Delivery of nanoparticle antigens to antigen-presenting cells: From extracellular-specific targeting to intracellular responsive presentation.

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Introduction

An appropriate delivery system can improve the immune effects of antigens against various infections or tumors. Antigen Presenting Cells (APCs) are specialized to capture and process antigens *in vivo*, which link the innate and adaptive immune responses. Functionalization of vaccine delivery systems with targeting moieties to APCs is a promising strategy for provoking potent immune responses. Additionally, the internalization and intracellular distribution of antigens are closely related to the initiation of downstream immune responses. With a deeper understanding of the intracellular microenvironment and the mechanisms of antigen presentation, vehicles designed to respond to endogenous and external stimuli can modulate antigen processing and presentation pathways, which are critical to the types of immune response. This section outlines the intracellular stimulus response strategies that may help in the extracellular targeting of antigens to APC and the rational design of vaccine delivery systems [1].

Description

Nanotechnology has been applied to various areas of medical research, including vaccine development. It helped improve the efficacy of vaccine candidates and, more importantly, their safety. The benefits of Nanoparticles (NPs), such as up regulation of the immune response, biodegradability safety, tissue or cell targeting ability by size modulation, and binding to immunomodulatory, can be leveraged at multiple stages of vaccine development. Taking advantage of these properties, NP has been applied to the development of potent vaccine delivery agents or immune stimulatory vaccine adjuvants [2]. Nano vaccines consisting of NPs (as antigens themselves, adjuvants, or delivery/target substances) are known to selectively induce humoral and/or cell-mediated immune responses, thus attracting the attention of the scientific and medical industries. Beyond the traditional antibody-inducing effects of vaccines, the role of the cell-mediated immune response represented by activation of CD8+T cells, which kills directly infected or abnormal cells, in vaccines against viral and cancer has recently been emphasized. In addition, several Nano vaccines, including CD8+T cell responses, are known to induce cell-mediated immunity. On the other hand, it is no exaggeration to emphasize the importance of understanding the principle of action of a vaccine in order to improve its safety and efficacy while minimizing the side effects of the vaccine. Nano vaccines represent a paradigm for the development of new vaccine platforms, but their mechanism of action has not yet been fully elucidated. This review discusses the role of Nano vaccines in inducing CD8+T cell responses in detail. Dendritic Cells (DCs), one of the most effective professional Antigen-treated Cells (APCs), are required to bridge innate and adaptive immunity through antigen uptake and to process and present epitopes on naive T cells. For proper CD8+T cell responses from extrinsic antigens, DC loads its epitope into Major Histocompatibility Complex (MHC) class I molecules on CD8+T cells by a mechanism called "cross-presentation. Presents the epitope of the antigen. Since most vaccines used in this field are exogenous to cells, DC plays an important role in vaccine induction of activation of Cytotoxic T Lymphocyte (CTL) response to viral or cancerous diseases [3]. For this reason, various Nano vaccine strategies targeting DC have been developed. Studies have been conducted to elucidate the mechanism of action of nano vaccines by focusing on intracellular components and their roles. Thanks to accumulated proof of concept studies of cross presentation, novel Nano vaccines have been suggested and designed to induce protective CTL responses. Many review articles on Nano vaccines dealt primarily with the types and physicochemical properties of Nano materials [4]. Although informative, the immunological context of these reports is not sufficient. In this review, by addressing the key concept of how Nano vaccines activate CD8+T cell responses, we discuss how nanoparticles advance antigenicity and adjuvant city to enhance effectiveness, Nano vaccines which target Lymph Nodes (LNs) and APCs, and intracellular mechanism to harness cross presentation of DCs [5].

Recent research on nano vaccines has helped the scientific community understand the immunological measures needed to improve the efficacy and safety of vaccines and prevent the side effects that determine the success of nano vaccine treatment. The application of nanotechnology in vaccine science has succeeded in improving the effectiveness of vaccines, and the advent of nano vaccines has created a new paradigm for vaccine development. However, research into their function and exact mechanism is relatively inadequate. Undoubtedly, by maximizing safety and minimizing all possible side effects, you can fully understand its mechanism of action. In recent years, both the fields of immunology and nanotechnology have grown rapidly, and efforts to elucidate the mechanism of action of Nano vaccines in the context of protection at the molecular and cellular levels have increased significantly. Of particular note are studies on the induction of CD8+T cell responses to viral or cancerous diseases.

Conclusion

Hoping that these efforts will lead to the development of better and safer vaccines, this review leverages the properties of nanoparticles to enhance antigenicity and the adjuvant effect amplifies or specifically targets lymph. By doing so, we described the application principles of Nano vaccines targeting CTL responses with nodes and APCs. In addition, if exogenous antigens are a vaccine candidate option, we propose cross-presentation as an important mechanism for CTL activation. Cross-presentation of DCs is the most important and valuable target of CTL response, as most vaccines use exogenous antigens. Technological advances in the field of immunology and outstanding scientific understanding of nanomaterials are major contributions to vaccine development. In the near future, the concept of cross-presentation in APC combined with activation of CD8+T cells may enhance a powerful vaccine against devastating incurable cancers and intracellular pathogens.

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