Mechanisms of Cold Atmospheric Plasma Effects on Cells and Tissues in Preclinical Studies

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ABSTRACT

Introduction: Plasma medicine applies non-thermal atmospheric plasma to interact with biological tissues. Drawing from physics, it solves biological problems. Early research has shown that plasma can kill microbes while sparing healthy hosts. Preclinical studies are now investigating the underlying mechanisms. Ionization produces ions, electromagnetic fields, and radiation, which induce chemical changes in cells and trigger diverse biological responses. These insights aid in predicting therapy outcomes.

Materials and Methods: Atmospheric plasma jets worked under room conditions. Helium-air mixtures were used to produce reactive species. Keratinocytes were briefly exposed to the plasma. Cell viability was assessed using MTT assays, while apoptosis was evaluated through flow cytometry. Mouse dorsal wounds received daily plasma treatment, and the tissues were analyzed histologically.

Results and Discussion: The effects of plasma treatment stem from the reactive species produced. Hydroxyl radicals oxidize cellular structures, compromising membrane integrity and enabling deeper signaling pathways. Normal cells activate antioxidant defenses, which boost their repair and migration abilities. In contrast, cancer cells, which are under oxidative stress, tend to accelerate their apoptosis. The electric fields generated during treatment create pores in the cell membranes, facilitating the uptake of these species, while ultraviolet exposure contributes additional stress to DNA. Dosing is critical; lower doses promote healing, lead to faster closure, and result in less inflammation, whereas higher doses can cause damage. Furthermore, fibroblasts proliferation increases with treatment. Animal studies suggest improved granulation and a more balanced cytokine profile in response to plasma treatment. The synergistic interaction between physical and biological factors ensures safety.

Conclusion: Cold plasma can modulate cellular behavior through various physicochemical mechanisms. The reactive species generated during treatment shift redox balance in cells, potentially leading to either positive or negative impacts. Preclinical work clarifies these mechanisms and advances the field of medicine. Accurate dosing is essential for achieving the desired therapeutic outcomes.

Keywords: Cell mechanisms, Cold atmospheric plasma, Preclinical models, Reactive species, Tissue interactions

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