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Model Evaluation of Action Potential Block in Whole-Animal Nerves Induced by Ultrashort, High-Intensity Electric Pulses

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Abstract : There have been decades of research into the action potential block in nerves. To our best knowledge electrical voltages can reversibly block the conduction of action potentials across whole animal nerves. Blocking biological electrical signaling pathways can have a variety of applications in muscular and sensory incapacitation and clinical research, including urethral pressure reduction and relieving chronic pain relief from a peripheral nerve injury. The cessation ability has been used in muscle activation and fatigue reduction. Ultrashort, high-intensity electric pulses modulate the membrane conductivity to block nerve conduction through the electroporation process. Nanopore formation on the membrane surface would increase the local membrane conductivity and effectively "short-out" the trans-membrane potential of a nerve that inhibits action potential propagation. This block would be similar in concept to stopping the propagation of an air-pressure wave down a "leaky" pipe. This research focuses on a distributed electrical model with an additional time-dependent membrane conductance to calculate the poration induced by the ultrashort, high-intensity electric pulses. The changes in membrane conductivity are used to predict changes in action potential transmission. A "strength-duration (SD)" curve is generated for action potential blockage and would be used as a design guide for benchmarking safety thresholds or setting the pulse voltage and/or durations necessary for neuro-muscular incapacitation.

Keywords : action potential, ultrashort, high-intensity, nerve, strength-duration
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