review article

Radiation-induced impairment of skeletal muscle regeneration

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Background. Radiotherapy is a cornerstone of treatment for various cancers, but often causes collateral damage to surrounding healthy tissue, including skeletal muscle. Ionizing radiation leads to oxidative stress and inflammation, which impairs the regenerative capacity of muscle tissue. Irradiation reduces the number and functionality of satellite cells and disrupts the tightly regulated processes of myogenesis and tissue remodelling. In addition, irradiation alters the muscle microenvironment by promoting fibrosis and vascular damage, which further impedes effective regeneration. Cytokine signalling pathways are also dysregulated following irradiation, contributing to impaired activation and differentiation of satellite cells.

Conclusions. There is evidence that factors such as melatonin and growth factors can improve muscle regeneration. Understanding the molecular and cellular mechanisms underlying the impairment of muscle regeneration after radiotherapy is crucial for the development of targeted strategies to mitigate side effects and improve patients' quality of life. Overall, the preservation and restoration of muscle function in irradiated tissue remains a critical challenge that requires multidisciplinary approaches.

Key words: skeletal muscle; muscle microenvironment; radiotherapy; muscle regeneration, melatonine

Introduction

Radiotherapy remains one of the most important component of cancer treatment with approximately 50% of all cancer patients receiving radiation therapy during their course of illness; it accounts for 40% of cancer's curative treatments.[1] The main goal of radiation therapy is to deprive cancer cells of their proliferation (cell division) potential. X-rays, gamma rays and charged particles are the most types of radiation used for cancer treatment.

The biological effectiveness (cell killing) of radiation is influenced by factors such as linear energy transfer (LET), total dose, fractionation scheme, and the radio-sensitivity of the targeted cells or tissues.[2,3] Low LET radiation transfers a smaller amount of energy, while high LET radiation delivers a higher dose of energy to the targeted areas. Although radiation is aimed at destroying tumour cells, it is unavoidable that surrounding healthy tissues may also suffer damage. The primary goal of radiation therapy is to deliver the highest possible dose to tumour cells while minimizing the exposure to normal, healthy tissues.[4]

Skeletal muscle is one of the most dynamic and plastic tissues of the human body. In humans, skeletal muscle comprises approximately 40% of total body weight and is often exposed to ionizing radiation during radiotherapeutic treatment. Many studies have explored the effects of radiation on skeletal muscle, demonstrating that muscle damage from irradiation can persist for many years.[5]

The effects of ionizing radiation on skeletal muscle can be categorized into early and late ef-