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The Effect of X-Ray Radiation on Malondialdehyde Levels in Radiology Workers in Hospitals

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Abstract

The radiology unit uses ionizing radiation sources for disease diagnosis. Radiation of ample energy can ionize matter as it traverses. The purpose of the study is to analyze the effect of effective doses of X-ray radiation on malondialdehyde (MDA) levels. The design of this study is observational. The study is quantitative. The study is cross-sectional. The study was conducted in hospitals X and Y from January 2023 to April 2023 and involved 19 radiographers who work directly with X-ray radiation exposure. Based on the data in Table 3, all respondents show abnormal blood malondialdehyde (MDA) levels. The effective dose of radiation has no effect on MDA levels. The findings yield extra data on MDA, its link to oxidative stress, and radiation impact. All radiation doses received are deemed safe, participants exhibit abnormal blood MDA levels, work hours impact MDA levels, and effective radiation doses have no influence on MDA levels.

Keywords: *Radiation, hospital, ionizing, X-rays, MDA, safe work*

Introduction

Hospitals have several units to address health and disease-related issues, and one of them is the radiology unit, which functions for diagnosis, treatment, and care. The radiology unit uses ionizing radiation sources for disease diagnosis, such as X-rays, which are a form of ionizing radiation.

According to a study (Ardiny, 2014), ionizing radiation has enough energy to ionize atoms and molecules of the matter it passes through, causing ionization processes. Some types of ionizing

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radiation include alpha (α) and beta (β) particles, gamma (γ) rays, neutrons, and beta (β) particles, which can cause direct ionization. Although X-rays, gamma rays, and cosmic rays have no mass and electric charge, they are considered ionizing radiation because they can cause indirect ionization.

Based on the study (Ardiny, 2014), ionizing radiation can cause stochastic effects, meaning that even the smallest radiation dose that passes through the body can cause damage to cells. X-ray radiation is one of the sources of ionizing radiation in hospitals, and according to the Nuclear Energy Regulatory Agency (2011), ionizing radiation has high energy that can cause ion formation.

While this energy can be beneficial to humans in small amounts, excessive exposure can be harmful.

According to (Simanjuntak et al., 2013), medical activities that use radiation make up the second-largest source of radiation exposure, accounting for 20% of all sources. Excessive radiation exposure can cause skin reactions, hair loss, damage to normal functions (such as radiation pneumonitis), carcinogenesis, and genetic effects. X-ray radiation can damage cells directly or indirectly. Direct damage occurs to specific targets, such as DNA/RNA in the nucleus. Indirect damage occurs due to free radicals. Excessive formation of free radicals can have adverse effects, from disrupting cellular communication to various pathological conditions, and is believed to be involved in cell death (Freitinger Skalická et al., 2012).

When radiation enters the body, it acts as a free radical. Free radicals can be influenced by antioxidant enzyme activity in the body. Oxidative stress occurs when there is an imbalance between the amount of free radicals and the body's ability to destroy them. One sign of increased oxidative stress is high levels of malondialdehyde (MDA) in the body. Oxidative damage can cause damage to various cells, tissues, and organs, which is one of the consequences of uncontrolled oxidative stress in the body. One example of damage to cells, organs, and tissues in the body is liver dysfunction (McKee & McKee, 2003).

According to (R, 2006), if blood sugar levels increase, sugar will be filtered from the blood and supplied by the vein vessels in the liver, where it will be stored in glycogen. If blood sugar levels decrease, the liver will break down the sugar in glycogen and release it into the blood. Based on this information, further research is needed to determine whether there is an effect of effective radiation doses on malondialdehyde (MDA) levels and liver function in radiographers in hospitals.

The purpose of the study is to analyze whether there is an effect of effective doses of X-ray radiation on malondialdehyde (MDA) levels.

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Methods

This study design is an observational study, as it only involves observation of variables without any intervention. The study is quantitative based on the type of data and analysis. The study is cross-sectional, as data collection from the dependent variable is done only once during the study. The study was conducted in hospitals X and Y from January 2023 to April 2023, and involved 19 radiographers who work directly with X-ray radiation exposure.

