World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:11, No:04, 2017

Model Evaluation of Nanosecond, High-Intensity Electric Pulses Induced Cellular Apoptosis

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Abstract : High-intensity, nanosecond, pulsed electric fields have been shown to be useful non-thermal tools capable of producing a variety of specific cellular responses. While reversible and temporary changes are often desired based on electromanipulation, irreversible effects can also be important objectives. These include elimination of tumor cells and bacterial decontamination. A simple model-based rate-equation treatment of the various cellular biochemical processes was used to qualitatively predict the pulse number-dependent caspase activation and cell survival trends. The model incorporated the caspase-8 associated extrinsic pathway, the delay inherent in its activation, cytochrome c release, and the internal feedback mechanism between caspase-3 and Bid. Results were roughly in keeping with the experimental cell-survival data. A pulse-number threshold was predicted followed by a near-exponential fall-off. The intrinsic pathway was shown to be much weaker as compared to the extrinsic mechanism for electric pulse induced cell apoptosis. Also, delays of about an hour are predicted for detectable molecular concentration increases following electrical pulsing.

Keywords : apoptosis, cell survival, model, pathway
Conference Title : ICBBB 2017 : International Conference on Bioelectronics, Bioinstrumentation and Biosensors
Conference Location : Boston, United States
Conference Dates : April 24-25, 2017