($p<0.05$) decreases were recorded for the second group. For MDA and GSH high significant ($p<0.001$) increasing and decreasing respectively, recorded for both groups. The study revealed that low doses of X-ray can change some liver functions and proteins and the number of working years has discernible effects on the cumulative doses in diagnostic technicians.

KEY WORDS: Cumulative dose, X-ray, Proteins, Diagnostic, liver functions
DOI: http://dx.doi.org/10.21271/ZJPAS.33.3.5
ZJPAS (2021), 33(3);43-50.

1. INTRODUCTION:

Ionizing radiation was used for diagnosis and therapy in medicine broadly especially after the discovery of X-ray by Roentgen in 1895. The medical use of radiation widespread to a lot of countries in the world during the twentieth century, and is becoming more familiar (Agency 2001). Today X-rays are widely used for diagnostic in medicine using different technics such as computed tomography (CT), fluoroscopy and conventional X-ray (Brenner and Hall 2007), ((Hall and Brenner 2008),(De Santis, Cesari et al. 2007)). There are risks associated with X-ray imaging as in many aspects in medicine.

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Article History:
Received: 26/11/2020
Accepted: 03/03/2021
Published: 20/06 /2021

The most common effects are the induction of cancer after a long period of years ((Hall and Brenner 2008), (De Santis, Cesari et al. 2007), (Brenner 2010)). X-ray classified as carcinogenesis by World Health organization (Roobottom, Mitchell et al. 2010). Different factors such as types, energy and doses of the radiation, age, individual health and volume of body exposure to have the main rule on the biological effects of ionizing radiation. Different types of effects may be produced after exposure to the radiation such as deterministic and stochastic effects. Deterministic effects result from acute exposure while stochastic effects resulting from chronic exposure. Deterministic effects occur due to cell death or delay in cell division, if large numbers of cell die to affect the function of the tissues or organ. In stochastic effects the cells are not dying but alter in some way causing delay effects such as carcinogenesis and hereditary effect ((Bohm, Hendry et al. 2010), (Podgorsak 2005)).

During diagnostic procedures the technicians might expose to low X-ray doses especially those who omit radiation protection tools. Exposures to low doses of the radiation for a long time are the main risk factors in X-ray imaging ((Cengiz, Gurkaynak et al. 2003), (Hashim, Karim et al. 2016), (Protasova, Maksimov et al. 2001)). In the first half of the past century many of serious health problems such as increasing of skin cancer and leukemia along with enhanced cancer and all cause death rates have been reported in radiologic technologists and radiologists (Dublin and Spiegelman 1948). It was demonstrated that increasing breast cancer risk in US cohort radiologic technologists is due to occupational radiation exposure in low to intermediate dose range (Preston, Kitahara et al. 2016), however the above cases happened before the recommendations of protection implemented by international organizations.

It has been proved that there is a relationship between ionizing radiation and malignant diseases ((Pierce and Preston 2000), (Ochs 2011)) including various liver diseases presenting with tender hepatomegaly, hyperbilirubinaemia and ascites ((Lawrence, Robertson et al. 1995),(Helmy 2006)) . It has been proved that ionizing radiation can induce hepatic dysfunction or liver cancer in patients without liver diseases who undergo radiotherapy ((Walsh, Grosche et al. 2015), (Ozasa, Shimizu et al. 2012),(Pan, Kavanagh et al. 2010),(Zielinski, Garner et al. 2009)). Liver can be damaged by high doses of ionizing radiation but the effects of chronic exposure of the radiation on liver damage are not clear (Sun, Mao et al. 2018). (Bakshi, Azimzadeh et al. 2015) showed that liver inflammation in male mice increase after exposed to single dose ranging from 0.02 to 1.0 Gy. Although, the liver was once believed to be relatively radio-resistant, hepatic morphologic and functional alterations have been noticed after radiation therapy ((Tai, Erickson et al. 2009), (Gore and Levine 2010)).

