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Review article

Basic immunological concepts applied to vaccination☆

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ABSTRACT

Vaccination has been one of the major successes in Public Health, and continues to have a great impact in terms of the prevention of diseases and mortality throughout the world. However, certain population groups are not being fully protected by the available vaccines, and there are pathogens for which vaccines have not yet been developed. Deep understanding of the immune response is needed in order to successfully deal with these challenges and develop new effective vaccines. Bearing this in mind, it must be underscored that many advances have been made in this field. The present article intends to offer a review of the basic immunological concepts needed for a better understanding of vaccinology.

Although vaccination efficacy has traditionally been measured based on antibody production, other correlates of immune protection or biomarkers are currently being investigated. The generation of a specific response by different cell types needed for defence against microorganisms is crucial for predicting the efficacy of a vaccine. It is therefore necessary to understand the immune response and the vaccines' mechanisms of action in order to develop new effective vaccines. This review addresses the evolution of immunology and vaccinology. It then examines the innate and acquired immune responses, and lastly discusses innovating elements and challenges facing the development of new vaccines.

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Conceptos inmunológicos básicos aplicados a la vacunología

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RESUMEN

La vacunación es uno de los mayores éxitos de Salud Pública y a día de hoy sigue teniendo un gran impacto a nivel mundial en la prevención de enfermedades y muertes. Sin embargo, existen algunos grupos de población que no están siendo totalmente protegidos con las vacunas disponibles y, de igual manera, patógenos específicos para los que aún no existen vacunas. Para superar estos retos y poder desarrollar nuevas vacunas eficaces es indispensable un entendimiento preciso de la respuesta inmune. Con esto en mente, se debe enfatizar que muchos progresos han sido efectuados en este área y este artículo constituye una revisión de los conceptos básicos necesarios para el mejor entendimiento de la vacunología.

Además, de forma tradicional, la inmunogenicidad vacunal se ha medido mediante la producción de anticuerpos, mientras que hoy en día se están buscando otros biomarcadores subrogados de protección. La generación de una respuesta específica de distintos tipos celulares necesarios para la defensa frente a microorganismos podría ser la clave para predecir la eficacia de una vacuna. Por ello, para poder desarrollar nuevas vacunas inmunógenas y eficaces es preciso entender la respuesta inmune y cómo funcionan las vacunas. En esta publicación se revisa, como punto de partida, la evolución de la inmunología y la vacunología. Posteriormente, se revisa la respuesta inmune innata y la adquirida, para, finalmente, hablar de elementos innovadores y retos en el desarrollo de nuevas vacunas.

Introduction

Immunology and vaccinology, together from the very beginning

Modern concepts of vaccinology go back to the late eighteenth century, when Edward Jenner observed that people who had had contact with cows infected with the smallpox germ did not get the human form of this disease. In 1796 he decided to inoculate healthy people with fluids from cowpox pustules and, based on this experimental observation, demonstrated that doing this conferred cross-protection against human smallpox.[1] He coined the term "vaccination" from the Latin "vaccae" (meaning "from a cow"), based on the origin of his vaccine. At that time the concept of microorganisms as a cause of infectious diseases was still to be discovered and the approach to vaccination was derived from observation and chance.

In the nineteenth century, Pasteur and Koch demonstrated that microorganisms were responsible for transmitting diseases; they established a causal relationship between an infectious agent and disease, and thus initiated the science of immunology.[1] At the end of 1870, Pasteur developed a technique to attenuate pathogens and was able to develop the first attenuated vaccine against rabies.[1] By the end of the nineteenth century, many aspects of vaccinology and immunology had been established thanks to the work of Pasteur and Koch[1]; antibodies and passive immunotherapy of diphtheria were discovered, and there was increased understanding of the interaction between the pathogen and the host.[2]

A number of Nobel Prizes in Physiology or Medicine have been awarded to scientists for their discoveries in the field of immunology: to Ehrlich and Metchnikoff[2,3] in 1908; to Zinkernagel and Doherty in 1996 for the discovery of the mechanisms of cellular immunity[3]; and, more recently, in 2011 to Beutler and Hoffman for their discoveries about the activation of innate immunity and to Steinman for the discovery of the dendritic cell and its role in the adaptive immune system.

The development of vaccines is not only the most successful outcome to have emerged from the application of immunology,[3] it is also one of the best public-health prevention strategies and continues to have a huge impact on the prevention of infection-related diseases and deaths worldwide.[4] Advances in technology and in knowledge have made great progress possible in the fields of both immunology and vaccination. Understanding of the interconnection between innate and adaptive immunity has lead us into a new stage in the design of vaccines, allowing the development of vaccines adapted for each pathogen and population to be protected.[2] Since its origins, vaccinology has evolved hand in hand with immunology, whose basic concepts are an essential component of modern vaccinology.

Therefore, to understand how vaccines are designed and how they work, we need to understand the mechanisms of the immune response and immunological memory,[5] and that is the objective of this article.

Description of the immune system

The immune system is a complex system in the body composed of different cells and molecules that interact with each other, either directly, or through different mediators. The purpose of the immune system is to defend the body against