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ALARA Concept in Radiation Protection and Application in Radioiodine Treatment- A Short Review

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Abstract

Ionizing radiation is used in a variety of clinical, industrial, and research professions to efficiently carry out necessary tasks, but prolonged exposure to such radiation puts these workersat risk. As a result, as low as reasonably achievable (ALARA) safety regulations were created as a result to safeguard specialists who work with ionizing radiation by reducing their exposure to it. It is a crucial principle to abide by because it reduces radiation exposure while enabling radiationworkers to produce their best work. Thus, the main objective of this review paper is to prove that ALARA safety guidelines is the best way to protect professionals who work with ionizing radiationwhile not interfering with their ability to perform tasks successfully. Thus, this paper consists of the effectiveness of ALARA principle that applied for pediatric patients, radiation worker and also innuclear sector. Radiation protection measures must also be taken to prevent unneeded radiation exposure after treatment. Therefore, this review discussed (a) the radioactive iodine treatment (b) preparation for the patient before treatment (c) the side- effects of radio-iodine therapy as the content of this review.

Keywords: Radiation Protection, Radiation, Nuclear, Safety, Metabolism

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1. Introduction

Medical imaging is the main of radiation exposure. Nevertheless, evidence indicates that when receiving diagnostic scans, patients are not adequately informed about radiation exposure [1]. Most of all health physicians are concerned about ionizing radiation exposure because it results from prolonged, repeated exposure. ALARA measures, which include shielding, source reduction, maximizing distance, and minimizing time, are used to reduce doses [2]. Therefore, it is important to prioritize and treatradiation safety seriously [3]. Besides, it has appeared and changed ourgeneral conception of the biological sequel of ionizing radiation exposure. More significantly, there has been a cultural shift in how physicians, radiologists, parents, and patients in viewing theALARA principle's significance [4]. Good implementation and a radiationprotection initiative are used in current nuclear facilities as prerequisites for the operation of ALARA. It is a primary goal is to sustain ALARA personnel doses by limiting worker exposure to radiation hazards and radiation hazards themselves [5]. In the United States, thyroid cancer affects more than 40 000 people annually, with the vast majority of cases being well-differentiated thyroid cancer [6]. A thyroidectomy is the usualcourse of treatment for thyroid cancer with good differentiation.

After total thyroidectomy, radioactive iodine is frequently given to patients with visible, inoperable, iodine-avidmetastases to ensure complete eradication of residual thyroid tissue and to treat lingeringdisease. Since more than 80 years ago, radioactive iodine has been used in clinical practice asa very effective thyroid cancer treatment [7]. The medication is generally well tolerated. However, because patients must reduce their iodine intake and raise their levels of the thyroid-stimulating hormone before treatment, it can be logistically challenging for them. Radiation protection measures must also be taken to prevent unneeded radiation exposure after treatment. A low-iodine diet and discontinuing thyroid hormone replacement therapy have historically been the main methods of RAI preparation (LID). The former can now be avoidedin the majority of patients by using recombinant human thyroid-stimulating hormone (rhTSH), but there is disagreement over the precise indications, and prescribing habits vary dependingon the institutional practice. Similar to the previous example, there is a lack of high-levelevidence that supports the benefit of LID (and/or the ideal time to avoid iodine-containingfoods and medications), which leaves clinicians in the dark and causes patients' anxiety because they may worry that ingesting any iodine may reduce the effectiveness of treatment.

As ^{131}I is an unsealed isotope that emits both beta- and gamma-radiation, there are strict regulations governing the administration of treatment and monitoring following it, as well as specific radiation protection instructions [8]. Although an inpatient isolation period has alwaysbeen necessary, day-case ablation in an outpatient setting is gaining popularity. In both situations, release from the hospital is allowed when radioactivity tiers exceed a level that has been defined nationally, but the length and extent of restrictions differ significantly based on the local laws.

2. Effectiveness of ALARA on Pediatric Patients

When providing care for pediatric urology patients, the ALARA principle has beenelevated to the top of the list of priorities. Due to the cumulative nature of radiation exposure, children are most at risk for developing cancer. Children make up a very small percentage of patients receiving radiation therapy, with some departments treating pediatrics patients infrequently or never. It can be challenging to develop expertise in pediatrics imaging when thereare such small patient populations. Compared to adult patients, children may have a variety of different treatment needs, such as awareness of long-term effects, a potential need for anesthesia during treatment, and the need to modify procedures [9]. Pediatric Urology Radiation Safety Evaluation (PURSE) demonstrate that radiation exposure during pediatrics endourological procedures was not negligible. Thus, surgical procedures reduce patient exposure and improve fluoroscopic settings while it provides safety for pediatric patients [10]. Over the past ten years, there have been more imaging procedures related to radiotherapy planning and administration in addition to more diagnostic imaging procedures.