MDA is the last product of peroxidation; major aldehyde product that is mutagenic in cells and could be used to assess cell damages ((Marnett 2002), (Dalle-Donne, Rossi et al. 2006)).GSH is a common antioxidant in human body and participated in human defense system against oxidative damage. It has been reported that GSH level can be reduced by oxidative stress (Sener, Kabasakal et al. 2006).

Several studies have been done on the cumulative effects of low X-ray doses on the different parameters in diagnostic technicians. (YASMIN, GARIMA et al. 2009) showed that X-rays can inhibit the immune activity and induce damage to kidneys and liver in radiologic technicians. (Taqi, Faraj et al. 2018) reported that some hematological parameters in diagnostic technicians can be significantly changed after chronic exposures to X-ray and work duration has discernible effects on the some parameters. (Nureddin and Alatta 2016) 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.

Biological impacts of low doses of the radiation still are not clear, so more researches are required. However, studies on the effects of low doses on proteins and liver function are limited, the aim of the current study was to assess the cumulative effects of low X-ray doses in diagnostic technicians through measuring aspartate aminotransferase (AST), alanine aminotransferase (ALT), total proteins, albumin, globulin, serum ferritin (s.ferritin), malondialdehyde (MDA) and glutathione (GSH).

2. Materials and Methods

Twenty four male diagnostic technicians at Kirkuk hospitals participated in the study, depending on their working experiences they classified into two groups, each group with 12 technicians, the mean work duration of the first group was 6.2 years ranging from (3-9) years with the average age (45.3±6.6) years and the second group was 17.2 years ranging from (10-25) years with the average age (33.8±8.9) years. Twelve male healthy controls was with the average age (40.5± 8.5) years selected from outside of the hospitals, they are non-smokers, non-taking any medications, they did not have any diseases before and during the study.

The aim of the study was explained to all participates and their participation was optional. Questionaries' data was filled out then the amount of 5 ml of blood was taken from the veins of each participate. All the technicians worked on the conventional X-ray machine, five of the technicians were smokers and two of them had hypertensions.

AST, ALT, total protein and albumin were measured by a technique according to the instructions of manufacturer company kit (Randox), while s.ferritin was measured by using ELISA technique. Globulin was determined using the following equation:

Globulin= total proteins - albumin

MDA was measured based on the colorimetric reaction with thiobarbituric acid (TBA) using spectrophotometer (Rao, Soufir et al. 1989). GSH level estimated by mixing 2.3 ml buffer with 0.2ml of the sample and then added 0.5ml of 5,5-dithio-bis-(2-nitrobenzoic acid) (DTNB). The mixture was analyzed by spectrophotometer (Moron, Depierre et al. 1979).

During performing this study at the hospitals, the technicians did not use radiation protection tools for themselves and patients.

The t-test was used for a statistical difference between the means of the measurements in diagnostic technicians and control groups. P values < 0.05 were considered as statistically significant and P values < 0.001 considered as high significant.

3. Results

The cumulative effects of X-ray doses on ALT, AST and total proteins in the diagnostic technicians are shown in Table 1 and Fig.1, ALT, AST and s.ferritin increased significantly ($p<0.05$) for the first groups compare to the control while high significant ($p<0.001$) increasing was recorded for the second group. The mean values of ALT were (18±3.83) U/L, (25.16±9.81) U/L, (60.83±14.89) U/L for control, first group (work duration 3-9 years) and second group (work duration 10-25 years) of the technicians respectively. The values of AST for control, first and second groups were (16.25±2.86) U/L, (25.33±9.61) U/L, (59.83±19.48) respectively, and for s.ferritin the mean values were (44.43±3.89) ng/L, (51.55±7.39) ng/L, (64.73±8.48) ng/L for the same order of the groups.

