

Editorial

Potential Benefits and Challenges of mRNA Cancer Vaccines

Nemat Khansari^{1*}

¹Department of Immunology, Tehran University of Medical Sciences, School of Medicine, Iran

*Correspondence author: Nemat Khansari, Department of Immunology, Tehran University of Medical Sciences, School of Medicine, Iran;

Email: nkhansari928@gmail.com

Citation: Khansari N. Potential Benefits and Challenges of mRNA Cancer Vaccines. J Clin Immunol Microbiol. 2023;4(3):1-3.

<http://dx.doi.org/10.46889/JCIM.2023.4307>

Received Date: 26-11-2023

Accepted Date: 12-12-2023

Published Date: 20-12-2023



Copyright: © 2023 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CCBY) license (<https://creativecommons.org/licenses/by/4.0/>).

Editorial

Cancer is a complex and multifaceted disease that affects millions of people worldwide. One of the most promising advances in cancer treatment and prevention is the development of mRNA cancer vaccines. These vaccines are designed to harness the power of the immune system to target and eliminate cancer cells, offering a revolutionary approach to cancer therapy. Recently, one mRNA vaccine (mRNA-4157/v940) received FDA approval to be used as an adjuvant with Pembrolizumab therapy in melanoma patients. In addition, several mRNA cancer vaccines are in the development stage as follows:

BNT111: BioNTech's personalized mRNA vaccine for melanoma, has shown promising results in clinical trials.

MEDI1843: Moderna's personalized mRNA vaccine for melanoma, which is also in clinical trials.

ZYN001: CureVac's mRNA vaccine for pancreatic cancer, which is in Phase II clinical trials.

INO-5401: Inovio's mRNA vaccine for cervical cancer, which is in Phase II clinical trials.

mRNA-4157/V940 is a novel investigational messenger Ribonucleic Acid (mRNA)-based personalized cancer vaccine consisting of a single synthetic mRNA coding for up to 34 neoantigens that is designed and produced based on the unique mutational signature of the patient's tumor. Upon administration into the body, the algorithmically derived and mRNA-encoded neoantigen sequences are endogenously translated and undergo natural cellular antigen processing and presentation, a key step in adaptive immunity.

Personalized cancer vaccines are designed to prime the immune system so that a patient can generate a tailored antitumor response specific to their tumor mutation signature. mRNA-4157/V940 is designed to stimulate an immune response by generating specific T-cell responses

based on the unique mutational signature of a patient's tumor. Pembrolizumab (KEYTRUDA) is an immunotherapy that works by increasing the ability of the body's immune system to help detect and fight tumor cells. Based on early clinical studies, combining mRNA-4157/V940 with KEYTRUDA may potentially provide an additive benefit and enhance T cell-mediated destruction of tumor cells.

The process of mRNA cancer vaccine production offers several advantages over traditional cancer therapies:

- **Rapid development:** mRNA vaccines can be developed relatively quickly compared to traditional cancer vaccines, allowing for personalized vaccines tailored to individual patients
- **Precision targeting:** mRNA vaccines specifically target tumor-specific antigens, minimizing the risk of off-target effects and enhancing the efficacy of the vaccine
- **Enhanced safety:** mRNA vaccines do not introduce live or attenuated pathogens, reducing the risk of infection or adverse side effects
- **Versatility:** mRNA vaccines can encode a wide range of antigens, making them adaptable to various cancer types

While mRNA cancer vaccines have generated considerable interest, it is essential to understand how they differ from other immunotherapies, such as checkpoint inhibitors.

Mechanism of Action

mRNA cancer vaccines work by introducing synthetic mRNA molecules encoding cancer-specific antigens into the body, training the immune system to recognize and target cancer cells expressing those antigens. This approach focuses on activating the immune system against specific targets found on cancer cells.

In contrast, checkpoint inhibitors function by removing the "brakes" on the immune system. Cancer cells often exploit immune checkpoint pathways to evade detection and elimination by T-cells. Checkpoint inhibitors are monoclonal antibodies that block these pathways, allowing T-cells to recognize and attack cancer cells more effectively. This strategy aims at enhancing the overall activity of the immune system rather than targeting specific antigens.

Personalization and Specificity

mRNA cancer vaccines offer a higher degree of personalization compared to checkpoint inhibitors. By tailoring the vaccine to target unique antigens present in an individual's tumor, mRNA vaccines provide a customized approach that can potentially increase treatment success rates.

Checkpoint inhibitors are not personalized; they target specific immune checkpoint proteins expressed by various types of cancer cells. While this broader approach may be effective in treating multiple cancers, it lacks the specificity offered by mRNA vaccines.

