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The Effect of Ionizing Radiation on Workers in Baghdad Hospital for Radiotherapy and Nuclear Medicine

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Abstract

This work involves the investigation of the effect of ionizing radiation on hospital workers to estimate the risks they are exposed to during their daily working hours and for many years, and to take the necessary precautions to ensure the occupational safety of this category of workers. Blood samples were collected from Baghdad Hospital for Nuclear Medicine in the Medical City in Iraq. Some parameters were studied clinically using specific kits, including liver enzymes ALT, AST, ALP, vitamin D3, S-Firrtin, and urea, under a P value less than 0.05. The results showed that all parameters did not change (not significant) in this study, except for urea, which was significant. In conclusion, urea can be used as a biomarker to determine the effect of low-dose ionizing radiation on healthcare workers.

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1. Introduction

Ionizing radiation (IR) is a double-edged sword. It can contribute to the medical field through diagnosis and treatment, but at the same time, it may pose challenges related to the danger that health workers may be exposed to [1]. Due to use the ionizing radiation in nuclear medicine for diagnosis and treatment is one of the most important applications of ionizing radiation, such as linear accelerator technologies - Linacs, computed tomography (Micro-CT), and positron emission tomography (PET-CT), which use X-rays by applying photons or charged particles for treatment and diagnosis [2, 3]. Ionizing radiation has negative and many positive aspects, and many workers in various fields are very concerned about its health effects when used. Therefore, it is necessary to study the health effects, especially on workers in the health field, and to set strict rules for use, as well as supervision of use and prevention of negative effects, to ensure complete protection for workers in the health field [4]. There are dangers associated with occupational safety in the radiography sector, both direct and indirect. These risks may arise from malfunctions or other causes outside the realm of human ability. The human body experiences radio-biological impacts from exposure to radioactive materials. These effects might be physical for the individual receiving radiation exposure or genetic/hereditary for their progeny. The results can have immediate or delayed bodily repercussions. Genetic effects are all random, but physical impacts can be classified as either random or non-random (deterministic). Safety is a key component in lowering the hazards associated with working in radiological facilities and the impact of radiation exposure because of the high potential for radiation hazards in radiation use [5, 6]. Both low and large doses of ionizing radiation, greater or lower than 100 GY, can have stochastic consequences to cause varying degrees of cell death or damage. The hazards brought on by non-deterministic reactions to radiation exposure are also evaluated. In addition to assessing damage to DNA fragments due to fractures in bonds or modifications in the replication codes, genetic risks, and genetic mutations, it is essential to determine which tissues are most susceptible to radiation [7-8]. Ionizing radiation has harmful target effects (HTE) such as nucleic acid ionization and non-target and minor harmful effects (NTHE) resulting from oxidative stress, which results from the effect of radiation[9] Ionizing radiation interferes with the cell, causing physical damage and/or chemical changes, as shown in the following figure 1 [10]. In recent years, the category of Health Care People (HCR) has received great attention due to the danger of exposure to ionizing radiation, which works directly or indirectly to affect the body through several mechanisms that lead to changing some parameters or genetic influence, leading to some diseases such as cancer [11, 12]. Since nuclear radiation has entered the field of treatment, it is necessary to research and find different ways to reduce the damage that can result from exposure to ionizing radiation [13]. Free radicals are generated and produced by the breakdown of active oxygen as a result of oxidative stress and directly affect these biological changes in the body [14]. Studies were conducted in different hospitals using ionizing radiation to monitor, study and generate free radicals and evaluate the oxidation and reduction state that occurs to them during exposure to radiation by monitoring some enzymes that work as antioxidants and learning the types of free radicals that can be generated by the oxidative system, as in the figure 2, showing a relationship between some markers of nuclear medicine workers and the state of unstable oxidation and reduction in the blood [15]. Oxidative stress parameters can be used to evaluate DNA damage and changes in complete blood count in hospital workers exposed to low doses of ionizing radiation. Numerous research have been carried out to examine the connection between the body's reaction to the minuscule amount of radiation that professionals in this sector are exposed to, as well as between the years of service and the dosage amount. In the field of ionizing radiation in hospitals, a real correlation was discovered between the radiation dose, exposure duration, amount, and length of service [16-18]. In this study, some markers were taken to diagnose and estimate the effect of low radiation dose on health workers. These markers include liver enzymes, which are ALT and AST; any change in either is evidence of liver injury or damage. As for the ALP enzyme, it is a test of kidney efficiency in conjunction with the urea test, Bone injury, or liver damage. Also, the S-ferritin parameter was taken to examine the body's iron stores, the deficiency of which is evidence of some diseases, such as anemia. Finally, the D3 parameter is a fat-soluble vitamin that the body uses for several purposes. Vit comes primarily from sunlight [19-22]. The international system was established to ensure full protection for workers working with radiation by applying lessons based on knowledge of the extent of this damage and the danger of radiation and generating knowledge of the safety procedures standards that must be followed using several specialists and experts in this field [23]. To ensure complete protection from the harms of low exposure to ionizing radiation on hospital staff and to avoid causing fatal diseases such as cancer, a periodic examination of the radiation levels used in these hospitals for treatment and diagnosis must be conducted, so that they do not exceed the permissible limit and rise, and to follow the assumption that there is linear no-threshold (LNT) [24]. Conducting radiation tests and protection examinations for workers in the radiation field is also one of the most important means of assessing awareness and knowledge of the risks of working in this field and increasing awareness among workers to ensure the necessary protection for them [25].

