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Review Article

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Radiation Hazards, Protection, and Cultivating a Radiologically Safe Environment for Nurses

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ABSTRACT

Medical diagnostics has been revolutionized with the discovery of X-rays. The number of radiological procedures performed globally has increased rapidly during past decades and according to UNSCEAR 2021 report, 4.2 billion medical radiological procedures are performed annually. Ionizing radiations if not used appropriately and carefully can lead to health hazards for health professionals involved in the radiation work as well as patients undergoing the radiological procedure. However, the awareness about the ionising radiation and radiation safety is very limited among the healthcare professionals. This educational paper will provide basic insights in radiation protection training, and key topics to cover during education and training for nurses working in various medical radiological procedures of patients. Nurses need to understand radiation protection principles and ways to minimize their exposure of radiation during radiological procedures. They should be able to practically apply radiation protection principles in healthcare settings with enhanced patient and occupational safety without Radiophobia. Applying radiation safety culture in nursing practice improves quality and safety in patient care.

Keywords: Radiation Protection, Nurses, Ionizing Radiation, X-Rays

Introduction

Immediately after the discovery of X-rays on 8 November 1895 and discovery of radioactivity in 1896, they found applications in diagnosis and treatment of various ailments. Both the discoveries of ionising radiation have revolutionised the medical diagnosis and treatment. Medical uses of ionizing radiation include a wide variety of diagnostic and therapeutic procedures performed in radiology, nuclear medicine, and radiation therapy, as well as image-guided interventional procedures in medical specialties such as cardiology, vascular surgery, urology, gastroenterology, neurosurgery etc. as per the recent United Nations Scientific Committee on Effect of Atomic Radiation [UNSCEAR] [1].

According to the UNSCEAR current evaluation report, over 4.2 billion medical radiological examinations/ procedures including diagnostic radiology, interventional radiology, and nuclear medicine are conducted across the globe, every year. Further 2.63 billion diagnostic radiology examinations, 1.1 billion diagnostic dental examinations, 400 million CT scan examinations, 24 million interventional radiology procedures, 40 million diagnostic nuclear medicine procedures, 6.2 million courses of radiation therapy treatment, and 1.4 million radionuclide therapy treatments were undertaken annually worldwide. The resulting estimated annual effective dose per caput from medical radiological examinations is 0.57 mSv, the highest contribution due to manmade radiation.

In a few years of use of ionising radiation, it was revealed that ionising radiation can pose health hazards if not used carefully and appropriately. One of the World Health Organization's global initiatives is to develop radiation safety standards and support their national implementation, especially in health care settings [2]. In 2019, the WHO report of "Ten Facts on Patient Safety" emphasized that "medical exposure to radiation is a public health and patient safety concern." Unskilled and inappropriate use of medical radiation may result in potential hazards for patients and occupational staff [3]. Further, radiation is a dual edged sword and poses significant risks to healthcare professionals, especially nurses who play a crucial role in patient care. Radiation safety is a paramount concern in healthcare settings, particularly for nurses who are at the forefront of patient care and majorly involved while accompanying the patients during radiological procedures [4]. The lack of awareness about ionising radiation and radiation

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safety among nurses may lead to compromised safety of nurses as well as patients [5,6]. Establishing a radiation safety culture is not merely a checklist of protocols; it's a mindset that permeates every aspect of nursing practice. Understanding the potential dangers, implementing radiation safety measures, and fostering a safety culture are essential components in ensuring the well-being of healthcare workers. Therefore, it is very important to understand various aspects of radiation hazards, radiation protection, and the importance of cultivating a safety culture for nurses.

Importance of Education and Training

Often, nurses are not trained on radiation protection, they have fear and anxiety with radiation and are less comfortable when they are assisting patients while undergoing medical radiological procedures [7]. Fear of radiation often known as Radiophobia, negatively impacts patient care [8,9]. Nurses must undergo comprehensive education and training on radiation safety [10,11]. This includes understanding the different types of radiation sources in healthcare, the potential hazards associated with exposure and methods to keep the exposure As Low As Reasonably Achievable (principle of ALARA). Regular updates and ongoing education programs ensure that nurses stay abreast of the latest safety protocols and technologies. A crucial aspect of a radiation safety culture is the effective dissemination of knowledge. Nurses should have access to clear and concise information about radiation safety measures, protective equipment usage, and the importance of adhering to established protocols. Often, the participation in radiation safety trainings appears to be on voluntary basis which results in low attendance. The development of organisational protocol for compulsory radiation safety training can be seen as solution, as in US, it is mandatory to undergo radiation safety training for nurses before entering into theatre room [12].