Variable measurement methods

The primary and secondary data for this study were obtained from the hospital and are as follows:

1. Secondary data obtained were the results of personal monitoring measurements (Film Badge), issued by the Health Facility Security Agency (BPFK) Surabaya.
2. A questionnaire was used to conduct direct interviews with relevant workers about age, length of service, working hours, and worker characteristics.
3. Malondialdehyde (MDA) testing for workers was obtained from the integrated laboratory of the Faculty of Public Health.

Data analysis

The research data was analyzed using SPSS. The following data analysis tests were used:

1. Descriptive analysis

Descriptive analysis was conducted on each variable of the research results using a frequency distribution table to produce the distribution and percentage of each research variable. The data presented includes the mean, median, minimum and maximum values, standard deviation, and coefficient of variation for numerical data, and percentage or proportion for categorical data.

2. Bivariate analysis

Bivariate analysis was conducted by performing a simple regression analysis to test the effect of one independent variable on the dependent variable.

3. Multivariate analysis

Multivariate analysis was conducted to examine the effect of two or more variables that are suspected to influence each other. This analysis was performed to determine the effect of independent variables on the dependent variable using a significance level of $\alpha < 0.05$. The analysis used logistic regression statistical tests.

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Results

Identification of Effective Radiation Dose

Table 1. Effective Dose Results for Radiographers' Radiation

Variable	Category	Frequency (n)	(%)
Effective Dose	Safe	19	100
	Not Safe	0	0
Total		19	100

From **Table 1**, it is shown that the effective dose is in the safe category of 100% in the blood. The results of the annual effective dose examination in the blood conducted on 19 radiographers at hospitals X and Y can be seen:

Table 2. Annual Effective Dose Examination Result.

Annual Effective Radiation Dose	Value
Frequency (n)	19
Minimum	0.7
Maximum	0,746
Mean	0,707
Std. Deviasi	0,0412

From **Table 2**, it is shown that the highest annual effective dose in the blood was found in radiographers at hospitals X and Y, which was 0.746.

Identification of Malondialdehyde Blood Test

Table 3. Radiographer Blood Examination Results.

Variable	Category	Frequency (n)	(%)
Malondialdehyde (MDA)	Normal	0	0
	Abnormal	19	100
Total		19	100

From **Table 3**, it is shown that the examination results of Malondialdehyde (MDA) in the blood indicate that all respondents have abnormal levels of **MDA** in their blood. The results of the examination of Malondialdehyde (MDA) in the blood conducted on 19 radiographers at hospitals X and Y can be seen in **Table 4**:

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Table 4. Blood Malondialdehyde Examination Results.

Malondialdehyde (MDA)	Value
Frequency (n)	19
Minimum	3,620
Maximum	5.741
Mean	3.593
Std. Deviasi	1.404

From **Table 4**, it is shown that the highest level of Malondialdehyde (MDA) in the blood was found in radiographers at hospitals X and Y, which was 5.741 nmol/ml.

Table 5. Analysis of the Effect of Individual Characteristics on MDA Levels.

	Unstandarized Coeffisients		Sig	Information
	B	Std. Error		
Age	0.080	0.70	0.252	No effect
Working hours	0.620	0.574	0.280	No effect
Gender	-1.200	1.515	0.428	No effect
Work period	-.044	0.294	0.881	No effect
Education	-22.481	40192.977	1.000	No effect

To test the effect of individual characteristics on MDA levels, a backward Wald logistic regression test was used. From **Table 5**, it is known that individual characteristic variables (age, education, gender, working hours, and work period) did not have a significant effect on MDA levels, as indicated by a significance value > 0.05. This means that these variables do not have a direct effect on MDA levels.

Table 6. Analysis of Radiation Effective Dose on MDA Levels.

	Unstandarized Coeffisients		Sig	Information
	B	Std. Error		
Effective dose	20.984	17.793	0.238	No effect

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It is known from **Table 6** that the effective radiation dose variable did not have a significant effect on MDA levels, as indicated by a significance value > 0.05. This means that this variable does not have a direct effect on MDA levels.

