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Review: Recent Progress in Nanomedicine for Gene Delivery Applications; An Overview of the CERRMA Lab Experience

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Dr. Samar El Achy is an Assistant Professor of Anatomical Pathology, at the Faculty of Medicine, Alexandria University, also holds the position of the Executive Manager of the Nanomedicine laboratory at the Center of Excellence for Research in Regenerative Medicine and its Applications. Dr. EL Achy, earned her Bachelor Degree in Medicine and Surgery 2002, from the Faculty of Medicine, Alexandria University. She, commenced her career path in the field of Anatomical Pathology since 2004, handling all aspects of cancer diagnosis and management, experiencing, and acknowledging the gaps in this science which triggered her interest to explore new methods for cancer diagnosis and treatment, namely the field of nanomedicine. From thereon, she completed her PhD studies in the field of nanomedicine at Northwestern University, Chicago, USA. Upon returning to her home country, she played a key role with the Alexandria Faculty of Medicine team in building a comprehensive research center for regenerative medicine, cell culture, and nanomedicine.

Her main experience in research, for the past 10 years, focuses on the use of nanotheranostics for detection, and treatment of cancer, nanotoxicities, as well as a special recent focus on gene delivery nanotherapeutics. She has been involved in a number of funded projects from national and international funding agencies, and has been actively fostering "nanotechnology education" in her university through workshops, conferences and observorships run in her lab. Dr El Achy can be reached on her Linked In page as well as her email: samarelachy@gmail.com, samar.elachy@alexmed.edu.eg.

ABSTRACT

Decoding of the human genome, has unraveled numerous canonical molecular pathways having great significance in cancer and chronic diseases. Recent advancements in the development of genomic high-throughput platforms have fueled genome-wide approach to mine novel biomarkers and paved the way for better diagnostics and the discovery of promising therapies.

The technology of using nucleic acid-based therapeutics is powerful, as it enables precise modulation of the expression of genes known to be involved in disease progression and can thereby be used for precision medicine. DNA and mRNA are used to induce a specific genes of interest, whereas siRNA and miRNA are used for silencing and modulation of specific genes. The sequence of nucleic acids can further easily be modified to enable patient-specific treatments and can encode essentially any gene involved in specific molecular pathways, or oncogenes, to facilitate treatments of otherwise so-called "undruggable" tumors. Accordingly, nucleic acid therapeutics can be designed to target specific genes involved in cell proliferation, migration, invasion, apoptosis, as well as inflammation, including gene editing correction using CRISPR-Cas9.

Currently employed pharmaceutical nanocarriers, like micelles, liposomes, nanoemulsions, polymeric nano-particles, etc. amongst which few have already entered clinic, whilst others are ongoing preclinical development, exhibit a variety of advantageous characteristics. Herein, we discuss the mechanisms of nanoparticle-targeted drug delivery, recent advancement of therapeutic strategies of nanoparticles based carriers for siRNA, miRNA, and gene augmentation therapies. We also discuss the future prospects and challenges of nanoparticle gene therapeutics. Additionally, a brief overview of our research experience in nanoparticle gene therapeutics at the Center of Excellence for Research in Regenerative Medicine and its Applications (CERRMA) at the Faculty of Medicine, Alexandria University, Egypt.