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Cold Atmospheric Plasma in Burn Wound Management

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ABSTRACT

Introduction: Burn wounds pose therapeutic challenges due to necrosis, inflammation, ischemia, and infections. Effective treatment required multimodal strategies for microbial control, inflammation modulation, perfusion enhancement, and tissue regeneration. Cold atmospheric plasma (CAP) generates reactive oxygen and nitrogen species (RONS), UV radiation, and electric fields for simultaneous antimicrobial, anti-inflammatory, and pro-regenerative effects.

Materials and Methods: This review synthesized evidence from 2023 to 2025 regarding the use of CAP in burn treatment. It included in vitro studies on biofilms, animal models, and clinical trials involving pediatric patients, focusing on the mechanisms of action, efficacy, available devices, and limitations.

Results and Discussion: CAP achieves a 3–5 log reduction in microbial load within <60 seconds against *Staphylococcus*/*Pseudomonas biofilms* (including Methicillin-Resistant *Staphylococcus aureus*) via RONS-mediated damage, without inducing antibiotic resistance. It also inhibits the nuclear factor kappa-light-chain-enhancer of activated B cells pathways while boosting vascular endothelial growth factor/Extracellular matrix organization, leading to a 1.5–2-fold acceleration in epithelialization and reduced scarring. In second-degree burns, the use of adjunct CAP has been shown to reduce infection rates, minimize the need for debridement and pain management, and reduce the necessity for grafting, especially in children.

Conclusion: CAP provides non-invasive, synergistic therapy that complements standard burn care and minimized the use of antibiotics, thus reducing the risk of resistance. However, challenges such as dosing standardization, device variability, and limited number of randomized controlled trials still need to be addressed. Future enhancements in burn management could arise from integrating CAP with hydrogels, nanoparticles, scaffolds, cell therapy, and artificial intelligence.

Keywords: Biofilm, Burn wounds, Cold atmospheric plasma, Epithelialization, RONS

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