A study on the efficacy of cold plasma disinfection on various relevant human pathogenic bacterial species

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Introduction

The global rise in antibiotic-resistant bacteria presents a growing challenge to public health, as many bacterial infections are becoming increasingly difficult to treat with conventional antibiotics. Consequently, there is an urgent need to explore alternative mechanisms of bacterial eradication. One promising approach is the use of cold plasma, a non-thermal ionized gas that has been shown to effectively inactivate microorganisms. The aim of this study was to evaluate the bactericidal efficacy of cold atmospheric plasma (CAP) on a broad panel of clinically relevant Gram-positive and Gram-negative bacterial pathogens, with a focus on potential applications in infection control.

Materials and Methods

The bactericidal efficacy of CAP was tested using different plasma applicators on a variety of bacterial isolates. The plasma devices used are a modified ViroMed medical system operating with Indoor air. Suspensions of twenty-one human-pathogenic bacterial species, including 10 Gram-positive and 11 Gram-negative strains, were plated in different dilutions on blood agar, followed by exposure to CAP for defined durations (60–180 seconds) at different working distances. Experiments were done at room temperature to exclude thermally induced effects. After a 24-hour incubation at 37°C, colony counts were assessed to determine the impact of CAP on bacterial survival.

Results

The study demonstrated a statistically significant bactericidal effect across all tested Gram-positive and Gram-negative species. Quantitative analysis revealed a marked reduction in colony-forming units (CFUs) in all treated samples, indicating a consistent antimicrobial efficacy. Some clinical isolates, including *Staphylococcus aureus*, *Escherichia coli*, and *Citrobacter freundii*, exhibited complete growth inhibition following the longest exposure duration. This suggests a time-dependent antimicrobial response. Control plates, which were not exposed to cold plasma, showed consistent bacterial growth.

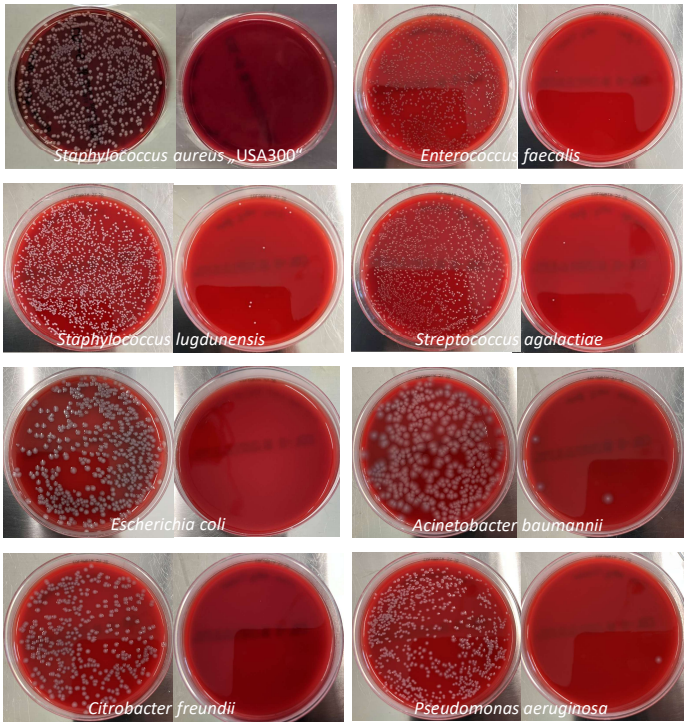

Figure 3: Agarplates without and with exposure to CAP after incubation at 37°C over night

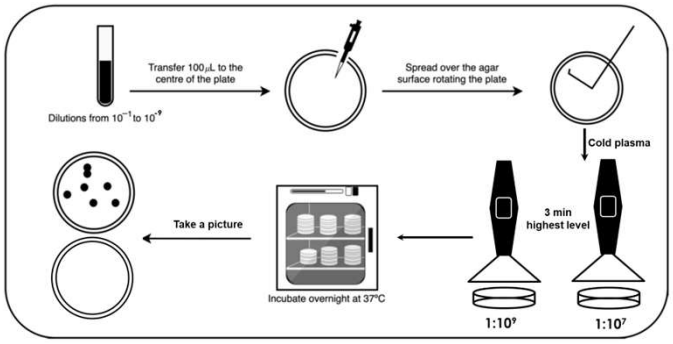

Figure 1: Test principle for the use of cold plasma

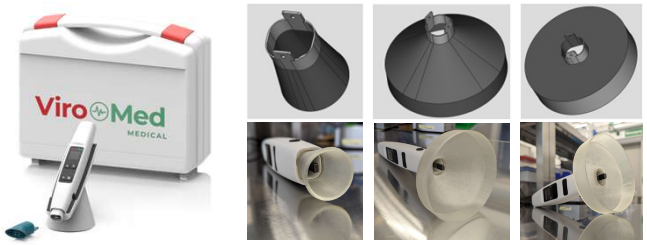

Figure 2: Cold atmospheric plasma devices equipped with various adapters for application on agar plates

Gram-negative Spezies			Gram-positive Spezies		
01	240608	Escherichia coli	01	95430	Staphylococcus aureus
02	98213	Enterobacter hormaechei	02	95428	Staphylococcus epidermidis
03	98229	Klebsiella pneumoniae	03	95735	Enterococcus faecium
04	240611	Acinetobacter baumannii	04	95247	Staphylococcus xylosus
05	279615	Citrobacter freundii	05	112975	Staphylococcus hämolyticus
06	279584	Pseudomonas aeruginosa	06	98171	Staphylococcus lugdunensis
07	132911	Salmonella enterica_Heidelberg	07	97424	Bacillus atrophaeus
08	97946	Serratia marcescens	08	95737	Enterococcus faecalis
09	97950	Proteus mirabilis	09	98553	Streptococcus dysgalactiae
10	227455	Shigella sonnei	10	98653	Streptococcus agalactiae
11	97675	Legionella pneumophila			

Table 1: Strain test panel

Discussion

These findings highlight the potential of CAP as a novel antimicrobial tool in medicine, particularly in the management of chronic wounds, skin and soft tissue infections and for treating multi-drug-resistant bacteria. While early experimental concepts suggest applicability to respiratory infections, such as ventilator-associated pneumonia, clinical implementation in this area is actually exploratory. CAP offers several advantages, including a multifactorial antimicrobial mechanism that reduces the likelihood of classical resistance development and toxicological studies indicate good tolerance under controlled conditions, and no adverse effects on human tissue. The results of this study contribute to the growing body of evidence supporting cold plasma as a viable alternative to traditional antibiotic treatments, with significant implications for the treatment of bacterial infections that are increasingly resistant to conventional therapies.

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