International and National Radiation Protection Regulations

Internationally radiation protection principles stated by the International Commission on Radiological Protection [ICRP] and International Atomic Energy Agency [IAEA] are adapted and followed by the member states [13,14]. For India a nationally radiation protection regulations and legislations are well in place and enforced by the Atomic Energy Regulatory Board (AERB) and need to be followed by medical diagnostic radiation facilities in India [15]. According to AERB directive, occupational doses of any radiation worker should not exceed an effective dose of 20 mSv/year [16]. Furthermore, regulation clearly states that all personnel should use radiation protection devices such as lead apron during diagnostic radiological procedures [17]. The detailed practical knowledge of radiation protection empowers nurses to make informed decisions during patient care activities involving radiation.

Biological Effects of Ionising Radiation

The radiation is divided in two major categories

1. **Ionizing Radiation:** X-rays, gamma rays, and particles with sufficient energy to ionize atoms, posing potential harm to living tissues.
2. **Non-ionizing Radiation:** Radiowaves, microwaves, visible, and infrared light, ultraviolet, which lack the energy to ionize atoms.

The ionising radiation use started immediately after discovery of X-rays and radioactivity for diagnosis and treatment and today diagnosis of many diseases needs use of ionising radiation such as X-ray machines, fluoroscopy guided interventional procedures, Computed tomography (CT) scans, Gamma Camera, positron emission tomography scans and treatment of cancer by radiation therapy uses X-rays and radioisotopes in addition to nuclear medicine uses radioisotopes for diagnostic and therapy. In radiology, CT and interventional procedures contribute to high dose procedures than other radiology procedures [18].

X-rays are high energy photons within the electromagnetic spectrum and pose enough energy to break molecular bonds thereafter ionize atoms. This ionisation produces free radicals which initiates the chemical reaction that can indirectly damage DNA. The radiation damage or hazards can be classified as Somatic (occurring in an individual who is exposed to the ionising radiation) and Genetic (occurring in the progeny of the exposed individual). Further they are classified as Stochastic (probabilistic) effects (a radiation effect having no threshold dose for occurrence of the effect, e.g., induction of cancer, Leukaemia, genetic effect) and non-stochastic (deterministic) effects (a radiation effect having a threshold dose for occurrence of the effect, i.e., below a certain dose no possibility of the effect e.g., skin burn, sterility, cataract). The biological effects of radiation illustrated in Figure 1.

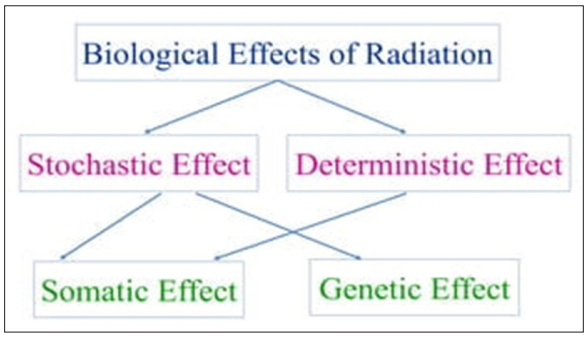

Figure 1: Schematic representation of classification of biological effects of ionizing radiation

Methods to Achieve Radiological Safety

In order to reduce radiation exposure, nurses should use radiation protection devices/personnel protective equipment such as lead aprons, lead goggles, thyroid shields, gonad shields, ceiling suspended screens, couch hanging lead equivalent rubber flaps and mobile protective barrier during diagnostic radiological procedures. Moreover, they prevent excessive exposure and ensure radiation safety in diagnostic radiology. Nurses should be aware about general principles of radiation protection and conform to the ALARA, time-distance-shielding and the inverse-square law of the radiation. Inverse-square law states that radiation intensity level is inversely proportional to the square of the distance from the radiation source. For example, when you increase the distance from 1 metre to 2 metres from the radiation source then the intensity of radiation will reduce to one fourth of the initial value. Hence, in order to practically minimize the radiation exposure, the key factors are spending less time in radiation field, increasing the distance from the source of radiation and use of appropriate physical shielding. Nurses should meticulously look over patient needs, radiological

procedure requirements and prepare plan of action to act accordingly by adopting good practices following the radiation safety principles.

Thermoluminesent dosimeter (TLD) badge is a device used for measurement of radiation dose received by the radiation worker. TLD badge should be worn by the radiation worker at chest level inside lead apron while working in the proximity of radiation. After work, TLD badge should be stored in a radiation free area outside the X-ray room. In India, TLD cards should be changed quarterly for radiation dose assessment by the accredited laboratory.

