Inactivation of microorganisms on skin surface by cold atmospheric plasma

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Eradication of multiresistant superbugs is one of the clinical challenges of the 21st century. In the last twenty years new antibacterial agents approved by the U.S. FDA decreased whereas in parallel the resistance situation of multi-resistant bacteria increased. Thus, community and nosocomial acquired infections of resistant bacteria led to a decrease in the efficacy of standard therapy, prolonging treatment time and increasing healthcare costs.
Successful decolonisation of patients colonised with multi-resistant bacteria is of interest for controlling and preventing bacterial spread in hospital daily routine. The decolonization treatment consisted of mupirocin nasal ointment, chlorhexidine mouth rinse, and full-body wash with chlorhexidine soap. However the success depends on how many body regions are colonised by MRSA, as well as on the compliance of the treatment protocol by the patients and the health care workers. This emphasizes the need for the development of additional strategies for the decolonisation of bacteria.
The challenge of the antimicrobial plasma treatment is to find appropriate parameters which inactivate bacteria without harming the surrounding tissue. Therefore the present study was performed to evaluate the efficacy of two different cold-atmospheric plasma devices for decolonisation of ≥ 3 $\log_{10}$ steps ($\geq 99.9\%$) of *S. aureus,* MRSA and *E. coli*, when these bacteria were applied to an *ex vivo* porcine skin model.
Freshly excised skin samples were taken from six month old female pigs (breed: Pietrain). After application of pure bacteria on the surface of the explants these were treated with cold atmospheric plasma treatment for up to 15 min. Two different plasma devices were evaluated. A decolonisation efficacy of 99.9% was achieved already after 6 min of plasma treatment. Longer plasma treatment times achieved a killing rate of 99.999% independently from the applied bacteria strains. Histological evaluations of untreated and treated skin areas upon cold atmospheric plasma treatment within 24 h showed no morphological changes as well as no significant degree of necrosis or apoptosis determined by the TUNEL-assay indicating that the porcine skin is still vital. This study demonstrates that cold atmospheric plasma is able to very efficiently kill bacteria applied to an intact skin surface using an *ex vivo* porcine skin model.
Cold-atmospheric plasma generated by both new plasma devices are a novel anti-infective to decolonise bacteria, which are applied to intact skin surfaces, very efficiently.
Therefore cold atmospheric plasmas might evolve to a powerful tool for topical use to prevent nosocomial transmission of multiresistant pathogens, like MRSA, in the future.