■ Article

Radiogenomics: The Promise of Personalized Treatment in Radiation Oncology?

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Significant variability exists in normal tissue reactions in patients with cancer receiving radiotherapy, with a subpopulation exhibiting increased toxicity to ionizing radiation. Genomic studies have proposed that single nucleotide polymorphisms in DNA repair genes, cytokines, and reactive oxygen species may play a role in clinical radiosensitivity. Additional research examining the association between genetic variants and radiation-induced inflammation and fibrosis may spur the development of targeted therapy in radiation oncology, which could increase cure rates and limit toxicity. As more people become long-term cancer survivors, oncology nurses must aggressively assess and manage late treatment side effects to optimize patient functioning and quality of life. The purpose of the current article is to describe the effect of ionizing radiation on normal and irradiated tissue, discuss genetic mutations that are proposed to influence radiosensitivity, and identify future areas of research on the association between genetics and radiation toxicity.

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The field of radiation oncology has undergone many advances. New technology has spurred the development of intensity-modulated and image-guided radiation therapy, proton therapy, high-dose rate brachytherapy, and stereotactic radiosurgery techniques (e.g., gamma knife, CyberKnife®). About 60% of all patients with cancer receive radiation therapy for curative intent, tumor control, or palliation of symptoms (Halperin, Wazer, Perez, & Brady, 2013). The goal of treatment delivery is to provide a precise dose of radiation to the tumor and limit damage to surrounding normal tissue. Although most patients tolerate treatment with minimal side effects, a subset of individuals develop severe toxicities as sequelae of radiation therapy. Molecular profiling of tumors has begun to revolutionize the systemic treatment of cancer, but radiation oncology lags in identifying genetic factors that may confer individual susceptibility to radiation injury and toxicity.

Radiosensitivity is influenced by the effects of ionizing radiation on intracellular DNA, leading to cellular damage or death via double-strand breaks. Radiation also triggers the release of multiple cytokines, which are regulatory proteins that exert their intracellular effects via receptors on immunomodulatory cells (Martin, Lefaix, & Delanian, 2000). About 5%–10% of patients who receive radiation therapy exhibit a heightened sensitivity to conventional radiation doses (Gatti, 2001; Ozsahin et al., 2005; Popanda, Marquardt, Chang-Claude, & Schmezer, 2009). To limit toxicity, standardized dosing regimens have been developed and extensively researched for safety and efficacy. Advances in genetic research would enable radiation oncologists to design personalized therapy and optimize treatment plans for each patient, which would increase efficacy and minimize acute and late side effects (Ghazali, Shaw, Rogers, & Risk, 2012; Henríquez-Hernández et al., 2012). The current article describes the effect of ionizing radiation on normal and irradiated tissue, discusses genetic mutations that are proposed to influence radiosensitivity, and identifies future areas of research on the association between genetics and radiation toxicity.