The results for total proteins, albumins and globulins are presented in Table 2. Total proteins decreased significantly ($p<0.05$) in the first group and high significant ($p<0.001$) decreasing was recorded in the second group compared with the control group. The values for control, first and second groups were (7.30±0.29) mg/dl, (6.65±0.37) mg/dl, (5.85±0.60) mg/dl respectively. High significant ($p<0.001$) decreasing for albumin was recorded in the both groups of the technicians while globulin decreased insignificantly ($p>0.05$) in the first group and significant ($p<0.05$) decreasing was recorded for the second group. The mean values of albumin were (3.03±0.33) mg/dl, (2.68±0.28) mg/dl for first and second groups of the technicians and the value for control was (3.59±0.23) mg/dl. Globulin measurements were (3.70±0.37) mg/dl for control group and (3.63±0.31)mg/dl, (3.10±0.42) for first and second groups of the technicians respectively. The results also are shown as a chart in Fig.2.

For MDA and GSH, high significant ($p<0.001$) increasing and decreasing respectively, recorded for both groups compared with the control, the data are shown in the Table 3 and Fig.3. The mean values for MDA were (1.24±0.07) mol/l, (1.52±0.10) mol/l, (1.95±0.19) mol/l and for GSH were (0.44±0.01) mol/l, (0.41±0.02), (0.37±0.03) mol/l for control, first and second groups respectively.

The important results significant difference ($p<0.01$) between first group (work duration 3-9 years) and second group (work duration 10-25) were observed for nearly all measurements which is the main purpose of the study as shown in the tables.

Table 1; AST, ALT and s. ferritin measurements for both groups of the technicians and control

Groups / Parameters	Control Mean ± SD	Diagnostic technicians Work duration (3-9)years Mean ± SD	P-Value	Diagnostic technicians Work duration (10-25) years Mean ± SD	P-Value
AST (U/L)	18±3.83	25.16±9.81*	<0.05	60.83±14.89**	<0.001
ALT (U/L)	16.25±2.86	25.33±9.61*	<0.01	59.83±19.48**	<0.001
S.ferritin	44.43±3.89	51.55±7.39*	<0.05	64.73±8.48**	<0.001

Table 2; total proteins, albumins and globulins measurements for all groups

Groups / Parameters	Control Mean ± SD	Diagnostic technicians Work duration (3-9)years Mean ± SD	P-Value	Diagnostic technicians Work duration (10-25) years Mean ± SD	P-Value
Total proteins (mg/dl)	7.30±0.29	6.65±0.37*	<0.01	5.85±0.60**	<0.001
Albumin (mg/dl)	3.59±0.23	3.03±0.33**	<0.001	2.68±0.28**	<0.001
Globulin (mg/dl)	3.70±0.37	3.63±0.31	>0.05	3.10±0.42*	<0.05

Table 3; Measurements of MDA and GSH for both groups of the diagnostic technicians and control

Groups / Parameters	Control Mean ± SD	Diagnostic technicians Work duration (3-9)years Mean ± SD	P-Value	Diagnostic technicians Work duration (10-25) years Mean ± SD	P-Value
MDA (mol/l)	1.24±0.07	1.52±0.10**	<0.001	1.95±0.19**	<0.001
GSH (mol/l)	0.44±0.01	0.41±0.02**	<0.001	0.37±0.03**	<0.001

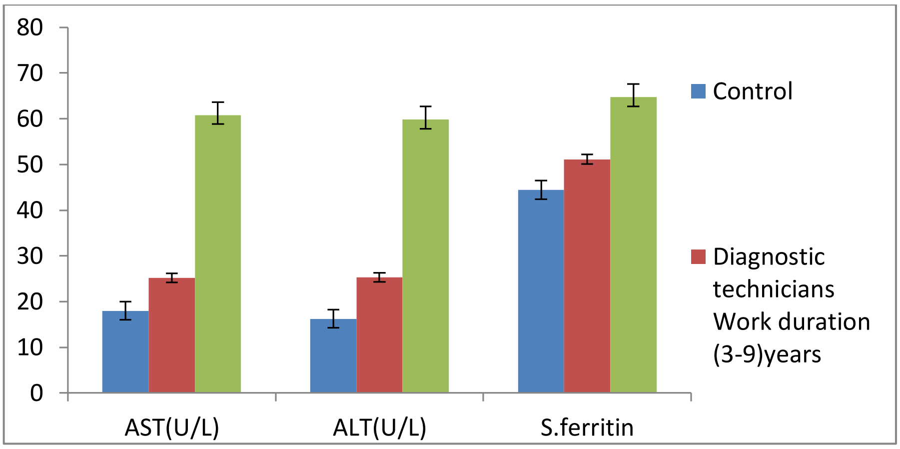

Figure1; Chart of AST, ALT and s. ferritin for the two groups of the technicians and control

