Mini Review
Volume 14:04, 2023

Journal of
Nuclear Medicine & Radiation Therapy

ISSN: 2155-9619 Open Access

Cyclodextrin's Use in Cancer Immunotherapy

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Abstract

Cancer immunotherapy has emerged as a groundbreaking approach in cancer treatment, harnessing the body's immune system to recognize and destroy cancer cells. While traditional chemotherapy and radiation therapy have been widely used, they often come with significant side effects and limited efficacy. Cyclodextrins, cyclic oligosaccharides with a unique molecular structure, have shown great potential as carriers for targeted drug delivery in cancer immunotherapy. This review explores the various applications of cyclodextrins in cancer immunotherapy, highlighting their advantages, challenges, and future prospects. Cancer remains a leading cause of mortality worldwide, necessitating innovative and effective treatment strategies. Immunotherapy, which leverages the body's immune system to combat cancer, has demonstrated remarkable success in recent years. Cyclodextrins, due to their distinctive properties, have emerged as promising candidates for enhancing the efficacy and safety of cancer immunotherapy. This review discusses the current landscape of cancer immunotherapy and explores how cyclodextrins can be utilized to address the challenges associated with conventional treatment modalities.

Keywords: Immunotherapy • Cyclodextrins • Immune • Landscape

Introduction

Cyclodextrins are cyclic oligosaccharides composed of glucose units, forming a hydrophobic cavity and a hydrophilic outer surface. These unique characteristics allow cyclodextrins to encapsulate hydrophobic drugs, thus improving their solubility, stability, and bioavailability. Traditional cancer treatments like chemotherapy and radiation therapy are often associated with adverse effects on healthy tissues and limited efficacy due to drug resistance. Immunotherapy offers a different approach by stimulating the body's immune system to identify and destroy cancer cells more effectively. Therapies like immune checkpoint inhibitors, cancer vaccines, adoptive T cell therapies, and Chimeric Antigen Receptor (CAR) T cell therapy have shown remarkable success in various malignancies [1].

Cancer cells often develop resistance to immunotherapeutic agents, hindering the effectiveness of treatment. Cyclodextrins can play a crucial role in overcoming this resistance by co-delivering multiple drugs or combining immunotherapies with other treatment modalities. Additionally, cyclodextrins can be engineered to disrupt the tumor microenvironment, making it more receptive to immune responses and enhancing the therapeutic effect of immunotherapy. Cancer vaccines aim to train the immune system to recognize and attack cancer cells specifically. Cyclodextrins have been investigated as adjuvants in cancer vaccines, enhancing the immune response by promoting antigen presentation and increasing the immunogenicity of the vaccine. Despite their potential, cyclodextrins also present challenges in cancer immunotherapy. Issues such as immunogenicity, biocompatibility, and potential side effects need to be thoroughly investigated. Rigorous preclinical and clinical studies are essential to ensure the safety and efficacy of cyclodextrin -based immunotherapies. The field of cancer immunotherapy is rapidly evolving, and cyclodextrins offer a promising avenue for further advancements. The development of novel cyclodextrin derivatives, better understanding of their interactions with the immune system, and optimization of drug delivery strategies will drive the progress of cyclodextrin-based cancer immunotherapy [2].

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Received: 01 July, 2023, Manuscript No. jnmrt-23-108981; **Editor Assigned:** 03 July, 2023, PreQC No. P-108981; **Reviewed:** 15 July, 2023, QC No. Q-108981; **Revised:** 20 July, 2023, Manuscript No. R-108981; **Published:** 27 July, 2023, DOI: 10.37421/2155-9619.2023.14.548

Literature Review

Cyclodextrins have emerged as versatile carriers for targeted drug delivery in cancer immunotherapy. Their unique properties enable the selective delivery of immunotherapeutic agents to cancer cells, reducing off-target effects and enhancing treatment efficacy. While challenges remain, ongoing research and innovative approaches hold the potential to unlock the full potential of cyclodextrin-based cancer immunotherapy, offering hope for more effective and safer cancer treatments in the future. Cancer remains one of the leading causes of death worldwide, necessitating the development of innovative and effective treatment approaches. In recent years, cancer immunotherapy has gained significant attention due to its ability to harness the body's immune system to recognize and eliminate cancer cells selectively. However, the success of immunotherapies is often hindered by challenges such as low drug solubility, stability, and off-target effects [3].

