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Review

Radiation burn—From mechanism to management

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ABSTRACT

Radiation burn can occur with diagnostic or therapeutic use of ionizing radiation. A nonintentional radiation burn is relatively uncommon. Skin has a specific tolerance to radiation, above which different grades of radiation burn can occur. Being a rare and less studied problem, no precise guideline is present for its management. Because of few unresolved issues in the pathophysiology of deep radiation burn, its management is difficult. To date no specific guidelines are present for the treatment of radiation burn.

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1. Introduction

Radiation burn is damage to the skin or other biological tissue caused by exposure to radio frequency energy or ionizing radiation. The most common type of radiation burn is sunburn caused by an ultra violet radiation. Radiation burns can occur with high power radio transmitters. High exposure to X-rays during repeated diagnostic medical imaging, interventional radiology (IR) procedures or radiotherapy (RT) can also result in radiation burn. The commonly seen radiation burn is the one with therapeutic radiation. Many cancer patients will receive RT at some stage during their treatment for malignancy. An acute skin reaction represents a common side effect with different grades of severity. Radiation induced skin burn induces frequent nursing assessment and intervention.

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Understanding the pathophysiology of radiation burn and preventive measures with timely interventions can minimize the severity of skin reaction.

Thorough preparation of the radiologist, radiation oncologist and an interventional radiologist is important in terms of radiation safety measures and optimal equipment operational training. Detailed patient counseling and informed consent with regular follow up should be done. This will help in minimizing the risk of radiation burn [1,2]. An active involvement of radiation safety officer or medical physicist is needed for conducting timely quality assurance programs for radiation delivering instruments. Despite all care a nonintentional radiation burn can occur with X-ray or RT machines due to mechanical problems, electrical instability, human errors, etc. An example of this is a Bailystok accident [3].

Sparse studies have evaluated the management options for radiation burn and little is known about it. In this article we have discussed in length the pathophysiology and the management of radiation burn. Data was collected by conducting a computer aided search of Pub Med and Scopus database, supplemented by hand search book references.

2. Pathophysiology of radiation burn

There are marked differences between radiation and thermal burns in terms of physio-pathological mechanisms, clinical aspects and evolution. With understanding the pathogenesis of radiation burn, preventive measures can be implemented. From medical stand point most unique feature of the radiation and radioactive isotopes is emission of ionizing radiation. The term 'ionizing' is applied because the profound effects produced on living tissue by these radiations are related largely to ionization. All the radiation concerned produce ionization directly or indirectly (by production of free radicals) and practically all the biologic changes they produce are related to this ionization. The target for radiation effect is mainly the cellular DNA (Fig. 1). Different types of radiation particles will have different effects on the skin (Table 1). As the velocity and energy of radiation particle increases an ionization decreases and superficial tissues like skin are spared from reactions. The radiation burn is common with X-ray or gamma rays used for teletherapy and IR. Severe radiation burn is commonly seen with the radioisotopes like ^{60}Cobalt and ^{192}Iridium used for brachytherapy. Burns caused by beta radiation particles tend to be shallow as beta particles are not able to penetrate deep into the skin.

Effect of radiation depends on host factors and radiation related factors. The host factors of prime importance are age, associated co-morbid conditions like diabetes mellitus and obesity, genetic or developmental abnormalities and intrinsic cellular radiosensitivity. Radiation related factors are the type of radiation, its energy, penetration and ionization power, total amount/dose, fractionation and overall exposure/treatment time. The severity of radiation reactions depends on total radiation dose and treatment time, dose per fraction, use of bolus or other beam modifying devices, size and site of treatment area, type of radiation therapy used (conventional versus conformal), use of concurrent chemotherapy or other agents and individual susceptibility.

Though the post-irradiation intracellular repair is complete within a few hours, repopulation of the cells in the dermis and epidermis takes much longer. Animal models suggest that full recovery of the epidermis occurs by six weeks as long as permanent damage is not induced [4]. In diagnostic radiology skin damage is rarely seen. The cumulative dose from multiple diagnostic procedures can cause radiation skin reaction [5]. Skin injuries from fluoroscopically guided procedures are described in detail by Koenig et al. [6]. The dose rate in IR may vary over a wide range depending on the procedure and disease burden. If high doses are delivered instantaneously, interim repair is not possible. Protraction of total dose results in higher threshold dose for skin reactions [4]. When large dose of therapeutic radiation is given in less number of fractions e.g. for palliation (8 Gray in single fraction where Gray [Gy] is the SI unit of radiation dose) radiation skin reaction is not a major concern. In curative setting when total dose is delivered in large number of fractions e.g. 60 Gy is delivered in 3o fractions with 2 Gy per fraction per day, the radiation tolerance of normal tissues like skin becomes a dose limiting factor. The effect of radiation on various skin appendages is described in Table 2.

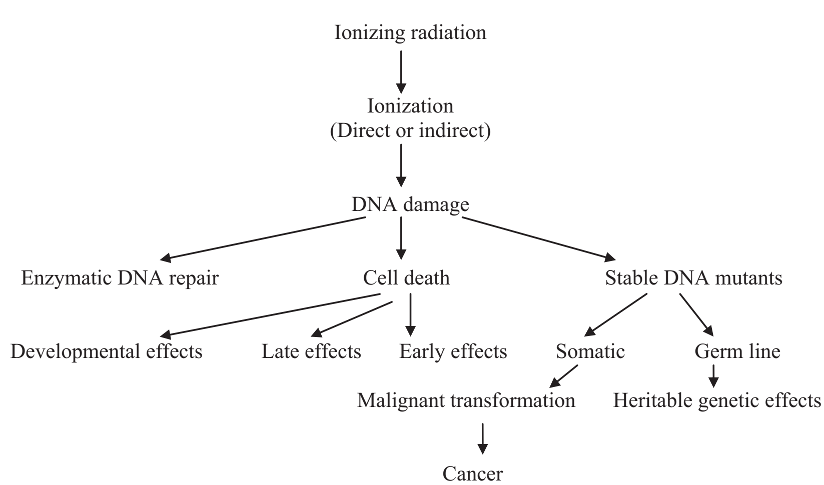

Fig. 1 – Effect of irradiation on a cell.