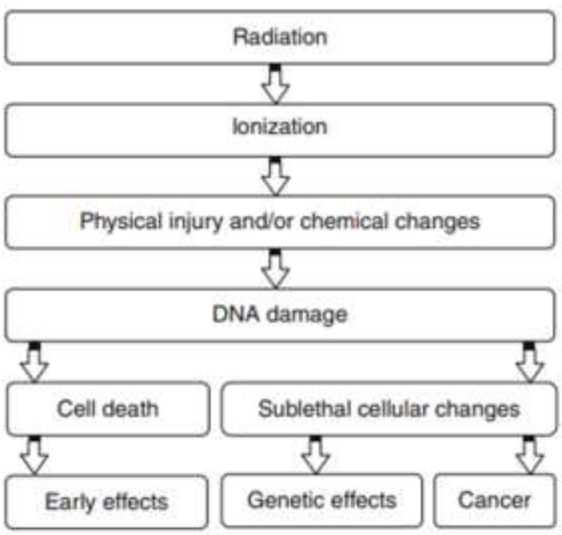

Figure 1. Effect of radiation.

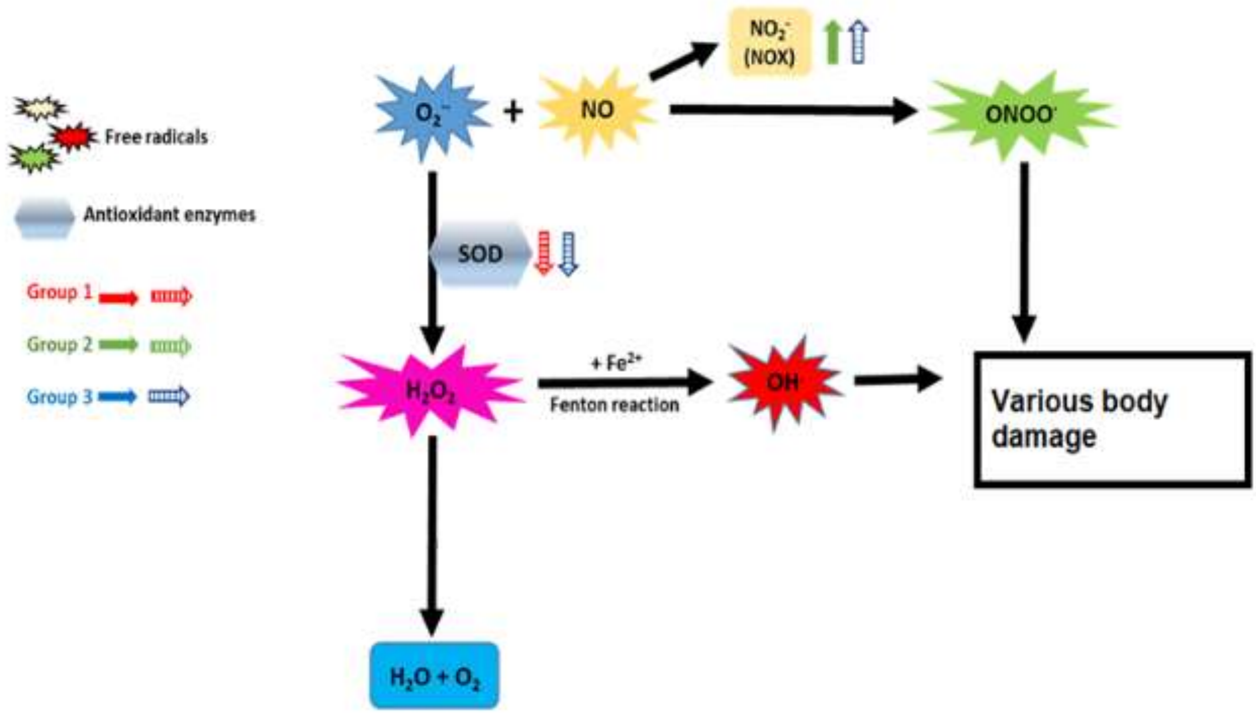

Figure 2. Reactive oxygen specials.

