Commentary

TIPS Trends in Pharmaceutical Sciences 2022: 8(2): 67-68.

Witnessing a revolution in the vaccinology field: A thought on its probable impact on future vaccines

Manica Negahdaripour[1,2*], Younes Ghasemi[1,2]

[1]Pharmaceutical Sciences Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.
[2]Department of Pharmaceutical Biotechnology, School of Pharmacy, Shiraz University of Medical Sciences, Shiraz, Iran.

Vaccines have been one of the most remarkable achievements through medical history and have had a very high positive impact on human health (1). The number of prevented deaths through vaccination is estimated to be about 2-3 million per year (2). Reduction of the risk of many infectious diseases and eradication of smallpox have been the result of intensive immunization programs (3). Given that such health benefits are also translated to economic advantages, the indirect positive outcomes of immunization could be very broad. For instance, lost working days due to different diseases could partly be prevented through vaccination. Thus, despite the huge investments needed for immunization programs, they are usually assumed as cost-effective projects (4).

The history of vaccinology has witnessed several major breakthroughs since the first attempts practiced by ancient nations in China, India, Middle East, Africa, and some others in the 12th to 15th centuries. The studies performed by Edward Jenner in 1796 using cowpox virus instead of smallpox scabs in human was the first scientific move in this regard and the birth of vaccination as we know today (5). Coming to industrial vaccine production, traditional vaccines, or the first-generation vaccines, containing killed or inactivated pathogens have been manufactured and used for more than one century, so their safety profiles are studied well enough. Despite some difficulties in their manufacturing and development, such as need to grow the pathogen, they are still being employed in vaccine development. In the case of COVID-19, several candidate vaccines were introduced based on such platforms, and a few were approved in different countries, including the Chinese Sinopharm vaccine (Sinovac®) (6). With the advent of biotechnology and genetic engineering methodology and great achievements made in this field, the second-generation or subunit vaccines were born, which are made of some antigenic parts of the pathogen instead of its whole structure (1). These subunits are usually made of protein or polysaccharide. This class of vaccines has offered many benefits compared to the traditional vaccines including no need to cultivate pathogens, which brought their higher safety and easier production, as well as possibility of vaccine development for cancers.

A more novel group of vaccines, referred as third generation vaccines, are made of genetic materials (DNA or RNA). They are similar to subunit vaccines in that they include just some parts of the pathogen, but are classified as a separate class due to their unique material. The ease and rapid designing and production of nucleic acid-based vaccines are assumed as their advantages. Despite years of research,

Please cite this article as: Manica Negahdaripour, Younes Ghasemi. Witnessing a revolution in the vaccinology field: A thought on its probable impact on future vaccines. Trends in Pharmaceutical Sciences. 2022;8(2):67-68. doi: 10.30476/TIPS.2022.94005.1131

Corresponding Author: Manica Negahdaripour, Department of Pharmaceutical Biotechnology, School of Pharmacy, Shiraz University of Medical Sciences, Shiraz, Iran
Email: negahdaripour@sums.ac.ir

Received: 25/12/2021; Accepted: 01/05/2022

there were no approved human vaccine from this group before introduction of COVID-19 vaccines. However, the urgency of COVID-19 pandemic led to an urgent need for vaccines and employment of nucleic acid platforms, which helped to introduce several vaccines in around one year. Not only bioinformatics tools, structural vaccinology, and reverse vaccinology (3), partly contributed to this short-term vaccine introduction, but also the routine licensing procedure was also fast-tracked for the present COVID-19 vaccines.

The available vaccines against SARS-CoV-2, the causing virus of COVID-19, have revolutionized the vaccinology field from three aspects. First, introduction of novel platforms including mRNA vaccines (7) (Pfizer and Moderna vaccines), which were studied for several years but approved as vaccines for the first time, as well as viral-vector DNA vaccines (developed by Oxford-Astra-Zeneca, Johnson & Johnson, and the Gamaleya Research Institute (Sputnik V)) (6,8), which had only been used for Ebola before (9). Second, the fast-track development and rapid approval process, which have never been experienced before. Third, highlighting the role of bioinformatics tools (3), which helped to design vaccines in a few days. Still, there some other aspects that should also be noticed. For instance, the safety of vaccines is a very serious concern, because vaccines are administered to large populations of healthy people. Generally, vaccine would undergo a very long and complicated sets of studies and clinical trials that may take about 8-17 years totally (5), so that their side effects are usually checked in human clinical trials for several years. Since this process was shortened to about one year for these novel COVID-19 vaccines (6), and as these platforms are being used in the society for the first time, the prolonged usage data gathered through phase IV post-marketing studies should be taken into account. Besides, considering the fact that they are made from some parts of viral genes, more studies might be essential to assure they do not affect the human genes or cells in the long term. Thus, more precautions and evaluation in longer periods of time are suggested for the development of future similar vaccines.

All in all, the value and profound effect of the COVID-19 fast vaccine development could not be ignored, and they would certainly open new avenues in the vaccinology field. On the other hand, the case of COVID-19 fast vaccine development could not become possible without a combination of technological, wide knowledge sharing, funding, regulatory, and operational factors. Availability of such factors for all future investigational vaccines is not very probable. Though, future vaccine development procedures might be accelerated to some extent based on COVID-19 experiences, but such very short-term licensing is not very probable for all future vaccines.

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