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The role of reactive oxygen and nitrogen species in plasma cancer treatment

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Low temperature plasmas are emerging as an exciting development for therapeutics. The unique properties of cold non-equilibrium plasmas have enormous potential in disease therapeutics and plasma pharmacology as drug alternatives. Applications of these plasmas include surface sterilization and bacterial decontamination, biofilm inactivation, antimicrobial treatment in food preservation, wound healing, to cancer treatment. Non-equilibrium plasmas, operated at ambient atmospheric pressure and temperature, are very efficient sources for highly reactive neutral particles e.g. reactive oxygen and nitrogen species (RONS) (such as atomic oxygen, atomic nitrogen, hydroxyl radical, superoxide, singlet delta oxygen, nitrogen oxides), charged particles, UV-radiation, and electro-magnetic fields. Individually many of these components have been implicated in therapeutics. RONS are known to play a crucial role in biological systems, such as signalling, and generating oxidative damage to a variety of cellular components, which can ultimately lead to cell death. Plasmas have the advantage of delivering these simultaneously providing potentially superior processes.

We have assessed the *mechanisms* of cell death after plasma treatment of *both* benign and cancerous prostate epithelial cells, mapping the immediate cellular responses, which ultimately result in cell death. Exposure to the plasma for >3 minutes showed high levels of DNA damage compared to untreated and hydrogen peroxide controls. At time periods up to 96 hours post-treatment, cell viability was significantly reduced. Cell recovery was found to be greatly inhibited following treatment times of up to 10 minutes, with results suggesting the cells die through necrotic mechanisms. All the findings were common to both cell lines, suggesting the potential of LTP therapy for both benign and malignant disease.

RONS produced by the plasma are believed to be the main mediators of the plasma-cell interaction and response [1, 2]. We found that the concentration of reactive oxygen species (ROS) induced inside the cells increased with plasma exposure. Quantitative measurements of short- and long-lived reactive species in the core plasma and plasma jet are essential for further understanding. These measurements are particularly challenging in the collision-dominated environment of atmospheric pressure plasmas, requiring extremely high temporal (picosecond) and spatial (microns) resolution. Two advanced optical diagnostic techniques are applied, and will be presented, to measure absolute radical densities: Pico-second two-photon absorption laser induced fluorescence (ps-TALIF) and synchrotron vacuum ultra-violet (VUV) high-resolution Fourier-transform absorption spectroscopy [3]. Radical densities have been measured in the plasma for varying parameters.

References

[1] O'Connell, D., et al., Applied Physics Letters, 2011. **98**(4): p. 043701-3.

[2] Graves, D.B., Journal of Physics D-Applied Physics, 2012. **45**(26).

[3] K. Niemi, et al., *Appl. Phys. Lett* **103**, 034102 (2013)