Antisepsis of the skin by treatment with tissue-tolerable plasma (TTP): Risk assessment and perspectives

J. Lademann[1], H. Richter[1], A. Patzelt[1], M. Meinke[1], A. Kramer[2], K.-D.Weltmann[3], O. Lademann[2]

[1] Charité - Universitätsmedizin Berlin, Department of Dermatology and Allergology, Germany
[2] Institute of Hygiene, University of Greifswald, Germany
[3]Department of Internal Medicine, Helios Klinik, Bad Saarow, Germany
[3] Leibniz Institute for Plasma Science and Technology e.V. (INP), Greifswald, Germany
e-mail: juergen.lademann@charite.de

Résumé

The application of "cold" plasma is well suited for disinfection of non living materials. With "cold" plasma it is possible to decrease the microbial contamination of living tissues. In particular, when treating chronic wounds, it has several advantages in comparison to the classical application of antiseptics, which do not penetrate sufficiently into the tissue or inhibit wound regeneration. The mode of action of the plasma is based on the formation of free radicals, which destroy the bacteria and fungi. In the case of the investigated plasma-jet the present study could show that no electrical, UV or thermal damage of the skin can be expected, thus enabling an in vivo application.

Introduction

The application of cold atmospheric plasma is a promising method for wound healing [1-5]. It has antibacterial and antimicrobial effects and can stimulate fibroblast cells towards faster attachment and proliferation. In the present paper a risk assessment of cold plasma in dermatology is given.

In principle there are 3 properties of the plasma, which should be evaluated under the aspect of safety:

1. In the result of a gaseous discharge, radicals are produced on the skin surface. The human skin is continuously exposed to free radicals, which are produced by environmental factors like UV sun radiation. The human skin has developed a protection system against the destructive action of these highly reactive molecules in form of the antioxidative potential. The influence of the plasma on the antioxidative potential of the skin was investigated.

2. During the plasma formation, also UV radiation is produced. The spectrum of the plasma on the skin surface and in different depths of model tissue (pig ear skin) was investigated depending on different physical parameters influencing the formation of the plasma.

3. In the last series of experiments, the influence of the duration of the plasma treatment on the temperature of the skin surface was analyzed depending on different physical properties influencing the plasma parameters.

It was found that during the plasma treatment of tissue, the antioxidative potential is reduced only in the upper part of the stratum corneum, but not in deeper cell layers. Selecting the optimum parameters of the plasma formation, the UV exposure of the skin is less than in the case of UV irradiation of the sun on a summer day at noon.

If the duration of the plasma treatment of the skin is in the optimal range for wound healing, no thermal damage has to be expected.

The investigations have been carried out with an atmospheric pressure plasma jet (APPJ) working with Argon developed by INP Greifswald and neoplas GmbH.

Additionally the action mechanism of the plasma was investigated concerning the highly efficient in skin antisepsis [4-7]. The germs are not only located on the skin surface, but also in the hair follicles, from where they re-colonize the skin surface after antisepsis, e.g. It could be demonstrated that plasma is able to reach the follicular reservoir for antisepsis. For this purpose, a solution containing particulate chlorophyll dye had been applied onto porcine skin samples. The fluorescent properties of the dye changed during the plasma tissue interaction. The results demonstrate that TTP penetrates deep into the hair follicles, whereupon the hairs act as a conductor for the plasma. Therefore, it can be concluded that micro-organisms of the follicular reservoir are destroyed more efficiently by the plasma than by conventional liquid antiseptics.

References

[1] A. Kramer, N.-O. Hübner, K.-D. Weltmann, J. Lademann, A. Ekkernkamp, P. Hinz, O. Assadian, GMS Krankenhaushyg Interdiszip. **3** (2008) Doc13.
[2] J. Lademann, H. Richter, A. Alborova, D. Humme, A. Patzelt, A. Kramer, K.-D. Weltmann, B. Hartmann, C. Ottomann, J. W. Fluhr, P. Hinz, G. Hübner, O. Lademann, J. Biomed. Opt. **14** (2009) 054025.
[3] R. Matthes, C. Bender, N.-O. Hübner, G. Müller, K. Kohl, J. Mentz, I. Koban, E. Kindel, T. Kocher, K.-D. Weltmann, J. Lademann, A. Kramer, GMS Krankenhaushyg Interdiszip. **4** (2009) Doc08.
[4] O.Lademann, H.Richter, A. Patzelt, A. Alborova, D. Humme, K.-D. Weltmann, B. Hartmann, P. Hinz, A. Kramer, S. Koch, Laser Phys. Lett. **7** (2010) 458.
[5] A. Hammann, N.-O. Hübner, C. Bender, A. Ekkernkamp, B. Hartmann, P. Hinz, E. Kindel, I. Koban, S. Koch, T. Kohlmann, J. Lademann, R. Matthes, G. Müller, R. Titze, K.-D. Weltmann, A. Kramer, Skin Pharmacol. Physiol. **23** (2010) 328.
[6] O. Lademann, A. Kramer, H. Richter, A. Patzelt, M. Meinke, J. Roewert-Huber, V Czaika, K.-D.Weltmann, B. Hartmann, S. Koch, Laser Phys. Lett. (2011) accepted
[7] A. Kramer, J. Lademann, O. Lademann, et al., GMS Krankenhaushyg Interdiszip. **4** (2009) Doc10.