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Thyroid gland and vocational exposure to low dose ionizing radiation in health

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ABSTRACT: Healthcare workpeople may be exposed to low-dose ionizing radiation for both diagnosis and treatment purposes. In addition, one of the radiation-sensitive organs in humans is the thyroid gland. This study aimed to investigate the changes observed in thyroid structure and functions in healthcare workers exposed to occupational radiation. Radiological imaging procedures are among the leading applications of exposure to ionizing radiation. Radiotherapy, one of the treatment options for radiosensitive tumors, is one of the areas in medicine where ionizing radiation is used. Nuclear medicine, another field of medicine in which ionizing radiation is used, is the largest theranostic field in which radioactive substances are used. The risk of hypothyroidism increases in healthcare workpeople exposed to low-dose ionizing radiation. Additionally, this exposure has been related with an effect on thyroid hormones and an increased likelihood of developing thyroid immune diseases. Additionally, female radiation healthcare workpeople have higher levels of abnormal thyroid nodules, triiodothyronine, and thyroid-stimulating hormone than their male counterparts. In addition, abnormal thyroid nodules, triiodothyronine and thyroxine levels increase with age in people in this occupational group. On the other hand, exposure to low-dose radiation was not associated with the risk of thyroid cancer in these healthcare workers. As a result, occupational exposure to low-dose radiation can cause damage to the thyroid gland, which is a radiation-sensitive organ. In order to prevent health problems in the functions and structure of the thyroid organ, those who are occupationally exposed to ionizing radiation should apply personal protection methods as meticulously as possible.

Keywords: Radiation, Thyroid, Triiodothyronine, Thyroxine, Healthcare professional, Hypothyroidism.

INTRODUCTION

Ionizing radiation describes the flow of photons of electromagnetic radiation or particles of material that can ionize the atoms of the medium through which it passes. Damage at the cellular level can occur through changes in cytogenetic information or cell death. These events can lead to deterministic effects (adverse tissue reactions) or cytocastic effects by exceeding the dose threshold of symptoms (Havránková 2020). Ionizing radiation, whose worst cytological impact on the human is cell death, has begun to be used more widely in daily life with rapid technical developments (Jiao et al., 2022). Although ionizing radiation, which is an important application area in medicine in terms of both diagnosis and treatment, contributes to significant advances, it is not without risks. This risk includes a threefold increase in patient exposure to medical radiation since 1982. Although some potential risks are known, difficulties remain in measuring these risks (Chambers, 2017).

Current knowledge from health studies about the mechanisms of damage to living organisms by exposure to certain doses of ionizing radiation is based on the theory of "cytochastic breakage" of two strands or one strand of the deoxy ribonucleic acid (DNA) double helix. According to this theory, high doses of ionizing radiation can damage both DNA strands, causing breaks that can be fatal to the cell, while low doses of ionizing radiation can mostly cause easily repairable and nonpermanent breaks in single strands. On the other side, exposure to low doses of ionizing radiation has been shown to cause carcinogenic effects in both exposed people and later generations, even years later. Additionally, cells that survive after exposure to low doses, although apparently normal, accumulate damage that becomes apparent in their progeny, such as non-clonal chromosomal abnormalities, which can be detected even in cells that are not directly irradiated due to the complex tissue network and molecular signaling pathways (Burgio et al., 2018). In an epidemiological study, radiation-induced genomic instability is associated with cancer incidence. (Eidemüller et al., 2009). Streffer (2010) explored evidence for the role of genomic instability in carcinogenesis. He concluded that genetic predisposition to increased radiation sensitivity is associated with cancer susceptibility and increased genomic instability.

The thyroid gland is the largest endocrine organ and is located in the front of the neck. It contains and uses iodine to synthesize triiodothyronine (T3), thyroxine (T4) and thyroid hormones which regulate metabolism growth and other significant physiological processes of the people (Braverman ve Cooper, 2012). The thyroid gland is one of the organs in the people that is more sensitive (radiosensitive) to radiation than other organs. Significant radiation effects caused by hypothyroidism can be observed after high doses of irradiation. Unlike hypothyroidism, neoplasia is one of two major adverse consequences caused by radiation to the thyroid in humans (Virgili, 2020). On the other hand, it is stated that medium or low doses of irradiation may

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have a temporary effect on hypothyroidism and autoimmune thyroiditis, and if present, this effect is reversible (Nagayama, 2018).

