Cold Plasma Sterilization of Wounds and Burns

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Background

- Bacterial infections in wounds can cause 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).

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.

Results

- ~3 log reduction can be obtained within 2 minutes.
  - At high dose rate reduction is higher, but at higher risk of skin damage.
  - High dose rate treatment
  - Low dose rate treatment
  - Full coagulation in less than 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).