Discussion

Effective radiation dose

Radiation dose monitoring is an activity carried out to determine the level of radiation exposure to each radiation worker while working in the Radiology Installation.

The dose monitoring of personnel is carried out using film badges or TLD badges, and direct-reading personal dosimeters that have been calibrated. These tools function to measure the dose received by radiation workers.

If workers do not monitor their dose, they will not know how much radiation dose they have received while working. Hospitals X and Y have conducted individual radiation dose monitoring using TLD badges for radiographer personnel. TLD badges function to measure the dose received by radiation workers. If radiation workers do not use TLD badges, they will not know how much radiation dose they have received while working. The purpose of this dose monitoring is to ensure that the radiation exposure received by workers is below the NBD, and the hospital must provide individual dose monitoring tools. Radiology installations at hospitals X and Y perform individual dose monitoring using TLD badges, where readings are done indirectly and must be sent to the Health Facility Security Agency (BPFK) for evaluation. The results of the dose monitoring evaluation are received by radiation protection officers from the BPFK and are informed to each personnel.

Radiographers in this study received an average dose of 0.70 mSv per year, which is much lower than the minimum annual dose limit set by the International Atomic Energy Agency (IAEA) of 20 mSv.

However, this should still be monitored due to the stochastic effect, where stochastic effects are related to low-dose radiation exposure (0.25-1000) that can cause cancer (somatic damage) or genetic defects (IAEA, 1996). In stochastic effects, there is no known threshold dose, and any radiation dose received by the body, no matter how small, can cause cell damage. The effect occurs long after exposure and is only experienced by some of the exposed group. The severity does not depend on the radiation dose, and there is no spontaneous healing (Akhadi, 2000).

The workload is calculated based on the number of examinations performed. The more examinations performed by a radiographer, the higher the radiation dose received (Sigurdson et al., 2008).

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The radiation dose received by radiographers and other radiation workers is an accumulation of small daily doses received each working day in performing examinations.

Although weak, daily radiation exposure can result in cumulative chromosomal translocation. If a radiographer works in a department that uses high radiation, such as CT-Scan and interventional radiology, then rotation or shift changes are necessary (Bhatti et al., 2008).

Malondialdehyde (MDA)

In this study, the MDA levels were measured using blood samples from 19 radiographers, which were analyzed using the Thio Barbituric Acid Reactive Substances (TBARS) method. This method uses a spectrophotometer based on the color absorption formed from the TBARS and MDA reaction. The MDA level examination was carried out at the Nutrition Laboratory of Airlangga University. The average MDA level in this study was 3.93 nmol/ml, with the highest MDA level being 5.741 nmol/ml and the lowest value being 2.779 nmol/ml. The normal MDA level in humans is 1.076 nmol/ml.

Based on this study, all workers had MDA levels $\geq$ 1.076 nmol/ml, and all radiographers had abnormal MDA levels. The health effects of chemical exposure can be influenced by a person's age because it can be related to an individual's physical and physiological condition when exposed to chemicals.

A study by (Fatimah & Warno Utomo, 2020)stated that workers over 32 years of age are at risk of having higher MDA levels compared to workers under 32 years of age. According to (Suma'mur, 1996), the human body's resistance to toxic chemicals is also influenced by age. Gradual increases in disease risk, decreased physical and mental capacity are conditions caused by aging (WHO, 2018).

Malondialdehyde (MDA) is a dialdehyde compound that is the end product of lipid peroxidation in the body (Ayala et al., 2014). High MDA concentrations indicate oxidation processes in cell membranes. MDA levels in erythrocytes and plasma have been used as markers of tissue damage due to in vivo free radicals (Seçkin et al., 2014).

The more stable chemical properties of MDA make it more commonly used as a marker of oxidative stress than other compounds. Several studies have shown that MDA is a stable and accurate component of lipid peroxidation measurement and has helped explain the role of oxidative stress in several diseases, including skin diseases (Grotto et al., 2009).