The effect of ionizing radiation may occur through cell damage, cell death, or alteration of cytogenetic information. On the other hand, in medicine, both patients and healthcare professionals may be exposed to ionizing radiation for both diagnosis and treatment purposes. The thyroid gland, the largest endocrine gland, is one of the radiation-sensitive organs in our body. This study aimed to investigate the changes observed in the thyroid gland structure and functions of healthcare workpeople exposed to low dose ionizing radiation for a long time.

MATERIALS AND METHOD

In order to better understand the changes observed in the thyroid gland structure and functions of healthcare workpeople exposed to low dose ionizing radiation for a long-time, a literature review was conducted using the Web of Science, PubMed, Google Scholar and Scopus databases. The words "radiation", "thyroid", "triiodothyronine", "thyroxine", "healthcare worker" and "hypothyroidism", a health problem caused by radiation in the thyroid gland, were used as keywords. 30 articles were selected, taking into account their citation numbers and publication dates.

In the literature review, first of all, the areas where ionizing radiation is used in medicine were touched upon. In addition, a topic related to ionizing radiation and thyroid function structure was created. In the studies evaluated as reference, studies specifically related to healthcare workpeople were included.

USE OF IONIZING RADIATION IN HEALTH

Medical practices constitute the majority of artificial radiation sources to which people are exposed (Tuncel, 2008). The most important of these are radiological imaging procedures. Ionizing radiation are used in fluoroscopy, radiography, computed tomography (CT) and angiography. Imaging methods using ionizing radiation are frequently used in various health fields with advances in radiological imaging technology (Divrik Gökçe et al., 2012). In recent years, in parallel with the development of advanced technology devices such as multi-detector CT, dynamic contrast-enhanced, faster and higher resolution studies such as cardiac CT, virtual CT colonoscopy and CT angiography have become possible (Flohr et al., 2005). This has led to increased demands from clinicians for radiological studies and increased exposure of patients to ionizing radiation in order to re-plan treatment plans and diagnostic approaches (Divrik Gökçe et al., 2012). While CT constituted 4% of radiological applications in England in 1990, the proportion of CT in radiological applications reached 10% in 2000. These CT rates have been reported to be accountable for the majority of patient exposure to ionizing x-ray compared to the United States (UNSCEAR 2000). The increasing amount of ionizing radiation received from controllable artificial radiation sources creates a lifelong cancer risk and therefore threatens public health (Hall ve Brenner 2008).

Tumors are more prone to radiation damage than normal tissues (Minniti et al., 2012). Therefore, continues to be one of the most effectual cancer therapies. However, Personalized radiotherapy, which enables therapy according to the biological characteristics of normal tissues and individual tumors, needs to be implemented in the clinic (Domina et al., 2018). It has been known for many years that ionizing radiation has not only local effects, but also systemic impact by triggering several biochemical signaling pathways (Carvalho ve Villar, 2018). Although local irradiation is applied during cancer radiotherapy, ionizing radiation causes observable whole body reactions at blood metabolome and proteome values. In radiotherapy, irradiated tissues are affected by the volume and dose of radiation, while the blood molecular composition is a putative source of markers for monitoring and predicting systemic responses to radiation and radiation dose assessment (Jelonek et al., 2017). The clinical effectiveness of radiotherapy, which remains an effective conventional therapy method for cancer patients, may be compromised by the development of radiation-resistance in tumor cells at the time of therapy (Lu et al., 2022).

Nuclear medicine is the great protagonist of theranostics, which relies on radioactive substances to image biological events and deliver ionizing radiation to the tissues that receive these substances. With the advent of personalized medicine, nuclear medicine has gained importance, allowing personalized management of diseases, improving patient selection, better predicting responses, reducing toxicity, and predicting prognosis (Nunes et al., 2021). Standard radiographic procedures have mean effective doses ranging from 0.01 to 10 mSv, whereas the mean effective dose for many nuclear medicine examinations ranges from 0.30 to 20 mSv (Mettler et al., 2008). It is an undeniable fact that interventional radiology workers, another area of use of ionizing radiation in medicine, are exposed to the highest dose of ionizing radiation, and the exposure rates of nuclear medicine workpeople to ionizing radiation are monitored (Liu et al. 2022).