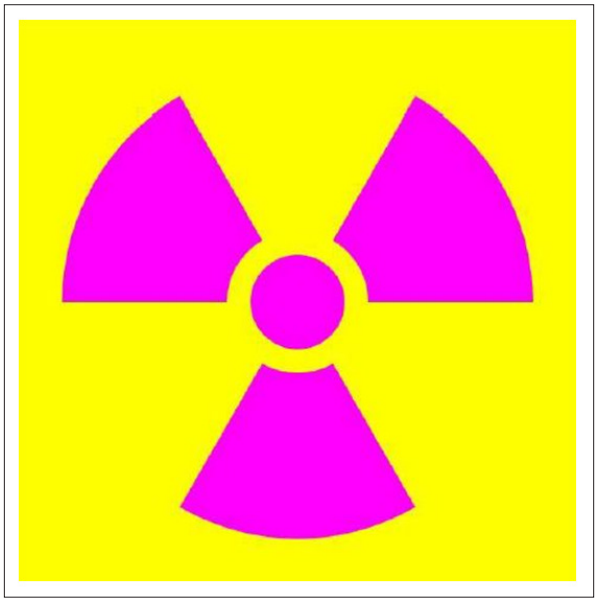

Figure 2: Caution symbols
(a) Symbol used to indicate radioactive source or radiation area. **Source:** AERB

(b) Symbol used to indicate X-ray tube housing. **Source:** AERB

Figure 3: TLD badges loaded in cassette. Source: AERB (www.aerb.gov.in)

Figure 4: Radiation protection devices
(a) Lead aprons placed on hanger to avoid cracks

(b) Thyroid shields hung in a theatre room

Radiation Safety Measures for Nurses
Personal Protective Equipment (PPE):

1. Radiation protection devices: Radiation protection devices such as lead aprons and thyroid shields are essential for protection during diagnostic imaging procedures.
2. Radiation Badge: Monitors individual radiation exposure over time.

Distance and Time:

1. Maintain a safe distance: Limit exposure by maximizing the distance from radiation sources.

2. Minimize exposure time: Reduce the duration of exposure to lower radiation doses.

Shielding:

1. The rooms housing the X-ray, CT scan, fluoroscopy unit should have brick walls of minimum 23cms thick to avoid radiation leakage outside the room.
2. Lead-lined doors: The doors of X- Ray, CT scan, fluoroscopy is lead lined (1.7 mm lead equivalent), to contain radiation leakage outside the room.
3. Protective Barriers: Ensure the use of shields and barriers to protect healthcare workers.

Adherence to Protocols

Nurses should strictly adhere to protocols and standard operating procedures to minimize the radiation risks and contributes to radiation safety culture.

Importance of Safety Culture

Education and Training:

1. Ongoing training: Regular updates on radiation safety protocols and guidelines.
2. Knowledge dissemination: Ensure nurses are well-informed about radiation hazards and safety practices.

Communication:

1. **Open dialogue:** Encourage communication about concerns or questions related to radiation safety.
2. **Reporting systems:** Establish mechanisms for reporting incidents or unsafe radiation practices.

Team Collaboration:

1. **Interdisciplinary approach:** Collaborate with radiologists, medical physicists, and other healthcare professionals for comprehensive safety measures.
2. **Shared responsibility:** Instil a sense of collective responsibility for radiation safety among the healthcare team. Radiation protection training sessions and meetings good way to address radiation hazards and protection.

Follow Local/ National Regulations

In India, the competent authority for radiation applications is Chairman, Atomic Energy Regulatory Board (AERB), Mumbai, India. AERB issues licenses for medical radiation facilities operating X-r ray equipment such as Radiography, Potable X-ray machines, Fluoroscopy, CT, Cath Lab, Digital Subtraction Angiography (DSA), C-arm, O-arm, Mammography, Dental, Bone Mineral Densitometry (BMD) etc. and provide radiation safety measures to implement in the medical radiation facility.

Conclusion

Nurses, as integral members of the healthcare team, therefore, must be well-versed in radiation hazards and equipped with the knowledge and tools to ensure their own and patient safety. By embracing a culture of safety, fostering ongoing education, and implementing robust safety measures, healthcare institutions can create an environment that prioritizes the well-being of nurses while effectively managing radiation risks associated with patient care. It is recommended that institutes should organize periodic radiation protection training, especially working with or exposed to radiation during radiological procedures in order to enhance radiation safety culture. Importantly, implementing radiation protection culture at workplace improve overall quality and safety in healthcare system.

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Ethics Committee Permission

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