Improving in vitro and in vivo Radiobiology Models Through Standardized Irradiation and Cerium Oxide Nanoparticle-Mediated Radioprotection

Ren, Will (School: Hoover High School)

Radiation therapy is a cornerstone of cancer treatment, but radiation-induced skin injury remains a significant clinical challenge. This study aims for precise, controlled irradiation with a biological irradiator to enable reproducible cellular and tissue-level radiation studies. Antioxidant nanomaterials, such as cerium oxide nanoparticles (CeNPs), can mitigate the adverse effects of radiation on skin. The biological irradiator's beam geometry was calculated for accurate placement and effective irradiation of cell culture samples. Mouse keratinocytes were grown successfully in vitro for testing. Female BALB/c mice (7–8 weeks old) were randomized into three groups: control, irradiation only (25 Gy), and CeNP treatment (200 μg/mL) before irradiation (25 Gy). Skin reactions were graded on an IACUC-approved scale (0–7) for erythema, desquamation, and necrosis. 18F-FDG PET/CT imaging was collected weekly to evaluate metabolic activity in irradiated tissue. The CeNP-treated group exhibited a delayed onset of skin erythema, suggesting a transient radioprotective effect. This group also showed a delayed decrease in brown adipose tissue uptake on PET/CT imaging, indicating an early, transient effect of CeNPs on brown adipose tissue. Topical application of CeNPs delayed the onset of radiation-induced erythema and likely modulated brown fat metabolism, indicating early antioxidative protection. Delayed erythema is clinically significant because early inflammation causes most pain and tissue damage. Preventing early damage could reduce patient discomfort and minimize treatment interruptions. Future studies will repeat the in vivo experiment with a larger cohort and conduct in vitro molecular analyses to confirm the protection provided by CeNPs.

Awards Won: