Burn wound healing: a role for plasma medicine?

Prof dr Esther Middelkoop[1], Roxana Tipa[2], Bouke Boekema[1], Coen van Gils[2], Sven Hofmann[2], Peter Bruggeman[2], Gerrit Kroesen[2]

[1] *Association of Dutch Burn Centres and Dept Plastic, Rec. and Hand Surgery, Research Institute MOVE, VU University Medical Center, Amsterdam Postal address: Red Cross Hospital, PO Box 1074, 1940 EB Beverwijk, The Netherlands*
[2] *Faculty of Applied Physics, Eindhoven University of Technology, The Netherlands*
E-mail: e.middelkoop@vumc.nl

Burn wounds represent a challenge in terms of the quality of healing. Wounds that extend through the dermis and into subcutaneous layers of the skin often heal with considerable scarring. Also, complications during the healing process such as bacterial colonization and infection will give rise to worsened scar quality.
Improvements in burn care over decades have provided some control over mortality, thereby increasing the focus on morbidity and quality of outcome.
Plasma treatment could provide interesting new treatment modalities for bacterial problems, as well as for scar improvement.
Bacterial colonisation and infection of burn wounds is usually treated with local or systemic antibiotics and/or antimicrobial agents. Clear disadvantages of these treatments are the increasing appearance of resistant bacterial species and cytotoxic effects towards the epithelial elements and cells in the wound bed.
We therefore designed an experimental setup to study these effects, in order to find conditions where bacteria would be effectively reduced and cells necessary in the wound healing process would remain unaffected.
We studied the effects of cold plasma treatment on skin cells and an in vitro burn wound model. A cold atmospheric plasma needle (13.56 MHz micro-jet) was used. Primary cultures of fibroblasts and keratinocytes were treated with plasma. Membrane leakage and proliferation were measured. For the burn wound model, small pieces of human skin were burned and treated with plasma. Samples were incubated air-exposed for 2 to 3 weeks to allow regrowth of the epidermis.

Short treatment times (30-60s) using argon plasma on cell cultures affected cell adhesion and proliferation. Treatment with compressed air or helium plasma for up to 2-4 min only marginally affected membrane integrity and proliferation.
Outgrowth in the burn wound model was reduced by longer plasma treatments (1 min) or with argon or compressed air. Helium plasma seemed to induce proliferation in keratinocytes but this was not accompanied by an increase of newly formed epidermis.

In conclusion, cold plasma can preserve the viability of skin cells. The effects on the cells are highly dependent on the distance between plasma surface and cell sample, the gas used for plasma ignition and the treatment type. Potentially, a contact-free disinfection method for burn wounds could be created.