Chapter 8
New Developments in Messenger Ribonucleic Acids (mRNA) Vaccine Technology:
Future Applications in Cancer Oncology

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ABSTRACT

Technological developments in clinical and medical oncology have made it possible to treat certain diseases, like cancer, at the root level through biological processes that requires genes to be transcribed and translated into proteins. The world has learnt about messenger ribonucleic acids(mRNA) technology in the last two years, and in that time, it has shown how quickly it can respond to situations and have almost limitless potential for future uses in the treatment of cancer. The genetic instructions or recipe that guide cells on how to use their own machinery to build proteins are carried by a molecule called messenger RNA (mRNA). This study demonstrated how mRNA can be a powerful tool for developing vaccines and diseases treatments, allowing human cells to put forth a lot of effort in generating proteins that trigger an immune response that defends against illnesses and preserves human organs, marking significant milestone in science and demonstrating the adaptability and versatility of mRNA technology for known and unknown diseases treatments.

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1. INTRODUCTION

Improvements in cancer treatment and drug discovery are among the instances of clinical oncology advancements that have improved the prognosis for many cancer patients in the recent time(Adebanjo, Bakare, Oseni, & Matthew, 2024). Advances in medical technology have enabled the treatment of some illnesses, including cancers, at the transcription and translation level. In the past two years, messenger ribonucleic acid (mRNA) technology has gained international attention as preventive and therapeutic vaccine applications(Jain, Venkataraman, Wechsler, & Peppas, 2021). During that time, it has demonstrated its rapid situational response and nearly infinite potential for future applications in cancer treatment. The mRNA is a molecule that carries the genetic instructions or blueprint that tell cells how to use their own machinery to build proteins which is encased in a protective bubble that permits it to freely circulate throughout the cells using lipid nanoparticles, an increasingly popular method of delivering genes that can contain both protein and nucleic acid(Hu, Li, You, Cai, & Chen, 2024),(Dinh, Mahon, & Yan, 2024). Within the human cells, the mRNA serves as a set of instructions for the production of proteins that bind to the distinct regions, or antigens, of the pathogen. When foreign antigens are interpreted as intruders, the immune system creates T-cells and antibodies quickly to strengthen defenses against further assaults. If and when the actual virus appears, the body may be able to identify the warning signal it is sending in order to assist prevent infection and disease. By enabling human cells to work hard at producing proteins that initiate an immune response that protects against illnesses and preserves human organs, this study showed how mRNA can be a potent tool for creating vaccines and disease treatments. It also marked a significant scientific milestone and illustrated the adaptability and versatility of mRNA technology for treating both known and unknown diseases. The paper presented a comprehensive analysis of mRNA vaccines and their potential applications in cancer immunotherapy. The authors emphasize the advantages of mRNA vaccines over traditional vaccination methods, including high potency, quick development, inexpensive manufacture, and safe delivery. In order to overcome the immunosuppression, mRNA cancer vaccines can be used in conjunction with other anti-cancer medicines, a tactic that is continuously being attempted on cancer patients.

2. BACKGROUND OF THE STUDY

The potential for treating a range of infectious diseases with mRNA therapy has significantly expanded, which has enabled human body to manufacture almost any functional protein or peptide following the recent rapid advances in biotechnology and molecular medicine, which introduced mRNA as a vaccine or therapeutic agent(Qin et al., 2022). One of the most notable advantages of mRNA vaccines is their ability to respond to major infectious disease outbreaks such as the ongoing COVID-19 pandemic. Scientists have constantly sought to improve the stability, immunogenicity, translation efficiency, and delivery mechanism of mRNA in order to make its distribution safe and efficient. These scientific intentions have been fascinatingly realized owing to the rapid and amazing developments in molecular biology, ribonucleic acid (RNA) technology, vaccinations, and nanotechnology(Hughes, 2024). Applications for mRNA-based treatments include protein replacement and vaccinations against cancer and infectious disorders. Typically, bacteriophage RNA polymerase is used to in vitro transcribe (IVT) synthesized mRNAs from a deoxyribonucleic acid (DNA) plasmid for clinical use(Singh, Smith, Arbuthnot, & Ely, 2024). Numerous delivery technologies, including viral vectors, inorganic drug car-