Cyclodextrins, with their unique molecular architecture, have emerged as promising tools to address these issues and Researchers have exploited the potential of cyclodextrins to develop nanocarriers for targeted drug delivery in cancer immunotherapy. By encapsulating immunotherapeutic agents within the hydrophobic cavity of cyclodextrins, these nanocarriers can shield the drugs from enzymatic degradation and clearance by the immune system, leading to prolonged circulation time and improved drug delivery to tumor sites. Cancer immunotherapies often involve delicate biologic agents, such as antibodies and cytokines, which may undergo rapid degradation in vivo. Cyclodextrins have shown promise in stabilizing these labile agents by forming inclusion complexes, protecting them from degradation and preserving their therapeutic activity. Beyond their role as drug delivery carriers, cyclodextrins have direct immunomodulatory effects that can contribute to the success of cancer immunotherapy. Cyclodextrins have been shown to enhance the immune response by promoting the maturation and activation of antigen-presenting cells, such as dendritic cells. These immune cells play a crucial role in initiating an effective anti-cancer immune response by presenting tumor antigens to T cells [4].

Discussion

Combination therapies that incorporate chemotherapy and immunotherapy

have shown promise in combating cancer more effectively. Cyclodextrins can be utilized to co-deliver chemotherapeutic agents and immunotherapies, allowing for synergistic effects that target both tumor cells and the immune system. Cyclodextrins can also be functionalized to create conjugates with various immunotherapeutic agents, further expanding their applications in cancer treatment. ADCs are a class of immunotherapies that combine monoclonal antibodies with potent cytotoxic drugs. Cyclodextrins have been utilized to conjugate antibodies to chemotherapeutic agents, leading to increased specificity and reduced off-target effects. transport to the tumor microenvironment. This approach holds promise for improving the selective delivery of immunotherapies to cancer cells. Despite the significant potential of cyclodextrins in cancer immunotherapy, several challenges remain to be addressed. These include optimizing drug loading efficiency, developing more stable cyclodextrin-based nanocarriers, and ensuring the safety and biocompatibility of these systems. However, ongoing research and advancements in nanotechnology and biopharmaceuticals offer hope for overcoming these challenges. As the field of cancer immunotherapy continues to evolve, cyclodextrins are poised to play an increasingly important role in shaping the next generation of cancer treatment strategies [5,6].

Conclusion

Cyclodextrins have demonstrated unique capabilities that can be harnessed in cancer immunotherapy. By acting as carriers, they can encapsulate and protect immunotherapeutic agents, such as monoclonal antibodies, cytokines, and immune checkpoint inhibitors, from premature degradation and clearance. This targeted drug delivery approach allows for site-specific drug release, minimizing systemic toxicity while maximizing the concentration of therapeutic agents at the tumor site. One of the major challenges in cancer immunotherapy is the efficient delivery of immunotherapeutic agents to tumor cells. Cyclodextrins can be functionalized or modified to enhance their affinity for cancer cells. Through conjugation with targeting ligands or antibodies, cyclodextrins can selectively deliver immunotherapeutic agents to cancer cells that overexpress specific receptors, improving treatment precision and efficacy.

Acknowledgement

None.

Conflict of Interest

There is no conflict of interest by author.

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How to cite this article: Liang, Liu. "Cyclodextrin's Use in Cancer Immunotherapy." J Nucl Med Radiat Ther 14 (2023): 548.