Computedtomography (CT) scans may be used to plan a patient's radiation therapy. Treatments like volumetric modulated arc therapy (VMAT) and intensity modulated radiation therapy (IMRT) arenow frequently available, and they frequently call for image guided radiation therapy (IGRT) to make sure the patient is positioned correctly for these precise treatments. More normal tissue mayreceive low-dose radiation thanks to IMRT and VMAT treatment methods and improved treatmentverification imaging. Greater normal tissue protection from the effects of radiotherapy can be achieved with IMRT and VMAT, which can reduce both acute and long-term radiation treatment side effects [9]. Proactive research demonstrates that a straightforward application of the ALARA justification and optimization principles can significantly reduce children's radiation exposure. Along with radiation awareness and better discussion between radiologists and physicians, suggestion, and recommendation regarding the appropriate demand for ultrasound, and CT are alsonecessary for developing nations where these practices are still developing [11].

3. Effectiveness of ALARA on Radiation Worker

Workers with exposure doses whether external or internal should be kept within the allowed range while nuclear power plants are operating. This ALARA principle should be appliedby all workers while it can be achieved by installing ventilation appliances, a radiation monitoring technique, and implementing a radiation protection strategy to lower down the amount of radiation doses. It also applies equally to the decommissioning operation.

Therefore, the policy is applicableto both individual and collective exposure doses. The evaluation is used to create a decommissioning plan. As a result, it's essential to optimize the decommissioning procedures, techniques, and safety equipment to assess the exposure dose of worker by looking at thedecommissioning plan beforehand [12]. An excessive external dose may cause cancer and benign tumors in some organs, among other stochastic effects. There is no threshold dose for radiation-induced cancers since all doses, no matter how small they are, are considered to increase risk. The U.S. Department of Energy (DOE)has confirmed that an outer of whole-body dose limit of 50 mSv/year in a way to bring down the risks of biological results linked to radiation. In the meantime, for the tissue DOE has establishedan extremity dose limit of 500 mSv/year. The effects of an excessive dose are deterministic up to acertain point below which radiation is not regarded as hazardous [13]. Thermo-luminescent dosimeters (TLDs), usually worn by the worker, measure the direct doses from external radiation sources. In order to determine how much neutron radiation has been exposed to the extremities, dosimeters at wrist are functionally worked to measure externally penetrating radiation. Most glovebox workers process TLDs and wrist dosimeters once a month. To block and reduce external radiation events, data on worker collective extremity and external dose have been examinate [12].

4. Effectiveness of ALARA in the Nuclear Sector

When nuclear power plants are decommissioned, a variety of radioactive wastes are created, including iron, alumina, scrap, soil, and concrete. As a result, a bio-shield wall surrounds the reactor and serves as a shield against external doses while it is operating by absorbing neutronsand gamma radiation released. Although the bio-shield has a long lifetime, its radioactivity variesseriously from one area of the building to another. The radioactivity is relatively high in bio-shieldconcrete because it is near the reactor. The Nuclear Safety Act dose limit should be adhered to during the performance of nuclear power plants [12]. To guarantee an appropriate strength of radiation protection, the minimization of all radiation doses has been tracked in accordance with the ALARA principle [13]. Regardless of whether they are PWRs or PHWRs, all nuclear power reactors are owned by Korea Hydro & Nuclear Power (KHNP), the sole holder of a nuclear license, and they all adhere to the same organizational dose limitations for their radiation protection project. Since radiation workers frequently perform maintenance tasks at two units. No one received a dose that exceededthe 50 mSv annual dose cap. Furthermore, since 2013, no person has ever received a dose of morethan 20 mSv/y. The ALARA program has been strengthened, and administrative dose constraints have been implemented. As a result, the dose issues have changed to low levels, and the supreme individual dose at Korean NPPs has gradually reduced from 29.8 mSv/y in 2009 to 13.7 mSv/y in2018 [13].

5. The radioactive iodine treatment

The radioisotope of iodine, iodide-131, is used in radioactive iodine (RAI) therapy (^{131}I). It haslong been used to treat thyroid disorders. Although it is safe and efficient, certain safety measures must be taken to reduce the small amount of radiation that the body and bodily fluidsmay expose other people to.

