DREXEL UNIVERSITY
School of
Biomedical Engineering,
Science and Health Systems

Cold Plasma Sterilization of Wounds and Burns

Greg Fridman, BioMed; Richard Hamilton, Emergency Medicine; Suresh Joshi, Surgery; Ari Brooks, Surgery

Background

- Bacterial infections in wound can causes serious complications that can range from increased healing time to death
- Non-thermal plasma generates chemically active species, ions, radicals (O, OH, NO) and electronically-excited atoms and molecules and UV that acts as bactericidal agents
- Cold plasma generates chemically active species,
- NO has been shown to be linked to inflammatory and proliferation phases of the healing process
- Short exposure show no adverse effect on living tissue
- Plasma can be used to inactivate antibacterial resistant strains of bacteria (e.g. MSRA)
- Plasma can also inactivate the toughest bacteria (*Deinococcus radiodurans*)

Plasma-Medicine Lab
Drexel Plasma Institute

Directive

- Use Floating Electrode Dielectric Barrier Discharge (FE-DBD) to treat cutaneous wounds and burns of bacterial infection
- Speed up blood coagulation
- Improve healing time

Plasma Device Profile
Operating Frequency:10-30 kHz
Operating Voltage: 0-30 kV
Operating Pulse Duration: 1.5 – 10 µs

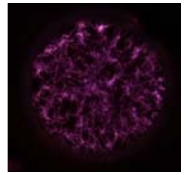
- Quartz Dielectric
- Ultem housing to prevent exposing target tissue to spark

Procedures

- Inoculate porcine skin surface with E. coli
- Treat bacterial inoculation site with plasma
- Use contact plate to determine efficacy of plasma sterilization / inactivation on skin

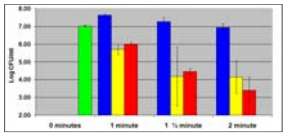
- Artificial wound is created on a porcine skin
- Wound is inoculated with ~10^7 concentration of *Staphylococcus aureus* and vigorously rubbed into the wound
- Incubate the wound for 0 hours, 2 hours and 24 hours.
- Buffer is added to the wound, wound site is scrubbed then aspirated to collect all the bacteria
- Bacteria then plated for counting

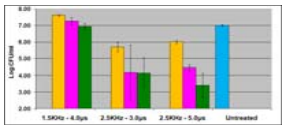
- Induce bleeding on live animal
- Treat wound with plasma
- Compare coagulation time



Plasma discharge from wound perspective

Results





Red circle shows the plasma treated area on the skin – colonies + no bacteria

Low dose rate treatment | High dose rate treatment

~3 log reduction can be obtained within 2 minutes.
At high dose rate reduction is higher, but at higher risk of skin damage

- Full coagulation in less tha1.5 minutes
- Untreated wound coagulates in ~3 min

Discussion

- Dose and dose rate – critical in preventing tissue damage while maintaining efficacy
- Even at same overall dosage (same level of bacterial reduction), high dose of plasma in short period of time causes skin damage, while low does over long time does not
- Find new method to deliver discharge at high dose rate without tissue damage

High dose rate (14J/s)– causes burns on the skin (5sec treatment, 70J total)

Low dose rate (5J/s)– no skin damage (14sec treatment, 70J total)

Coulter-Drexel Translational Research Partnership Program