Pulsed Atmospheric-pressure Plasma Streams produced by Plasma Gun: characterization and application for tumor treatment

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The need for remote, controlled delivery of plasma through capillaries in, for example, endoscopic procedures has presented challenges to the plasma medicine community. In response to the need of controllable remote plasma sources, the Plasma-Gun (PG) has been developed. The first part of this presentation will emphasize the detailed experimental analysis of the PG over a large range of parameters including voltage pulse shape, repetition rate, polarity, plasma expansion capillaries [1] and capillary geometry (T-shape, branched). This experimental work and the results from simulations designed to model the fast ionization wave launching and propagation [2], confirm the new moniker of "Pulsed Atmospheric-pressure Plasma Stream" (PAPS) to describe the plasma produced by the PG. These works have also revealed specific features of streamer propagation in dielectric constrained volumes. The key roles of the electron drift in the space charge ionization front and of the impedance of the plasma tail connecting this ionization front with the DBD powered electrode, described by the simulations are in good agreement with experimental data. These results clearly show that plasma expansion and dose delivery can be carefully controlled. This opens up new possibilities for the PG development, including endoscopic plasma delivery strategies.

In the second part of this presentation, we will discuss results from recent studies of both *in vitro* and *in vivo* assessment of helium plasma jet antitumor activity on different cancer cell lines and tumors. In the context of results obtained on the anti-tumoral effect of DBD produced plasmas, the first demonstrations of antitumor activity by PGs will be presented, including the first demonstration of treatment of mouse orthotopic pancreatic carcinoma. In this particular case, the protocol was a three-time plasma delivery, of 10 minutes each, with the PG operating at 2 kHz repetition rate. Four groups of mice have been followed during the five week duration of the study. Tumor growth was monitored through bioluminescence imaging. Besides the control group, a group received a reference chemotherapeutic treatment; a group was treated with the PG, while another one had a combination of both. The PG treatment not only produced a significant reduction in tumor activity and volume, but also led to better results than the chemotherapy alone. Most striking was that the best results were obtained with the group that received both treatments. This is the first evidence *in vivo* for a potential benefit of the association of non thermal plasma and chemotherapy.

References

[1] E Robert, V Sarron, D Riès, S Dozias, M Vandamme and J.M. Pouvesle, submitted to Plasma Sources Sci. Technol. 2012.
[2] Z. Xiong and M.J. Kushner, accepted in Plasma Sources Sci. Technol., March 2012.