2. Materials and Methods

2.1. Study Design

This research was approved by the Ministry of Health, approval number 14823 dated 21/4/2024. Samples were collected from Baghdad Nuclear Medicine Hospital in Baghdad Medical City, Iraq. 42 people working in the field of ionizing radiation therapy were taken from four places, ages ranged between 22 and 65, from the linear accelerator device (Linacs) The number of samples included 13 device operators, divided into 5 males, 8 females, and 5 administrators in the place, including 1 female and the rest males. In addition, samples were collected for the engineering divisions of the same place, and their number was 4, 1 male. The rest were females, in addition to the nurses, 4 of whom were all females Brachytherapy systems using radioactive iodine capsules. There were 3 of them, female, and the rest were male. Positron Emission Tomography Computed Tomography (PET-CT). The number of samples was 5, 1 male, the rest females, and the total number of micro-computed tomography (micro–CT)scans was 3, of whom 1 was male and the rest were female. 6 samples were taken by the supervisors of the equipment and the patients, and their number was 6, of whom 2 were male and the rest were female. As for the amount of control 15 samples of them are males and the rest are females. They were transferred from Ghazi Hariri Hospital for Surgical Specialization, Physiotherapy Department it ranged between 25 - 50. The blood samples collected were prepared for measurement of parameters required in the research, and when collecting samples, care was taken to avoid diseases (chronic, hereditary, or factors that could affect the results of the research. Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), as well as alkaline phosphatase (ALP) and urea mustered by ELITech Clinical Systems Selectra Pro Series Analyzers. While Vitamin D3 was measured using ELFA (Enzyme Linked Fluorescent Assay) and finally, S-FERRITIN was measured by An immunoassay device enhanced with a set of latex beads.

2.2. Sample Collection

About 5 ml of blood was drawn from each participant and separated at a constant speed in a centrifuge at room temperature. The parameters required in the study were measured using the measurement methods specific to each parameter, and the separated serum was frozen at sub-zero temperature for storage purposes, as shown in the histogram.

2.3. Histogram Sample Collection: Sample collection is illustrated in figure 3.

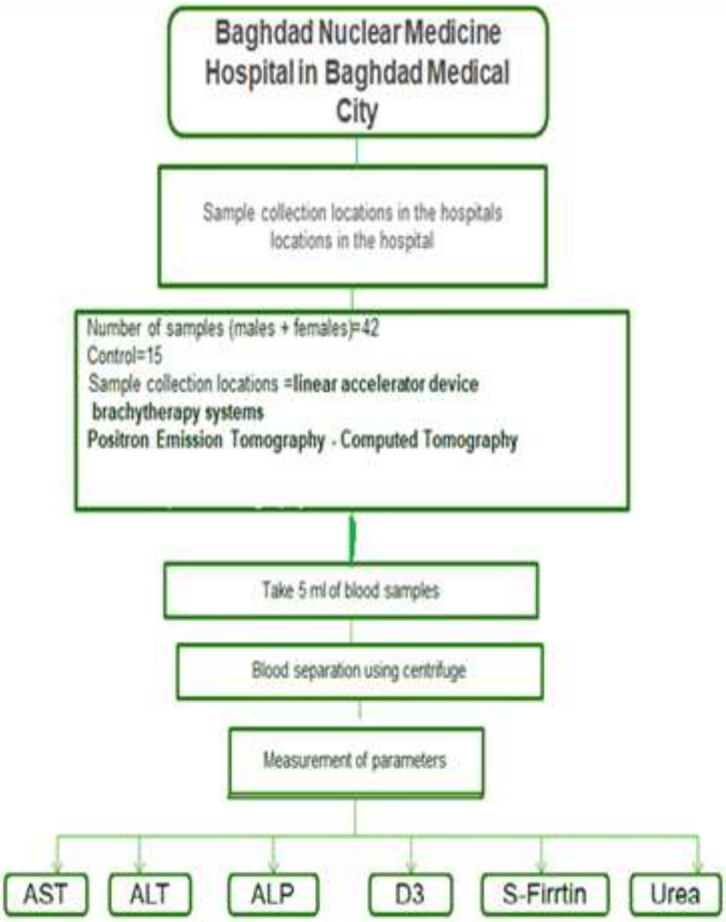

Figure 3. Histogram Sample Collection.