Oxidative stress is a condition of imbalance between pro-oxidants and antioxidants. This is caused by the formation of ROS that exceeds the antioxidant defense system's ability, or the ability of antioxidants decreases or remains constant. In physiological conditions, antioxidants as the body's defense system can protect cells and tissues against these ROS.

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A postulate of the 'Free Radical Theory' states that with the accumulation of damage caused by free radicals and oxidative stress, a number of biochemical and cellular processes begin to run abnormally (Nuttall et al., 1999). The condition where the level of free radicals in the body is higher than the level of antioxidants in the body can increase the MDA level.

The research results showed that all workers had MDA levels >1,076 nmol/ml, and workers with MDA levels above the mean value of 3.593 were mostly workers with long working periods of >10 years. Workers who work for a long time in a poor work environment will increase the risk of health problems.

This is supported by research conducted by (Yanti et al., 2019) that continuous exposure to X-ray radiation can increase the risk of cumulative radiation exposure during work that can affect long-term health. Research by (Nishi et al., 1986) showed that there was an increase in malondialdehyde levels in the submandibular gland of Wistar rats 7 days after X-ray radiation, and in plasma, lipid peroxidation levels increased at 2 hours, 7 days, and 14 days after radiation. Radiation exposure can trigger excessive free radicals and cause the body's defense system to be unable to overcome them, resulting in oxidative stress that can be marked by high MDA levels.

Analysis of the Effect of Effective Dose of X-ray Radiation on MDA Levels.

Radiation can cause ionization in tissues or media that it passes through. To measure the amount of radiation energy absorbed by the medium, a quantity that does not depend on the type of radiation, the type of radiation, or the properties of the absorber, but only depends on the amount of radiation energy absorbed per unit mass of the material receiving the radiation, needs to be introduced.

Absorbed dose is defined as the amount of energy delivered by radiation or the amount of energy absorbed by the material per unit mass of that material. The radiation dose received by the body can cause DNA damage, triggering the activity of the p53 gene, which plays a role in the process of cell death or apoptosis. Apoptosis is programmed cell death that aims to maintain cell population stability.

Oxidative damage causes damage to various cells, tissues, and organs caused by uncontrolled oxidative stress in the body. Liver dysfunction is one of the impacts of oxidative stress in the body. One sign of increased oxidative stress is indicated by high levels of MDA in the body (McKee & McKee, 2003). An increase in MDA levels indicates an increase in free radicals in the body. One prevention effort to deal with an increase in radicals in the body is to consume vegetables and fruits that contain vitamin C and E regularly to increase the antioxidant content in the body (Dwicahyo, 2020).

The research results showed that there was no effect of effective X-ray radiation dose on MDA levels. This is supported by research conducted by (Khoshbin et al., 2015) in three stages of treatment using radiation, where all patients received a radiation dose of 54 Gy in the chest wall and supraclavicular area as a standard protocol given by the Phoenix radiotherapy machine. The first sample was taken before starting chemotherapy, the second sample was taken before radiation therapy, and the third sample was taken after radiation therapy, showing no significant difference in MDA levels between the three stages of treatment.

Malondialdehyde (MDA) is a marker of lipid peroxidation and is widely used to assess cell damage. An increase in MDA levels can be caused by high levels of Reactive Oxygen Species (ROS), which are free radicals that play an important role in the physiological processes of the body's organs. Research conducted by (Al-Nimer & Ali, 2012) reported that radiology personnel showed higher plasma malondialdehyde (MDA) levels than the control group (non-irradiated). The radiation dose for each exposure is estimated simultaneously and individually up to 500 Kev is used in X-ray radiation per exposure. This indicates that radiation can increase oxidant levels (including MDA and hydroperoxides) in plasma, and a wide dose range shows its potential use as a biomarker in biodosimetry.

Conclusions

1. The radiation dose response received by the respondents is safe.
2. The MDA levels of all respondents are abnormal.
3. There is an effect of working hours on MDA levels.
4. There is no effect of effective radiation dose on MDA levels.

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Conflicts of Interest

The authors declare no conflict of interest

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