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Special Collection on Electroporation-Based Therapies: A Selection of Papers From the Second World Congress on Electroporation

Richard Heller
Old Dominion University, rheller@odu.edu

Rafael V. Davalos

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Special Collection on Electroporation-Based Therapies: A Selection of Papers From the Second World Congress on Electroporation

Richard Heller, PhD[1] and Rafael V. Davalos, PhD[2]

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The use of pulsed electric fields (PEFs) is a rapidly growing field with applications in medicine, food, industry, and environment. This special collection focuses on medical applications specifically aimed at developing effective cancer therapies and understanding the underlying mechanisms of those approaches. Pulsed electric fields can be applied in a variety of ways and is typically characterized by the pulse width (nanosecond to millisecond) and the specific intended application (ablation, delivery, or diagnostic). A general term that is used is electroporation, which is a means to increase the permeability of cells via the use of PEF and has applications ranging from gene and drug delivery to ablation to bacterial inactivation to food processing. When a cell is exposed to a sufficiently intense electric field (for a sufficient duration), local defects in the cell membrane appear and become permeable to molecules that otherwise cannot pass through it. In reversible electroporation, the cell membrane is permeabilized to molecules otherwise deprived of transmembrane transport mechanisms. This is a transient phenomenon as after a short time the membrane reseals and reestablishes its homeostatic semipermeable properties, allowing ions and other small molecules to passively cross.

With reversible electroporation, the cell can survive; though if the molecular transport disruptions to homeostasis are too great, the cell will die and this process is termed irreversible electroporation (IRE) and can be used to ablate tissue, particularly solid tumors. Reversible electroporation has been used in conjunction with chemotherapeutics, electrochemotherapy (ECT), and to deliver genes, gene electrotransfer.

At the second World Congress, there were many presentations highlighting the use of PEF in the medical field. In addition to traditional reversible electroporation and IRE, researchers are pushing the envelope and are assessing the potential application of nanosecond PEF and high-frequency electroporation for the treatment of cancer.

This special collection contains reports that cover many aspects of the use of PEF to treat cancer. In the area of IRE, several breakthrough approaches are reported. The use of high-frequency IRE (H-FIRE) as a means to enhance the treatment of intracranial meningiomas is reported (Latouche, 2018 #22). The collection also includes a report on the first clinical trial utilizing H-FIRE for prostate cancer (Dong, 2018 #9). Another interesting approach is the development of a navigation system combined with treatment planning to allow for application of IRE through a percutaneous approach. This approach will allow treatment of deep-seated tumors utilizing a minimally invasive approach (Fuhrmann, 2018 #30). In another aspect of IRE, a study on a new electrode design that can be utilized to treat liver tumors is reported (Ritter, 2018 #36). The collection contains a related study, a report on combining moderate heat with nanosecond pulses as a means of effectively treating squamous cell carcinoma in a preclinical model (Edelblute, 2018 #35).

The collection includes several reports on the use of PEF for drug delivery also known as ECT. An excellent review of the use of ECT is included (Probst, 2018 #5). An interesting study reports on the use of novel needle electrodes for the treatment of breast cancer (Vera-Tizatl, 2018 #15). There is also a report utilizing finite element analysis to evaluate the use of *in vivo* ECT (Pintar, 2018 #11). A new area related to ECT is the use of PEF to deliver calcium to treat cancer as opposed to a

[1] Frank Reidy Research Center for Bioelectrics (CBE), Old Dominion University, Norfolk, VA, USA
[2] Virginia Tech—Wake Forest University School of Biomedical Engineering and Sciences, Blacksburg, VA, USA

Corresponding Author:
Richard Heller, PhD, Frank Reidy Research Center for Bioelectrics (CBE), Old Dominion University, 4211 Monarch Way, Norfolk, VA 23508, USA.
Email: rheller@odu.edu

chemotherapeutic agent. The studies reported on the evaluation of the use of calcium electroporation and the effect on normal and malignant cells as well as an optimization study on multiple tumor models (Romeo, 2018 #24; Frandsen, 2018 #25).

An important aspect of advancing these technologies is to better understand the mechanisms that enable the success of these approaches. This enables a way to better apply the technologies in a safe and effective manner. One study reports on the effect of tissue inhomogeneity and how that can influence the application of PEF (Campana, 2018 #10). One study evaluated the use of high-frequency nanosecond pulses and how that relates to muscle contractions (Mi, 2018 #8). Two papers in the collection report on membrane permeability and transport through the membrane (Sweeney, 2018 #14; Sweeney, 2018 #31). Another paper demonstrates electrogene transfer of plasmid DNA in spheroids (Znidar, 2018 #2), while another, studies vascular effects after targeted gene therapy in combination with tumor irradiation (Savarin, 2018 #3). These are important analyses that will enable design of better protocols to enhance delivery. Included in the collection is an interesting use of magnetic resonance imaging to map hypoxic levels in tumors (Serša, 2018 #16).

This special collection contains an excellent overview of the use of PEF technologies to treat cancer. Manuscripts are provided by leading experts in the field. Whether you are new to the field or are already utilizing PEF technologies or just interested in finding out more about it, this collection will provide you with some of the latest breakthroughs.

We hope to have you join us in Toulouse, France, for the third World Congress, September 3-6, 2019 (https://wc2019.electroporation.net).

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ORCID iD

Richard Heller, PhD https://orcid.org/0000-0003-1899-3859
Rafael V. Davalos, PhD https://orcid.org/0000-0003-1503-9509