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Non-thermal Plasma and Oxidative Stress

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Thermal plasmas and lasers have been used in medicine to cut and ablate tissues and for coagulation. Non-equilibrium atmospheric pressure plasma (NEAPP; non-thermal plasma) is a recently developed, non-thermal technique with possible biomedical applications. Although NEAPP reportedly generates reactive oxygen/nitrogen species, electrons, positive ions, and ultraviolet radiation, few research projects have been conducted to merge this technique with conventional free radical biology. Recently, Prof. Masaru Hori's group (Plasma Nanotechnology Research Center, Nagoya University) developed a NEAPP device with high electron density. Here electron spin resonance revealed hydroxyl radicals as a major product. To merge non-thermal plasma biology with the preexisting free radical biology, we evaluated lipid peroxidation and DNA modifications in various in vitro and ex vivo experiments. Conjugated dienes increased after exposure to linoleic and alpha-linolenic acids. An increase in 2-thiobarbituric acid-reactive substances was also increased after exposure to phosphatidylcholine, liposomes or liver homogenate. Direct exposure to rat liver in medium produced immunohistochemical evidence of 4-hydroxy-2-nonenal- and acrolein-modified proteins. Exposure to plasmid DNA induced dose-dependent single/double strand breaks and increased the amounts of 8-hydroxy-2'-deoxyguanosine and cyclobutane pyrimidine dimers. These results indicate that oxidative biomolecular damage by NEAPP is dose-dependent and thus can be controlled in a site-specific manner. Simultaneous oxidative and UV-specific DNA damage may be useful in cancer treatment. Other recent advancements in the related studies of non-thermal plasma in Nagoya University Graduate School of Medicine will also be discussed.

[1] Okazaki et al. J Clin Biochem Nutr 55: 207, 2014

[2] Toyokuni S et al. FEBS Lett 358: 1, 1995