Efficiency and Medical Compatibility of low-temperature Plasma Sterilisation

René Pompl 1),
Tetsuji Shimizu 1),
Hans-Ulrich Schmidt 3),
Wolfram Bunk 1),
Ferdinand Jamitzky 1),
Bernd Steffes1),
Kathrin Ramrath 2),
Birgit Peters 2),
Wilhelm Stolz 2),
Takuya Urayama 4),
Raju Ramasamy 4),
Shuitsu Fujii 4),
Gregor Eugen Morfill 1)

1) Max-Planck Institute for extraterrestrial Physics, D-85748 Garching, Germany
2) Clinic of Dermatology and Allergology, General Hospital Munich Schwabing, 80804 Munich, Germany
3) Institute for Microbiology, General Hospital Munich Schwabing, 80804 Munich, Germany
4) ADTEC Plasma Technology Co. Ltd., 721-0942 Hiroshima, Japan

While sterilisation of medical instruments using low temperature plasmas is an established procedure, its application in vivo is practically unexplored. However, its properties like quality and speed of sterilisation, penetration of small cavities and contact-free treatment would be beneficial to many medical applications. In order to utilise these advantages in vivo, our project aims to apply this new technique at first to the therapy of chronic foot and leg ulcers.
We developed a low temperature plasma device, which operates under atmospheric conditions. In a first phase we investigated the sterilising effect on several strains of bacteria cultured on agar plates. In a series of experiments we determined that a treatment time of two minutes is sufficient to achieve a distinct and sustainable germ reduction. Under these conditions only few bacteria survived on the treated area. Culturing these survivors and repeating the treatment proved that they are not inherently resistant to plasma treatment. An investigation of their biochemical profile and their resistance to antibiotics revealed no difference to untreated bacteria. Having determined the suitable plasma parameter, we applied the device to a number of bacteria that are relevant to wound healing, including methicillin-resistant Staphylococcus aureus and Pseudomonas aeruginosa. The treatment was effective on every tested strain, while its efficiency was varying with respect to the size of the inhibition zone.
In the second phase possible side effects of the treatment were investigated ex-vivo in specimens of human blood and healthy human skin. Within the mentioned treatment times the blood count as well as the histological and structural evaluation of the skin specimen using electron microscopy and atomic force microscopy showed no deterioration.
We conclude that a distinct and sustainable germ reduction can be achieved by our low-temperature plasma device. The treatment is compatible and effective on many bacteria species that are relevant to wound healing. In the next step it will be investigated in vivo, if the device is capable of improving the therapy of chronic foot and leg ulcers.