Cold Atmospheric Plasma Disrupts Biofilm-Associated Infection: In-vitro, In-vivo Porcine and Clinical Studies

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Introduction

Cold atmospheric plasma (CAP) is a non-pharmacological adjunct for complex wounds complicated by infection, biofilm, impaired healing and multidrug-resistant (MDR) pathogens, including conflict-related injuries. This study evaluated a large-area occlusive plasma foil designed for homogeneous, standardized bedside CAP delivery over extensive wound surfaces, assessing its antibacterial efficacy and wound-healing potential. This technology is already being successfully used in Europe to treat Ukrainian casualties with severe burns.

Material & methods

Coldplasmatech therapy (CPT) was evaluated *in vitro*, in a deep-dermal porcine methicillin-resistant *Staphylococcus aureus* (MRSA) wound model with established biofilm (24–72 h), and in a prospective self-controlled clinical study of chronic lower-limb wounds. Assays quantified colony-forming unit (CFU) reductions in multidrug-resistant (MDR) isolates; porcine wounds were compared with sham dressings using microbiology and blinded histology. Clinically, fluorescence-based molecular imaging (MolecuLight®) tracked bacterial signals and tolerability.

Results I – in vitro

In vitro, CPT produced rapid 10^6-10^7 CFU reductions within seconds against 7 wound-relevant bacterial species, including multidrug-resistant strains, and fungus *Candida albicans*.

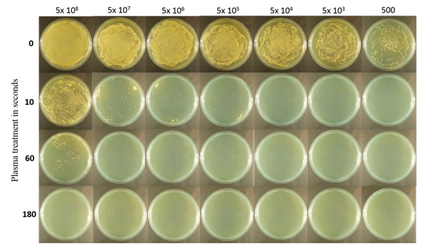

Figure 1: Representative image demonstrating the antimicrobial effect of cold atmospheric plasma.

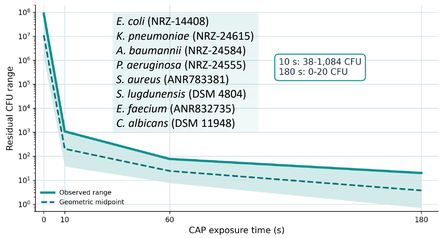

Figure 2: CFU reduction across all tested Gram-negative, Gram-positive and fungal wound pathogens.

Results II – in vivo

In the porcine model, plasma-treated wounds showed dose-dependent MRSA reduction and 72 h biofilm disruption, reaching up to 3.18 log10 (99.93%) reduction vs. baseline without macroscopic or histological damage.

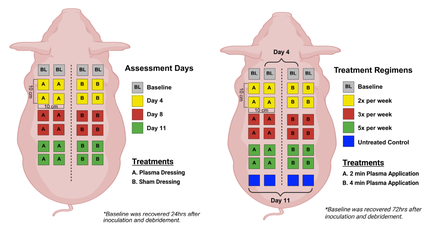

Figure 3: Experimental design of the porcine MRSA biofilm wound studies.
In Animal #1, 28 wounds were created: 12 wounds were randomized to active CAP treatment, 12 wounds to sham dressing, and 4 wounds were reserved for baseline microbial quantification.
In Animal #2, 32 wounds were allocated across CAP duration/frequency regimens, untreated controls, and baseline biopsies.

Results III – clinical

In molecular imaging of 20 patient wounds, fluorescence declined significantly over time ($p<0.001$) with significant paired conversion to fluorescence-negative status ($p<0.01$). The CPT foil was well tolerated with no treatment-related adverse events.

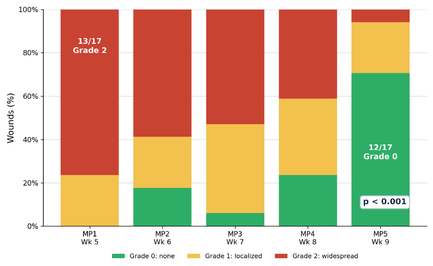

Figure 4: Summarized fluorescence grades (0-2) at each measurement point (MP1–MP5), corresponding to weeks 5–9 of the treatment period. At MP5, 16/17 (94.1%) were Grade 0 or 1; only 1/17 (5.9%) was Grade 2.

Conclusions

These findings provide a proof of concept for large-area CPT-CAP as an adjunctive biophysical therapy that reduces microbial burden including MDR pathogens, disrupts biofilm and may support wound-bed optimisation. In severe burns or other large area wounds, where infection control and graft-bed preparation are critical, CPT-CAP may offer an additional tool for an optimized wound therapy. Ongoing multicentre randomised evaluation (POWER study, expected mid-2026) will further define clinical utility, indications and treatment parameters.