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Occupational Hazards for Radiotherapy Technicians in a Radiation Oncology Unit

Abhishek Purkayastha

Department of Radiation Oncology, Command Hospital (Southern Command), Maharashtra India

***Corresponding Author**: Abhishek Purkayastha, Department of Radiation Oncology, Command Hospital (Southern Command), Maharashtra, India, Tel: 9650901736; E-Mail: abhi5296@gmail.com

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Editorial

The radiotherapy (RT) technician working in a radiation oncology unit of a tertiary care cancer institute does face common occupational hazards and concerns which includes radiation safety issues and development of latent diseases like cancers and cataracts. A pregnant lady worker caries the dual risk of radiation hazard to the foetus as well [1]. Carcinogenic potential of ionizing radiation and appearance of clinical symptoms of radiation hazard occur with persistent exposure over years due to its direct or free radical induced indirect chromosomal damage. The as-low-as-reasonably-achievable (ALARA) principle of the Nuclear Regulatory Commission (NRC) is of utmost importance in ensuring radiation safety [2]. The 3 doctrines of radiation safety [3] which should be followed religiously by a RT technician are reduction in time of radiation exposure, maintaining proper distance from the source, and appropriate shielding [4]. Apart from radiation hazards, the technician also faces physical wear and biohazard issues in their day to day practice.

Ionizing radiation cause human health hazard by two mechanism known as the stochastic effect without any threshold dose but with more probability with increasing dose causing cancer and the non-stochastic or deterministic effect with a known threshold below which there occurs no detrimental effect. Deterministic effect is the more relevant to general population and to RT workers as there is a threshold designated for its effect to appear as in cataractogenesis with a dose threshold of 2 Gray (Gy). A non-stochastic effect causes damage to tissues and large number of cells due to increased absorbed dose in an affected individual with increasing severity. Chronic exposures to low level radiation dose less than 10 centi-Gy (cGy) may induce gene mutations, chromosomal anomalies, malignancies like leukemia, thyroid neoplasms, and skin cancers, oligospermia, diminished life span and premature aging apart from adverse effects on foetus and children of the female RT worker [5]. Unlike the Gy which is the absorbed dose of ionizing radiation in one kilogram of matter, the Sievert (Sv) is used to calculate an *equivalent* dose that does not measure an actual deposit of energy into tissue but represents the effect of depositing one joule of energy in one kilogram of biological tissue which is computed using the actual deposited dose multiplied by a weighting factor (WR) which depends on the type and energy of ionizing radiation. Sv is a measure of the effect of low levels of ionization radiation in the human body and is of fundamental importance in radiation protection. There is no dose of radiation small enough not to cause any radiation hazard and more the exposure greater the risk. This concept was based on the linear no-threshold model [6] which denotes that an occupational worker who is has an annual exposure of 50mSv will have 10 times risk than a general public receiving annual 5 mSv. However this concept has been debatable and many studies have found it lacking scientific justification in the present era of potent radiation protection [7].

Occupational exposure of the RT technicians to ionizing radiations are limited to an annual effective dose equivalent of 50 mSv compared to exposure for the general public which should not exceed 5 mSv for infrequent exposure and 1 mSv for persistent or frequent exposure. [1, 5, 8] Some organs and body areas involving non-stochastic effects are less sensitive to radiation than others and higher dose limits are set for them. For example, the annual occupational dose equivalent limit to the lens of the eye is 150 mSv and to other organs like red bone marrow, breast, lung, gonads, skin, and extremities is 500 mSv. In terms of absorbed radiation, dose required to kill 50% of exposed population is 3-5 Gy in 60 days and to kill 100% of exposed population is about 10 Gy. For a female technician who has voluntarily declared her pregnancy should be excused from performing procedures in proximity to the radiation source as the foetus is most susceptible to radiation in the first trimester or organogenesis phase where cell division and stem cell development occurs. The total dose equivalent limit for the foetus should not exceed 5 mSv and in a month should not exceed 0.5 mSv. Radiation dose of 1 Gy is likely to kill 50% embryos while about 5 Gy is required to kill 100% of human embryos or foetus before 16 week of gestation. After 16 week of gestation post radiation exposure there is rise in abortion rates, still-births, growth retardation, malformations reduced intelligence quotient (IQ) and mental retardation which are dose dependent as mentioned above [1, 2, 9].