For differentiated thyroid cancer and hyperthyroidism, radioactive iodine (RAI) is regarded as one of the most important therapeutic modalities. ^{131}I emits beta particles and gamma rays with a half-life of 8.02 days, and the latter can destroy thyroid tissue locally [14]. In light of all these characteristics, administering ^{131}I can be a helpful adjunct therapeutic approach for thyroid cancer and hyperthyroid disorders. The use of RAI treatment as a supplement to therapy is likely to be crucial going forward given the significant rise in thyroid cancer incidence over the past few decades. Most often given as a capsule, ^{131}I is largelyexcreted in the urine after administration. Controversy exists regarding ^{131}I dosage for ablation. Outpatient treatment is a common method for low-dose ablation with doses under 30 mCi. The use of this strategy should berestricted to low-risk young patients who may benefit from overall less radiation exposure andwho are willing to accept the possibility that several low radioiodine doses may be required before successful ablation. Older high-risk patients, especially those with incomplete primarytumour resection, invasive primary tumours, tumours with intermediate differentiation, or metastases, should be given higher ablative doses ranging from 100 to 200 mCi in preference.

Recent research from two studies indicated that nearly all of the patients with "low-risk"differentiated thyroid cancer are likely to benefit from low-dose radioactive iodine ablation [15].Patients with thyroid cancer that has undergone a successful operation frequently use postoperative radioiodine ablation. The purpose of treatment is to remove any remaining thyroid tissue, stop locoregional recurrence, and enable long-term monitoring with whole-body iodine scans and/or stimulated thyroglobulin measurements. As an adjuvant therapy,radioiodine is also recommended to remove any subcutaneous cancerous cell foci that mightbe present in the thyroid remains and the body. Additionally, in the last ten years, this practicehas come under scrutiny [16]. Short-term morbidity and potential increases in the risk ofsecondary cancers are some of the consequences of radioiodine [17]. Finally, radioactive iodine can be used as both a diagnostic tool and a therapeutic agent to locate peoplewho have metastatic disease that has spread distantly and is responsive to radioactive iodine.

6. Preparation for the patient before treatment

A high blood level of thyroid-stimulating hormone (TSH, also known as thyrotropin), is necessary for RAI therapy to be as effective as possible. This hormone causes radioactive iodine to be absorbed by thyroid tissue, as well as cancer cells. There are a few ways to increase(TSH) levels if the thyroid has been removed before receiving RAI treatment which is to temporarily stop taking thyroid hormone supplements. When thyroid hormone levels are extremely low (hypothyroidism), the pituitary gland releases more TSH. Although this deliberate hypothyroidism is only temporary, it frequently results in symptoms like fatigue, depression, weight gain, constipation, muscle aches, and low concentration. Another approachis to receive a thyrotropin (Thyrogen) injection, which eliminates the need to withhold thyroidhormone for an extended period. After two days of taking this medication daily, RAI is administered on the third day. For RAI treatment to be effective, there must be both a relative iodine deficiency and ahigh TSH level (>30 mIU/l), which will cause ^{131}I to enter thyrocytes and/or DTC cells.

Traditionally, thyroid hormone replacement (levothyroxine for 3–4 weeks or liothyronine for 2 weeks) is stopped, and iodine intake is restricted for up to 3 weeks before treatment. It is wellknown that THW temporarily lowers the quality of life and can potentially worsen pre-existingmedical and psychological conditions. This prompted a different strategy, which is now workable thanks to the development of rhTSH. Iodine can also be found in a variety of sources, including medications and radiology contrast agents. However, the main method of preventingiodine deficiency is by reducing dietary intake. Before treatment, patients might need to followa low-iodine diet (LID) for a few weeks. This makes it possible for thyroid cells to absorb radioactive iodine. Iodine is present in all foods and beverages. Avoiding foods with a high iodine content is part of a low-iodine diet. According to the National Institutes of Health, an adult should consume 150 µg of iodine daily [18] Daily iodine intake is limited which is in the range of less than 50-100 µg per day [19]. Since fish, seafood, dairy products, and canned goods contain the highest amounts of dietary iodine, LID protocols advise avoiding or limiting their consumption. A significant source of iodine is thyroid hormone replacement therapy, but it can also be obtained through iodized salt, medications, and supplements. All things considered, it is advised that if LID is suggested, the duration should be 1 week, with a 2-week maximum. Vitamin supplements containing iodine should be avoided during the LID, but salt consumption is not required to belimited (unless it is iodized). It should be emphasized that patients may experience anxiety as a result of strict obedience to a LID. Avoiding foods may increase the pressure on patients while they are in isolation, so it is not advised.