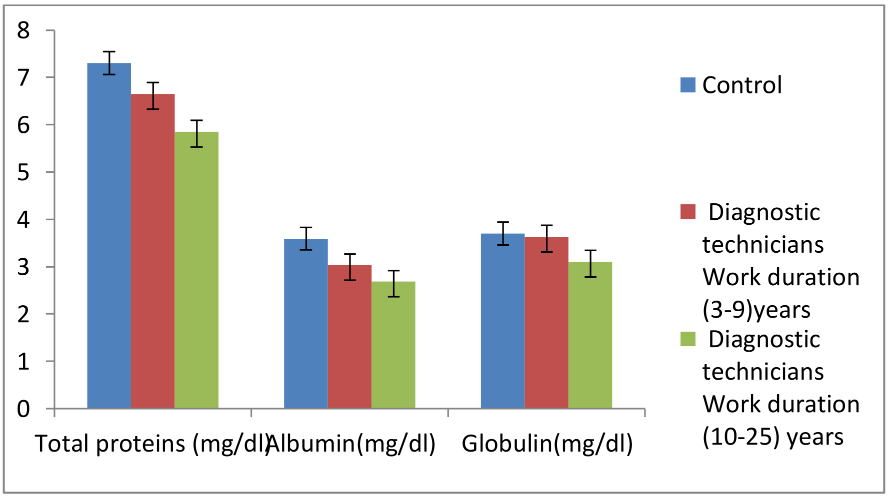

Figure 2; Chart for values of total proteins, albumin and globulin for the two groups of the technicians and control group

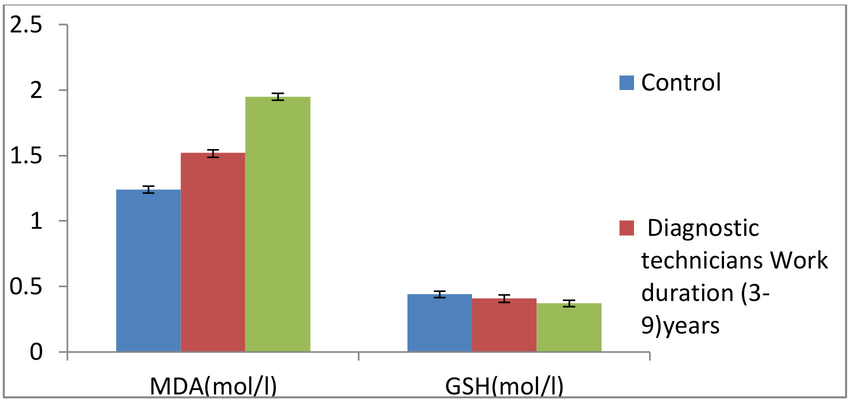

Figure 3; Chart of MDA and GSH measurements for the two groups diagnostic technicians and control group

4. Discussion

Chronic exposure to ionizing radiation may results various health effects (Meo 2004).Diagnostic technicians probably expose to low X-ray doses at their workplace especially those who omit radiation protection tools as was observed at the hospitals during the study. However the technicians during individual procedure exposed to low dose of X-ray but occupational risks arise from stochastic effects. Serious, long-term and possibly fatal adverse health consequences may arise from daily exposure procedures over a long time. It has known biological effects of ionizing radiation increases with increasing time of exposure.

This study was done for two different duration of the exposure. However studies on the effects of low dose on the proteins and liver function are limited. In this study changing of ALT, AST, s. ferritin, total proteins, albumins, globulins, MDA and GSH were observed between control group and the technicians who exposed for two different duration time depending on their working experiences.

