

Impact of Nuclear Radiation on Living Cells and Human Health: Review

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Abstract: Our surroundings are constantly filled with radiation, both natural and man-made, which is essential to many industrial, medicinal, and scientific processes. Modifying possible health hazards and optimizing its advantageous applications require an understanding of its diverse forms, origins, and biological impacts. This review examines the complex relationships between radiation and human health, taking into account biological processes, historical viewpoints, health consequences, legal frameworks, and new issues. After providing a summary of the origins and evolution of radiation science, we investigate the biological processes that underlie cellular damage caused by radiation, such as (DNA) damage and repair mechanisms. In this research, we review the sources and types of ionizing nuclear radiation and their impact on human health.

Keywords: DNA damage, Beta particles, Gamma rays, Alpha particle.

1. INTRODUCTION

Our surroundings inherently include radiation, which has existed since the beginning of time. Due to environmental changes, there are notable amounts of ionizing radiation in our daily lives. It usually comes from the ground (terrestrial), outer space (cosmic), or even from within our own bodies (internal). It can be found in the food we consume, the water we use, the air we inhale, and the materials we utilize to build our houses. Natural radiation levels are higher in brick and stone homes than in wood-framed ones [1]. There can be significant regional variations in the amounts of background or natural radiation. Since the beginning of time, radioactivity has existed on our planet. Naturally occurring radioactive materials (NORM) are found in the earth's crust, as well as in the walls and floors of our homes, workplaces, and schools, and in the food and drinks we consume.

Natural radioactive elements can be found in our own muscles, bones, and tissues. When most people hear the phrase "radioactivity," they typically think of something extremely dangerous or lethal, particularly in light of the Chernobyl Disaster in 1986 or the 1945 atomic bombings of Hiroshima and Nagasaki. Conversely, people will come to understand that radiation may be used in a calm and advantageous way in our daily lives [2]. Ionizing radiation is defined as radiation with sufficient energy to liberate tightly bonded electrons from atoms, resulting in the creation of ions. We use this kind of radiation for its advantages in various manufacturing processes, to produce electricity, and to destroy cancer cells. The energy that atoms emit and that travels as electromagnetic waves (gamma or X-rays) or particles (neutrons, beta, or alpha) is known as radiation. Radioactivity is the term for this atom-to-atom breakdown that occurs spontaneously [3,4]. Human are exposed to sources of ionizing radiation that are both natural (like soil, water, and plants) and artificial (such as x-rays and medical equipment). Although there are many advantageous uses for ionizing radiation, such as the creation of plant types for use in business, research, medicine, and agriculture, there is also a risk of health risks if it is not handled or contained appropriately [5]. Ionizing radiation possesses enough electromagnetic energy to remove atoms and molecules from tissue and modify chemical reactions in the body (turning molecules into ions either completely or partially). Two types of ionizing radiation are X-Rays and Gamma rays. It is known that these rays can cause harm, which is why a lead vest is necessary during X-ray examinations of our bodies, and nuclear power plants require heavy shielding around them. All life forms are continuously subjected to low doses of ionizing radiation from natural origins. Natural background

radiation primarily originates from visible, ultraviolet, and infrared light (sunlight), as well as radioactive materials present on the earth's surface, including those in granite and coal. Radon, a radioactive gas that leaks from the soil; cosmic rays from space that pass through the ionosphere and penetrate the earth's atmosphere; Human body radioactivity that occurs naturally [6,7].

2. RADIATION AND LIVING CELLS

Ionization, the process by which energy is transmitted to atoms or molecules and charged particles or free radicals are formed, is the main way that radiation interacts with biological tissues at the cellular level [8]. This ionising radiation can result in base alterations, single-strand breaks, double-strand breaks, and other types of DNA damage. If such damage is not repaired or is repaired incorrectly, it can cause mutations, chromosomal abnormalities, or cell death [9]. The ultimate biological outcome is predominantly influenced by cellular responses to radiation exposure, encompassing apoptosis, cell cycle arrest, and DNA repair mechanisms, as seen in Figure 1.