IONIZING RADIATION AND THYROID

Radiation causes DNA damage mainly through ionizing molecular compounds in tissues exposed to ionizing radiation. Ray that causes radiation is absorbed either directly in critical cellular structures such as membranes, organelles, and DNA, or indirectly through the induction of highly free oxygen radicals in the aqueous cytosol. In the presence of molecular oxygen, the likelihood of transient free radicals causing molecular damage increases, which helps stabilize biochemical damage (Minniti et al., 2012). Damage caused by radiation is a complex structure consisting of interconnected signaling pathways that can result in DNA repair defects, cell damage, apoptosis, and cancer. The thyroid cancer development in effect to radiation, from long-term x-ray exposure to nuclear disasters, has long been a subject of research. A fundamental overview of the effects of non-ionizing and ionizing radiation on thyroid gland alteration and cancer development is provided (Albi et al., 2017). Ionizing rays, which are considered to be a well-known risk factor for papillary thyroid tumor, have been found to release microRNA expression, which is significant for thyroid carcinogenesis. It shows that ionizing radiation deregulates microRNA expression, impairing the repair efficiency of irradiated thyroid cells by affecting double-stranded DNA (Penha et al., 2018).

Cioffi and colleagues (2020) conducted a study on thyroid functional changes with exposure to low-dose ionizing rays in healthcare workpeople. Cioffi et al. (2020) concluded that exposure to low doses of ionizing rays significantly affects thyroid-stimulating hormone (TSH), free thyroxine (fT4) and free triiodothyronine (fT3) levels. In addition, although no connected could be found with the ionizing radiation exposure category, it is stated that it indicates a possible increase in the hypothyroidism risk in healthcare workpeople (Cioffi et al., 2020). As a similar result, Luna-Sánchez et al (2019) observed that the risk of subclinical hypothyroidism increased depending on radiation doses (Luna-Sánchez et al., 2019). A recent study of healthcare professionals occupationally exposed to ionizing rays found that exposure to low doses of occupational ionizing radiation affects T3 and T4 values, and is associated with a higher likelihood of developing auto-immune thyroid illness (El-Benhawy et al., 2022). In another study conducted with 1039 healthcare workers, it was concluded that the annual cumulative dose of ionizing radiation was positively correlated with fT4 and tT4 levels and negatively correlated with tT3 and TSH values. In addition, it was concluded that the risk of thyroid dysfunction increased as age and annual cumulative dose increased (Lu et al., 2022).

Prolonged exposure to low doses of ionizing rays can cause thyroid damage in medical professionals; This should be a wider concern (Tu et al., 2018). In a study with a sample size of 4308 radiation workers, abnormal thyroid gland was found in 14.3% of radiation healthcare workers. Additionally, abnormal thyroid nodule, which is the main symptom of thyroid gland abnormality, was detected in 5.1% of radiation healthcare workers, and abnormal thyroid stimulating hormone level was detected in 7.1% of radiation healthcare workers. It was determined that abnormal thyroid nodules, T3 and TSH values were higher in female radiation healthcare workpeople than in male radiation healthcare workpeople. It was stated that as working age increases, abnormal thyroid nodules and T3 and T4 levels also increase. It was concluded that ionizing radiation may cause thyroid damage in radiation healthcare workpeople. Therefore, more attention should be paid to ionizing rays protection management to protect the health of radiation workpeople (Yang et al., 2022). In a study evaluating the personal dosimeters of healthcare workpeople for 37 years, it was stated that long-term, low-medium dose ionizing rays exposure to the thyroid gland was not related with an increase in the risk of thyroid cancer (Kitahara et al., 2018).

CONCLUSION

As a result, long term exposure to low doses of ionizing rays can cause a significant change in the functions and structure of the thyroid gland, which is a radiosensitive organ. In order to prevent health problems in the functions and structure of the thyroid organ, which is the largest endocrine gland in the human body, healthcare workpeople exposed to ionizing radiation should apply personal protection methods as meticulously as possible. In addition, one should stay in radiation environments for a short time.

CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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