7. Side-Effects of Radio-Iodine Therapy (RAI)

RAI has some side effects but is generally well tolerated and safe. Many of the adverse reactions start early and disappear quickly. Some, though, might take longer to manifest and end up staying. Local neck pain, sialadenitis, and gastritis are common early impacts of radio- iodine treatment that are not permanent and depend on the ^{131}I activities used [20]. The most common long-term side effect of chronic sialadenitis is xerostomia, which is characterized bytaste loss, an increased risk of developing cavities, and occasionally impaired lacrimal gland function. Increased individual measures for caries prophylaxis should be encouraged inxerostomia patients such as oral hygiene and dietary. Salivary glands are known to sustain short- and long-term radiation damage from ^{131}I treatment for individuals with differentiated thyroid cancer. It is necessary to take precautions to avoid this frequently occurring salivary gland impairment because this morbid aspect of ^{131}I therapy has significantly distressed patients. Differentiated papillary and follicular cancers have been successfully treated using ^{131}I, which is directed at the thyroid gland. This radioisotope simultaneously targets the salivary glands, where it is gathered and deposited into the saliva. The ^{131}I irradiation damages the salivary parenchyma in a dose-relatedsort of way. The parotid gland may exhibit swelling and discomfort. The symptoms might startto show up right away after receiving a therapeutic dose of ^{131}I or months later, and they mightget worse over time.

Secondary complications that have been reported in addition to radiation sialadenitis include xerostomia, taste changes, infection, increased caries, involvement of the facial nerves, stomatitis, candidiasis, and neoplasia. Utilizing sialagogic agents to speed up theradioactive iodine's passage through the salivary glands may help prevent ^{131}I sialadenitis. Amifostine has recently been recommended as a treatment for radiation side effects. Treatment options for the various complications that could arise include mouthwashes, sialagogic agents, duct probing, antibiotics, massage of the glands, sialagogic agents, and sialagogic agents. Problems with the salivary glands may be relieved by sucking on hard candy or chewinggum. Some people who receive radioiodine treatment also produce fewer tears, which causes dry eyes and excessive tear production. Men who undergo numerous RAI treatments and receive high cumulative radiation doses may experience decreased sperm counts or, in rare cases, infertility. Women's ovaries may be impacted by RAI, and some may experience irregular periods for up to a year after treatment. For six months to a year following treatment, many doctors advise against getting pregnant. Children born to parents who previouslyreceived radioactive iodine have not shown any negative effects. RAI therapy receivers may be slightly more likely to experience leukemia, stomach cancer, and salivary gland cancerin the future.

Although experts cannot agree on the precise amount by which this risk is increased, most of the largest studies have revealed that this complication is incrediblyrelatively rare. In the United States, thyroid cancer accounts for 3.8% of all new cancer cases, making it the ninth most prevalent cancer overall. Furthermore, it is the most prevalent endocrine cancer. It is possible to distinguish the most common thyroid cancer subtype, and the majority of patientsrespond well to the recommended course of treatment, which includes surgery and radioactiveiodine or observation. It is ideal for medical professionals with experience treating these cancers medullary and anaplastic to treat patients with other, uncommon subtypes of thyroid cancer. Targeted therapies with extended progression-free survival for differentiated and medullary thyroid cancers are available, but because they are not curative, they are only prescribed to patients with advanced or symptomatic disease. Since more than 80 years ago, radioactive iodine has been used in clinical practice as a very effective therapy for thyroid cancer. The medication is generally well tolerated. However, because patients must reduce theiriodine intake and raise their levels of the thyroid-stimulating hormone (TSH) before treatment, it can be logistically challenging for them.

8. Conclusions

Ionizing radiation is used in numerous professions in the clinical, industrial, and research fields in order to effectively complete necessary tasks, but long-term exposure to such radiation puts these workers at risk. ALARA safety guidelines were created as a result to safeguard specialists who work with ionizing radiation by reducing their exposure to it. Because it minimizesradiation exposure while enabling radiation workers to produce their best work, ALARA is a crucial principle to adhere to. The best way to safeguard professionals who work with ionizing radiation without interfering with their ability to effectively complete tasks is to abide by ALARA safety protocols. Following ALARA recommendations entails reducing the amount of time workers spend close to radiation sources, increasing the distance between them and the source, andinstalling a barrier to shield them from radiation. When these ideas are combined, radiation workers will always receive the lowest dose possible when they are close to a radiation source. The management tools used by endocrinologists to treat thyroid cancer and hyperthyroidism include radioactive iodine. The side effects, which can include dysgeusia, epiphora, and dysfunction of the salivary glands, are generally well tolerated, and effective, and pose a little radiation risk to family members. The patient may experience a side effect at any time, whether it manifests early or late. Ionizing radiation can cause cancer, but the likelihood of developing the disease is influenced by several variables, including the dose of radiation received, which organs were exposed to it, as well as the patient's age and gender. As a result, following treatment, the patient must receive adjuvant RAI therapy as determined by the treating clinicians. The type of cancer and tumour stage at the time of diagnosis affect the thyroid cancer prognosis and treatment. Numerous thyroid cancers are still microscopic, stable,and indolent. Total thyroidectomies for thyroid cancer patients increase survival and decreaserecurrence rates. To effectively treat thyroid cancer, ^{131}I must be used as adjuvant therapy.

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