2.4. Statistics Evaluation

All statistical analyses were conducted using Excel. Quantitative data were described using means and standard deviations, whilst qualitative variables were expressed using absolute frequencies and percentages. The two groups' characteristics were compared using unpaired and two-tailed variables (T-test). The difference between the two groups was deemed statistically significant if the p-value was less than 0.05.

3. Results and Discussion

The data that was obtained for the parameters was under the study of p-value < 0.05. The parameter that was measured for comparison between the samples of those working on ionizing radiation and the control samples. If the parameters are higher than 0.05, this means that they are non-significant to the samples, and the enzyme parameters, in addition to D3 and iron stores, are non-significant because they are higher than the p-value specified for the study. However, if the results of the parameters are less than the p-value of 0.05, this means that the parameters are significant, and the urea parameter is the only one under this study for the samples of the significant group, so it is less than the p-value specified for the study, as shown in the table 1. Although there was a high difference between the mean and standard deviation between the control samples and the samples of hospital workers exposed to radiation, the liver enzymes ALT and AST decreased in the mean and standard deviation, while the enzyme ALP decreased. On the other hand, in this study, there was an increase in the parameters of S-FIRTTIN and D3 stores between the control samples and the samples exposed to radiation, as shown in figure 4. The use of radiation in various fields, the most important of which is the field of medicine, is a phenomenon that has helped in the discovery and treatment of many diseases, the most important of which is cancer. Therefore, the dose that suits the patient must be taken into consideration and determined without affecting those working in the health field. Each form of radiation has a health effect on the body. The amount of this dose is transferred to affect the DNA, cells, tissues, and organs. The amount of this effect increases the deeper the radiation penetrates the body. The cells most exposed to radiation are the cells that are constantly dividing [26]. The use of ionizing radiation in treatment and diagnosis is considered a rescue tool for many medical conditions. Still, fear of future harms from exposure to different doses of radiation has been an obstacle to this application in the medical field. Therefore, determining doses for treatment and not using doses in which the threshold limit is exceeded in treatment ensures treatment for the patient and safety for the worker on ionizing radiation [27]. Low doses of ionizing radiation are also used in immunotherapy [28]. There are many challenges for health workers as a result of their radiation exposure. Low doses of ionizing radiation lead to changes in many parameters in the body. Failure to take the necessary precautions to protect against this radiation leads to damage to some rays and changes in some brakes and the possibility of contracting fatal diseases such as cancer [29] Ionizing radiation affects the body through a direct effect by causing damage to the body, tissues or organs, or an indirect effect through oxidative and reductive stress, which leads to the generation of free radicals. These radicals, through different mechanisms, cause damage to biological molecules, as well as the body and others. There are special enzymes that work to reduce these free radicals and thus reduce the level of their danger in the body. If the percentage of these antioxidants decreases significantly, the risk of radiation causing damage increases [12, 30]. It is well recognized that oxidative stress and free radicals are bad for human health. Numerous studies demonstrate that free radicals play a role in the onset and development of multiple diseases associated with oxidative stress. As a class of substances that can impact people's health, these substances have drawn a great deal of interest in the field of biomedical research, not just because of their effectiveness in preventing illness and/or therapy, but also due to the prevailing belief that they're safe [31]. Suppose the amounts of free radicals generated by oxidative stress are higher than the body's defense systems. In that case, the damage resulting from continuous exposure to small doses of ionizing radiation becomes clear over time [32]. The study of the decrease in antioxidants is evidence of the indirect effect of radiation, which leads to the generation of oxidative stress, which generates various radicals that will play a role in affecting many parameters in the body. Continued exposure to radiation, with increased working hours and years of service on the device, and the accumulation of low-dose radiation doses may lead to harm to technicians working on ionizing radiation [12]. Other factors may be combined with the small dose of ionizing radiation to which health workers are exposed and lead to various changes [33]. The study of high radiation doses on health workers and the focus on the resulting dangers has led to the neglect of the study of low radiation doses and the attempt to understand the future damages that are sometimes fatal [34]. The liver is considered the most sensitive organ to danger, so studies should be conducted that include examination and assessment of the risk of exposure to ionizing radiation for technicians working in hospitals on radiation devices, as well as measuring some parameters in the liver. To know the negative effects that occur to the body as a result of continuous exposure for long periods [35]. An increased ALT level is typically indicative of a condition such as Hepatitis, cirrhosis, hemochromatosis, fatty liver, and liver cancer. Liver illnesses, including pancreatitis, mononucleosis, toxic medications, and tumors, are among the potential reasons. Among them are: Hemochromatosis, hepatitis, a heart attack, or a liver attack. Among the reasons are malignancies, mononucleosis, toxic medications, trauma, and celiac disease. Pancreatitis is the name given to the illness. Anomalous alkaline phosphatase results. This illness has multiple origins, including hepatitis and biliary blockages, rickets, leukemia, hyperparathyroidism, Paget's disease, hypophosphatemia, insufficient protein, etc. The unusual Bilirubin levels can result in cirrhosis, jaundice, hepatitis, Gallbladder, pancreas, or Gilbert disease [36]. Chronic exposure to radiation, especially among technicians who use medical imaging tools, may contribute to chronic diseases, including kidney dysfunction. The current study found a significant change in kidney biochemical profiles that could lead to the development of kidney disease risks [1]. Some other markers of hospital workers' exposure to ionizing radiation, such as vitamin D3 [37], were also studied. In this study, results were reached when some parameters for workers were studied. It was found that there was no change in the readings obtained between workers exposed to ionizing radiation and between control samples for parameters (ALT, AST, ALP, D3 and S-firrtin). The doses of ionizing radiation during the hours and years of work of the technicians on the device had no effect, as these markers were not under the p- value of 0.05 except for the urea parameter which be significant under this value The presence of most of the parameters was not Significant as a result of the slight effect of ionizing radiation on the body and only the urea parameter, which affected the samples to a small extent. This is what we found with a slight difference from the control samples, and this indirect effect could be attributed to radiation [38].

