Atmospheric Plasma in Medicine: Chronic Wound Disinfection

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Cold atmospheric plasmas can play an important role in different areas of medicine, since they have a bactericidal property [1]. Such plasma contains charged particles, reactive oxygen and nitrogen species, heat, electric field and photons. They can react simultaneously on tissues. This topic is interdisciplinary and requires the knowledge of plasma physics, chemistry, fluid dynamics, and life sciences.

In medicine, active agents produced by plasmas can have an effect at the cellular level because the plasma gas can penetrate into small cavities. The plasmas can and must be designed depending on the purpose. In case of wound disinfection, there are requirements that the plasmas should reduce bacteria density on wounds without producing any harmful effect on human cell viability and genetic stability. It is essential to understand the action of different plasma components on human cells, prokaryotic cells, viruses, etc.

In this abstract we briefly show our study in medicine using a cold atmospheric plasma. A microwave driven argon plasma torch is used for our study and we describe the current status of our clinical study for wound care.

Since a few years, a clinical study has been carried out in collaboration with Department of Dermatology, Allergology and Environmental Medicine, Hospital Munich Schwabing, Department of Dermatology, University Hospital Regensburg, and Adtec Plasma Technology Co. Ltd. [2] Figure shows the clinical device used in the clinic. At the end of the flexible arm, the plasma torch is placed. Inside the plasma torch, microwave plasma is generated with ~80 W of microwave power at 2.45 GHz and ~2 slm of argon flow and this plasma flow is applied on wounds. Patients received standard wound care besides a two to five minutes argon plasma treatment on randomized wound(s). The bacteria load was detected by nitrocellulosis filters. A highly significant ($p<10^{-6}$) higher bactericidal effect of 34 % in plasma treated wounds compared to control wounds (n=291, 36 patients) is observed with five minutes treatment. Even with two minutes treatment resulted in a significant higher reduction rate in bacterial load(40 %, $p<0.016$, n=70, 14 patients). This reduction is found in all kinds of germs including multi-resistant one like MRSA. Until now, the treatment is very well tolerated and no side effects occurred.

The responsible agents for bactericidal effect in this study are mainly reactive species and UV light. The reactive species are produced through mixing between the argon plasma flow from the torch and the ambient air. It is quite important to understand the transport of the plasma, production mechanism of reactive species, and reactions on living tissues.

Figure: The clinical device for wound treatment. At the end of the flexible arm the plasma torch is placed.

References

[1] M. Kong, *et al.*, New Journal of Physics, **11** (2009), 115012.
[2] G. Isbary, *et al.*, British J. Dermatology, **163** (2010), 78.