Side Effects

The side effects associated with mRNA cancer vaccines tend to be milder compared to those observed with checkpoint inhibitors. Since mRNA vaccines specifically target cancer cells, damage to healthy tissue is minimized, reducing the risk of severe side effects.

On the other hand, checkpoint inhibitors can lead to autoimmune-like side effects due to their mechanism of action - unleashing the immune system without strict specificity towards cancer cells. These side effects may include inflammation or damage to healthy organs and tissues.

Combination Therapy Potential

Both mRNA cancer vaccines and checkpoint inhibitors hold promise for combination therapy approaches. Combining these immunotherapies can potentially maximize the immune system's ability to target and eliminate cancer cells while minimizing side effects.

For instance, an mRNA cancer vaccine could be used to prime the immune response against specific tumor antigens, followed by treatment with a checkpoint inhibitor to further unleash the immune system's activity against cancer cells. This synergy between the two approaches may lead to improved treatment outcomes in a variety of cancers.

Based on clinical applications it seems, mRNA cancer vaccines and checkpoint inhibitors represent distinct yet complementary approaches within the broader field of cancer immunotherapy. Both treatments offer unique advantages and challenges and their combined use may pave the way for more effective and personalized cancer therapies in the future.

The Role of mRNA Stability and Delivery Methods in Vaccine Effectiveness

One of the critical factors influencing the effectiveness of mRNA cancer vaccines is the stability of the mRNA molecules themselves. Naturally, mRNA is a fragile molecule that can be rapidly degraded by cellular enzymes. This degradation poses a challenge for vaccine development, as it may reduce the amount of functional mRNA available to produce target antigens and activate an immune response.

To overcome this issue, researchers have developed strategies to enhance mRNA stability and prolong its half-life within cells. These approaches include chemical modifications, such as incorporating pseudouridine or modified nucleosides, which can protect the mRNA from degradation while maintaining its ability to encode proteins efficiently. Additionally, optimizing the structure and sequence of the synthetic mRNA molecule can further improve its stability and overall effectiveness.

Delivery Methods for Optimal Efficacy

Effective delivery methods are crucial for ensuring that sufficient amounts of stable mRNA reach their target cells without being degraded or triggering unintended immune responses. Several delivery systems have been explored to optimize both the protection and uptake of the mRNA molecules in targeted cells.

Lipid Nanoparticles (LNPs)

One promising approach involves encapsulating the synthetic mRNA within Lipid Nanoparticles (LNPs). LNPs are microscopic spheres made up of lipids that can efficiently deliver their cargo into cells while protecting it from degradation. They also aid in avoiding rapid clearance by immune cells or filtration systems within the body. LNPs have been successfully employed in several approved COVID-19 vaccines and are currently being studied for use in cancer vaccine applications.

Electroporation

Another delivery method under investigation is electroporation, a technique that uses short electrical pulses to introduce nucleic acids into cells more efficiently. By temporarily disrupting cell membranes with these pulses, researchers can facilitate entry of synthetic mRNA molecules into target cells while minimizing damage to surrounding tissues.

Viral Vectors

Viral vectors are another potential mode for delivering mRNA cancer vaccines. These vectors are engineered viruses that have been modified to carry the synthetic mRNA encoding tumor-specific antigens. The viral vector infects target cells, delivering the mRNA payload and initiating antigen production, which triggers the immune response against cancer cells.

Addressing the challenges of mRNA stability and effective delivery methods is crucial for optimizing the efficacy of mRNA cancer vaccines. By employing innovative strategies to protect and deliver these fragile molecules, researchers can enhance their potential in targeting cancer cells and stimulating robust immune responses, ultimately contributing to improved treatment outcomes for patients.

In conclusion, mRNA cancer vaccines offer a revolutionary approach to cancer therapy, harnessing the power of the immune system to target and eliminate cancer cells. With their potential for personalized treatment, minimal side effects and possible preventive applications, these vaccines hold great promise in the ongoing battle against cancer. As research continues to advance, mRNA cancer vaccines may soon play a vital role in improving cancer outcomes and saving lives.

Conflict of Interest

The author has no conflict of interest to declare.

Journal of Clinical Immunology & Microbiology



Publish your work in this journal

Journal of Clinical Immunology & Microbiology is an international, peer-reviewed, open access journal publishing original research, reports, editorials, reviews and commentaries. All aspects of immunology or microbiology research, health maintenance, preventative measures and disease treatment interventions are addressed within the journal. Immunologist or Microbiologist and other researchers are invited to submit their work in the journal. The manuscript submission system is online and journal follows a fair peer-review practices.

Submit your manuscript here: <https://athenaeumpub.com/submit-manuscript/>