Table 1. Measured parameters in this study.

Parameter	Exposed Group mean ±SD.	Unexposed Group mean ±SD.	P value
ALT	26. 88±16.20	21.30±4.65	P>0.05
AST	32.03±16.35	18.5±5.12	P>0.05
ALP	78.31±23.34	198.13±34.49	P>0.05
UREA*	26.97±6.66	27.29±2.77	P<0.05
D3	17.95±9. 89	47.34±23.29	P>0.05
S-FIRTTIN	54.01±41	58.14±63.66	P>0.05

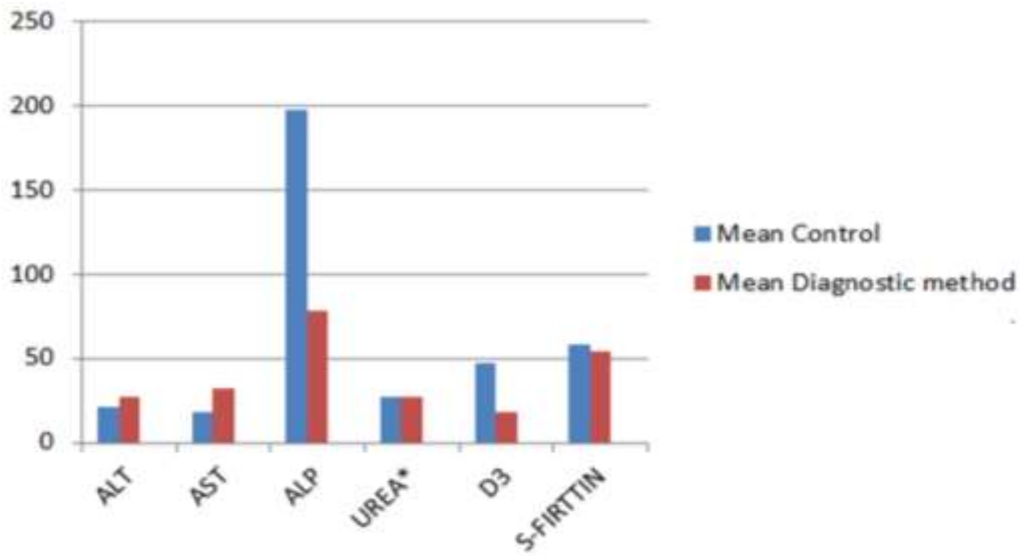

Figure 4. Measured parameters.

4. Conclusions

Hospitals are studying certain markers related to ionizing radiation to gauge the level of risk health workers encounter when using devices for extended periods. The identification of certain clinical markers as biomarkers for determining radiation dose to the body makes it necessary for healthcare workers to take precautions to ensure occupational safety. Radiation effects on hospital workers were determined using urea as a biomarker.

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