Time of radiation exposure is the most important factor out of the three major doctrines of radiation safety for RT workers. It is imperative that the RT technician will receive more radiation exposure the more time he spends around a radioactive source. This over-exposure due to radiation scatter and leakage through the source housing of a tele-Cobalt machine or a brachytherapy unit can occur by chance or by neglect, complacency and poor work habits. For example, a technician may switch on the radiation source without ensuring last man out or takes frequent breaks around a radioactive source site. Self-vigilance and use of radiation monitoring instruments like ionization chambers, gamma-zone monitors, Geiger-Muller (GM) counter, neutron detectors, personal equipment like film badges and thermo-luminescent dosimeter (TLD) may be beneficial in detecting low level radiation thus reducing the exposure time. The second doctrine of radiation safety to be followed is maintaining a safe distance from a radioactive source which is based on the inverse square law i.e. greater the distance, the less the radiation received by a factor of 1 over distance squared. The third principle or doctrine of radiation safety is shielding or protecting the RT worker from ionizing radiation with protective devices or shields. The γ-radiation and x-ray radiation most commonly used in a RT unit are shielded with high–atomic (z) number materials. The thickness of shielding materials required to protect the RT worker is determined by their half-value layer (HVL) and tenth-value layer (TVL) which attenuates the intensity of the incident radiation beam to half and one-tenth of its original values respectively. Therefore is the intensity of the incident radiation beam increases, the required thickness of the absorber also increases [10].

Biohazard safety issue is one more important occupational hazard encountered by the RT technicians. Microorganisms like bacteria, viruses and fungi can be vector borne and usually spread via fomites, from patient through direct contact, infectious material getting spilled or splashed onto exposed mucous membranes, breached skin, or open wounds, minor cuts or abrasions. Infestation may also occur through splashing or spilling, of contaminated droplets onto surfaces, equipment and personnel. The technicians have to follow the universal precautions like wearing disposable latex gloves, aprons, coats or scrubs which handling a cancer patient during radiation planning or simulation. Maintenance of proper hand hygiene by cleaning or washing them before touching a patient, before performing any aseptic procedures, after an exposure to body fluids and after touching the patient or his immediate surroundings is the most important precautionary measure which has to be followed. The Centre for Disease Control, the National Institutes of Health, and the NRC have recommended biosafety levels (BSLs) for working with infectious agents at workplace guidelines. [11] BSL 1: work without any known or minimal potential hazard; [2] BSL 2: work with indigenous agents causing moderate hazard associated with human disease;[2] BSL 3: work with indigenous or exotic agents causing infection by aerosols with serious or lethal consequences; BSL 4: work with exotic but dangerous agents with high risk of life-threatening disease or aerosol-transmitted laboratory infections or with agents with an unknown transmission risk.

Apart from the radiobiological hazard and biohazard, RT workers suffer from manual fatigue issues like acute to chronic back pain and generalized myalgia acquired while transporting radiation sources, lifting heavy RT equipment like a breast board or breast cone, phantoms, shifting patients from waiting room to simulator room or RT delivery room and from the operation theatre to computed tomography (CT) scan center and back to brachytherapy delivery room. This may happen due to improper way of conducting such procedure or due to sheer labor. Therefore a technician should keep the distance with the patient as low as possible to keep the Centre of gravity close to him for better stability. [2] The RT technician has to perform similar physical work in similar fashion resulting in repetition of his motions he may develop a plethora of disorders known as cumulative trauma disorders (CTD). CTDs may include tennis elbow, tendonitis, snapping finger and carpal tunnel syndrome. Though being educationally qualified and technically sound, these RT technicians do suffer from the constant psychological fear of getting impotent and weak if they work continuously in the RT unit even with optimal prevention and protection resulting in reduced work output.

Occupational hazards for a RT technician comprise of a wide spectrum of possibilities, from radiation and radiobiological safety to biohazard issues, physical labor, possible CTDs and even psychological stress. Optimal and strict implementation of the ALARA principles and compliance with the three essential doctrines of time, distance, and proper shielding as well as self-precautionary measures will help in lowering the safety concerns associated with radiation and biohazard. Handling and shifting of patients in a proper way can help to ameliorate the physical issues. CTDs become hard to prevent if the person is involved in performing the same physical activity every day, however it's worsening may be reduced by identifying these disorders at an early stage. Time to time counseling by the radiation oncologist, the medical physicist and by a trained psychologist does help in alleviating their mental stress issues.

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