Non-Thermal Plasma for Immunomodulation: Implications and Applications

Vandana Miller

Associate Professor; Microbiology and Immunology and Surgery, Drexel University

Non-thermal plasmas are increasingly being investigated for their potential biomedical applications. When discharged in ambient atmosphere, they form a variety of reactive species that exhibit direct biological activity against microbes and tumor cells and assist in wound healing. These effects are collectively attributed to the complex cocktail of effectors in plasma discharges, with no single component identified as the primary effector. Each plasma source produces a slightly different cocktail and delivers its components through different mechanisms, impacting the biological outcome and the associated toxicity.

Advances in the last decade have produced devices for direct ablation of tumors as an alternative therapy for cancer. Local application of plasma to tumors in vivo has led to reduced tumor size and increased life expectancy of treated animals. Until five years ago, most studies focused on the direct influence of plasma on tumors, but not all tumors are accessible for plasma application. Therefore, a different approach is required for deep tissue treatment and systemic elimination of cancer in patients.

The body’s immune system plays a vital role in the control of cancer. In fact, cancer immunotherapy, the control of cancer by employing components of the patient’s own immune system, is emerging as an appealing strategy and the Nobel prize for Medicine in 2018 was awarded to one such strategy. New approaches being explored include increasing the immunogenicity of tumor cells by inducing immunogenic cancer cell death (ICD). ICD of cancerous cells has been demonstrated with certain chemotherapeutic drugs and through physical methods such as X-ray therapy and UVC. Cells undergoing ICD express damage associated molecular patterns (DAMPs) which assist immune responses that may mediate systemic elimination of cancer.

It is now well demonstrated that non-thermal plasma is a good candidate for cancer therapy via immunomodulation by:
1) direct stimulation of innate immune cells and
2) indirectly, via induction of ICD of cancerous cells.

Plasma elicits ICD locally, in the treatment area, which leads to beneficial host immune responses both locally and systemically. The role of plasma augmentation of the immune system, based on ours and others in vitro and in vivo studies as well as early clinical trials, will be presented as a potential modality for clinical application in cancers. The contribution of different short and long-lived species will be discussed.

The clinical potential of plasma immunotherapy for cancer and other diseases, including infections, will be discussed and the challenges to address will be identified for further development of this technology.

Bio: Dr. Vandana Miller, MD is an Associate Professor in the departments of Microbiology and Immunology and Surgery at Drexel University College of Medicine. She has a visiting scientist position at INP Greifswald for 2019. Her research focus is on harnessing the immunomodulatory capability of non-thermal plasma for applications in cancer treatment, wound healing, skin diseases, viral diseases and vaccine delivery. She works closely with tumor immunologists, surgeons, dermatologists, virologists and immunologists, and collaborates with plasma scientists all across the world.