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Allergies: When the Immune System Backfires

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Vaccinations against SARS-Coronavirus type 2

In the Covid-19 pandemic, vaccines against SARS-Covid-19 were developed and approved at an unprecedented rate. It is not easy to understand how these vaccinations work. However, exploring the history of vaccinations as well as understanding the functions of the immune system may help you to better understand the concepts presented in this article.

In an earlier chapter of this course, you examined how the concept of vaccination was discovered and developed. As shown, this was a long process. It took centuries to eradicate a disease like smallpox - a virus that, contrary to many other diseases, is only transmitted from person to person.

During the COVID-19 pandemic, on the other hand, several types of effective preventive therapies were found in less than a year. This was due to a pre-existing immense wealth of knowledge and unprecedented international cooperation. In addition, the fact that so little time was needed for the development of these vaccines and for the clinical trials ignited an important discussion about efficacy and safety issues.

Many questions remain as yet unanswered. However, scientific evidence is being created at a fast rate. The field is rapidly developing; new science-based results are continuously being published. You will find some links below this step to get updated information.

Even if somebody survives an infectious disease, this does not prevent completely that this person might get infected again with the same pathogen. The Varicella-Zoster virus that causes chickenpox and may later trigger “shingles” is a well-known example of this phenomenon. Accordingly, it is possible for a person who is vaccinated to get infected with the pathogen which the vaccination is fighting. However, disease severity and duration are almost always milder in vaccinated or convalescent individuals. An exception are patients with a weakened immune system (immune deficiency) from severe diseases or immune suppressive drugs who cannot mount a sufficient immune response.

To date, there are several ways to trigger a protective immune response against SARS coronavirus type 2 (SARS CoV-2). One new way is to introduce a specific part of the genetic information from the virus (RNA or DNA) into the organism. Another approach uses selected viral proteins in the same way. Both approaches face several challenges. A first challenge is that these molecules used for vaccination are normally destroyed quickly in the organism, before they are taken up and presented by the antigen presenting cells. To make them last longer, the molecules are embedded in protective coatings (e.g., liposomes). A second challenge is the question of how to activate the innate immune response. This is a necessary step for the

vaccination to be successful. For this purpose, in some vaccines matter is added that stimulates the innate immune system, so-called adjuvants.

So, how does an organism obtain immunity to SARS CoV-2? There are several possibilities, similar to immunisation to other infections:

1. Natural active immunity means getting the infection and mounting a naturally acquired active immunity. The immune system produces specific memory B and T cells to produce antibodies and T effector cells to prevent a second severe outbreak of the disease. Although most patients have a mild reaction, a large number of patients fall severely ill, and a considerable percentage have died as the pandemic has lingered on. Survivors may suffer from ongoing symptoms subsumed as Long COVID or Post-acute COVID-19 Syndrome **(**PACS).
2. Active vaccination involves the induction of pathogen-specific antibodies and/or effector T cells. In 2021, more than 100 vaccines were developed against SARS-CoV-2. Here is a general overview of the different types:
    a) Inactivated SARS CoV-2 is injected, taken up by immune cells, processed and viral antigens are presented. So far, there is one vaccine under development with an attenuated (weakened) live virus.
    b) The vaccine uses other non-replicating viruses that are harmless for humans. These viruses are used as vectors for either RNA or the spike protein (carriers of SARS-CoV-2 RNA or proteins). Some companies use artificially made virus-like particles (VLP) for this purpose. The carriers are taken up by immune cells, processed and viral antigens are presented.
    c) The vaccine contains viral protein subunits. This means that, for instance, spike and other proteins of SARS-CoV-2 are injected, and these are then taken up by immune cells and presented.
    d) mRNA-based: These vaccines use part of the genetic code of the virus (mRNA) to directly produce the important antigens e.g., spike proteins of SARS-CoV-2. The corresponding proteins are produced and released from human cells, then taken up and presented by immune cells.
    e) DNA-based: These vaccines use part of the genetic code that are transcribed to RNA in a human cell in order to produce the corresponding viral proteins.
3. Natural passive immunity: There is actually very little information on this issue. The transfer of SARS-CoV-2 from a pregnant woman to her foetus seems to be a very rare event. Transfer of protective antibodies from pregnant women with COVID-19 to neonates was not demonstrable, at least in one controlled study.
4. Artificial passive immunity: Convalescent plasma is blood serum from patients who have recovered from COVID-19 that contains antibodies against SARS-CoV-2. Convalescent plasma has been used in patients with a severe COVID-19 disease to enhance and modulate their immune response. However, this treatment has had variable success. Another approach is the production of so-called recombinant, i.e., artificially made monoclonal antibodies directed against a protein of SARS-CoV-2. This concept has been used for years in the treatment of autoimmune diseases and tumours, with great

success. There are many open questions, however; therefore, controlled studies are needed to confirm the effect of this approach.

Adverse and allergic effects

Vaccines must stimulate an immune response to become effective. Therefore, signs of activation of the immune system such as local pain, redness, swelling, and even systemic symptoms such as fever, chills, muscle pain etc. are well known from any vaccine and are considered a normal response. However, there is a wide range of reaction patterns from no symptoms to a mild local nuisance to signs of a febrile illness. Most of these reactions fade within a couple of days. There are other extremely rare adverse events that occurred due to the very high number of vaccinated persons. Listing these rare events is beyond the scope of this article. An important point is that patients infected with COVID-19 experience these events significantly more frequently than people who have been vaccinated.

In an allergic reaction, the immune system mounts an unnecessary defence against an innocuous foreign molecule. Allergic reactions to any vaccines are very rare; they occur in the range of 1.3 - 1.4 cases per million vaccine doses and have not caused documented fatalities. Of course, because millions of CoV-2 vaccines have now been administered worldwide, the absolute numbers have become more evident. Fortunately, most patients with a known allergic disease such as food allergy, hay fever, drug rashes or eczemas are not at risk to suffer a severe allergic reaction from any type of vaccine. This includes, for example, egg-allergic people from a vaccine containing egg proteins. In CoV-2 vaccines, the most relevant and feared allergic reaction is anaphylaxis to an inactive ingredient, e.g. to substances that are used to stabilize the vaccine, to prevent bacterial growth, and so on. In the widely used mRNA (2d) and viral vector vaccines (2b), either polyethylene glycols (PEG) or polysorbates are present as stabilizers. These two substances are also present in other medications and are known to be a very rare cause of anaphylaxis. Current recommendations caution physicinas and their patients that have already reacted with anaphylaxis to an injected medication or a vaccine. In particular, patients with a known previous allergy to PEGs or polysorbates should be carefully handled and monitored. Most other individuals may safely receive the vaccines to prevent COVID-19.

Deepen your understanding

The facts around COVID-19 vaccines are complex and subject to ongoing research. If you want to deepen your understanding, we suggest that you to visit one of the following links.

References

WHO COVID-19 vaccines: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines

CDC - Different COVID-19 Vaccines: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines.html

Mayo Clinic - COVID-19 vaccines: Get the facts**:** https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/coronavirus-vaccine/art-20484859

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