In the current study ALT and AST increases with increasing duration time of exposure. It has been shown that liver is considered a radiation sensitive organ ((Rösler, Christiansen et al. 2015), (Stryker 2007)) and chronic exposure to radiation is a risk factor liver injury (Sun, Mao et al. 2018). (Bakshi, Azimzadeh et al. 2015) suggested that liver function and the development of liver disease in animals may affect after exposure to low dose radiation. (Nwokocha, Nwokocha et al. 2012) showed that the values of ALT and AST elevated significantly with increasing radiations after total body irradiations of rats to 1.27 Gy/minute as cumulative doses.

In this study s. ferritine also increases in the two groups compared with the control. The increasing may be due to oxidative stress and enzymes activity affected by the radiation. It has been reported that the change in ferritin subunits induced due to increasing in hepatic and the direct effect of different inflammatory mediators such as acute-phase cytokines ((Naz, Moriconi et al. 2013), (Torti, Kwak et al. 1988)).It has been shown that many diseases are related with iron overload or iron deficiency. S. ferritin has been described as a risk factor for veno-occlusive disease (Morado, Ojeda et al. 1999). (Feng, Chen et al. 2015) recorded that there is a significant association between s. ferritin and colorectal cancer. It has been shown that determination of ferritin is a suitable method for ascertaining the iron metabolism situation which provides a representative measure of body's iron reserves (Antonini and Albertini 1984).

Decreasing of total proteins, albumins and globulin were observed in the present study with increasing duration time of exposure. (Ditzel 1962) showed that after 1500 rad and 1000 rad of total-body X-irradiation of golden hamster the albumin fraction decreased, and the αl-, α2-, and β-globulin fractions increased. (Goranson, McCULLOCH et al. 1960) observed exposure of the animals to supra-lethal total-body irradiation produced changes in a number of the serum components. The most striking change is the increase in the α-globulin component (Fα2). The results of current study disagree with the above two studies may be due to the difference in the absorbed dose and the duration of exposure. (Nwokocha, Nwokocha et al. 2012) also shown that serum proteins increased significantly with increasing radiation and serum levels of albumins significantly ($p < 0.05$) increased at the beginning of radiation exposures but reduced when cumulative dose exposure increased which agree with the results of the present study.

Oxidative stress induced by radiation may increase MDA which being interested for scientific research and intracellular concentration of GSH can be used as indicator of oxidative stress (Mohamed, Mohammad et al. 2014). In the current study MDA increased significantly while GSH decreased significantly in the groups of the technicians compared with the control group. Decreasing of GSH may be due to low dose of radiation which can induce oxidative stress. (Meydan, Gursel et al. 2011) suggested that ROS cause negative effect on the antioxidant defense by depleting intracellular concentration of GSH. (Deger, Dede et al. 2003) showed that after irradiation of mice to 550 rad X-ray the level of MDA increased while GSH decreased and (Zhao, Wang et al. 2012) recorded that MDA increased and GSH decreased in liver tissues of mice after irradiation to 5Gy of Co-60, the results of these two studies agree with the results of the current study however they used high doses compared with the doses of the current study. Oxidant damage to the mitochondria and myocyte membranes that could promote cell death due to membrane damage termed as radiation induced apoptosis may be due to high MDA level (De Freitas, Boligon et al. 2013). (Qian, Cao et al. 2010) showed increasing of MDA in cardiac tissue of mice irradiated by gamma rays.

5. Conclusions: The present study provides estimation of accumulative effect of low X-ray doses on proteins and some liver functions and it is a basis for more studies on the effects of low radiation doses and accumulative effects on liver functions, proteins and other system. The study revealed that low X-ray doses can change some liver function and proteins and the number of working years has discernible effects on the cumulative doses in diagnostic technicians. The author recommended that more studies on the other effects of low doses of the radiations on human health are necessary to be done. Training and courses was recommended for the diagnostic technicians to improve their knowledge and protect themselves through using radiation protection tools during diagnosing.

Acknowledgment: The author would like to thank all participants for their cooperation during the study. Special thanks to the biologist in the Labs. who helped me during the measurements.

Conflicts of interest: the author declares that there is no conflict of interest.

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