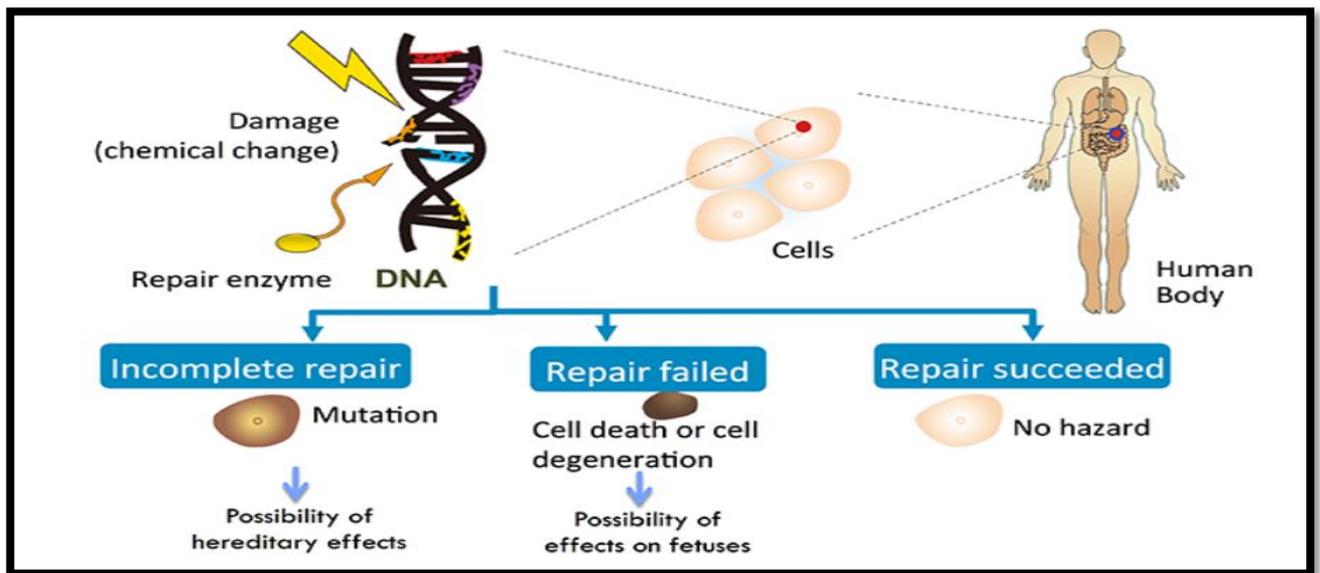


Fig.1: The Impact of Radiation Level on the Human Body.

Acute exposure to elevated radiation levels can lead to immediate symptoms such as skin burns, nausea, vomiting, and alopecia. In extreme circumstances, radiation sickness may occur, potentially leading to death. Prolonged low-dose radiation exposure may raise the risk of cancer, including solid tumors, thyroid cancer, and leukemia. Other health problems including cardiovascular disease and cataracts may also result from it [10].

Exposure to radiation in particular bodily regions, including the thyroid or reproductive organs, might raise the risk of acquiring certain cancers or induce health issues unique to those organs.

Similar to thermal burns but with unique features brought on by radiation damage, radiation exposure can result in burns to the skin and underlying tissues [11].

3. IMPACT OF RADIATION EXPOSURE ON HEALTH

Radiation exposure can have health effects that range from acute to chronic. Acute effects, including radiation sickness or “Acute Radiation Syndrome” (ARS). High-dose exposures can result in symptoms such as nausea, vomiting, diarrhea, and bone marrow suppression immediately thereafter [12]. Prolonged exposure to low amounts of radiation can result in chronic consequences, including cataract formation, genetic damage, and cancer development. Specific organs and tissues, such as the thyroid, lungs, and bone marrow, demonstrate variable susceptibilities to radiation-induced damage, reflecting their varying cellular compositions and physiological roles. The International Atomic Energy Agency [13] and the World Health Organization [14] state that the type, dose, and duration of radiation exposure can all have different health impacts. Mild to severe side effects are possible.

The tissue of the neurological system appeared to be radiation-immune until recently. But in the last few years, there has been mounting proof that even low radiation doses can cause a reaction in the nervous system, and that this reaction

frequently results in some damage. Ionizing Radiation therapy for cancer and space flight both have detrimental influence on the CNS [15,16]. Survivors of the atomic bomb and victims of the Chernobyl tragedy provide direct evidence of ionization radiation's detrimental impact on the central nervous system. Survivors suffer from mental health issues, memory loss, and cognitive decline; some also exhibit anomalies in their EEG patterns.

The hallmarks of gastrointestinal acute radiation sickness include notable intestinal malfunction caused by high radiation doses (6–15 Gy) [17]. Gastrointestinal syndrome is caused by radiation's effects on the cells that line the digestive tract. After being exposed to radiation of at least 6 Gy, within less than an hour, one could experience severe nausea, vomiting, and diarrhea, which could result in severe dehydration. They typically disappear, though, within two days. During the next four to five days, known as the latent phase, people feel OK, but the cells that line the digestive tract, which normally operate as a barrier of protection, start to deteriorate and die. Severe diarrhea, frequently bloody, then recurs, leading to further dehydration. Sepsis can result from germs from the digestive tract infecting the body [18].

Individuals who have been exposed to high levels of radiation also get hematopoietic syndrome, which raises the risk of infection and bleeding as well as death. Radiation doses of 6 Gy or more frequently result in death. Nonetheless, almost half of the population can survive with the help of contemporary medicine. The European Organisation for Research and Treatment of Cancer (EORTC) and the Radiation Therapy Oncology Group (RTOG) developed a gastrointestinal severity scoring system to evaluate radiation-induced gastrointestinal injury and mitigate the effects of acute radiation syndrome [19]. Rapid cell division makes it easier for radiation to damage bodily organs. In comparison to organs with a slower rate of cell division, such as muscles and tendons, unlike the intestines and bone marrow. The digestive system is one of the body's most delicate organs. which is made up of rapidly growing and differentiating cells. Elevated levels of ionizing radiation can produce various reactive oxygen species (ROS) and reactive nitrogen species (RNS), including radicals. These may result in adverse effects such as ulceration, discomfort, nausea, vomiting, diarrhoea, and malnutrition.

As a result, the digestive system is among the physiological systems most vulnerable to radiation therapy and typically experiences the most intense adverse effects. The digestive tract and auxiliary digestive organs (mouth, pancreas, liver, gallbladder, and salivary glands) make up the digestive system [20,21].

4. CONCLUSIONS

One of the most significant scientific discoveries of the past 200 years is ionizing radiation, which is essential to modern existence. The protection against the detrimental effects of ionizing radiation is crucial in the treatment of cancer patients.

In order to gain a better grasp of the workings of radiation and to devise more effective protective measures against it, additional investigation into the connection between genes and radiation is necessary. Effective management of acute radiation syndrome requires adherence to regulatory requirements, ongoing professional monitoring and control of radiation sources, ongoing training of medical personnel handling them, and the implementation of suitable preventative measures.

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