PedsCases Podcast Scripts

This is a text version of a podcast from Pedscases.com on "**Childhood Immunizations Part 1."** These podcasts are designed to give medical students an overview of key topics in pediatrics. The audio versions are accessible on iTunes or at www.pedcases.com/podcasts.

CHILDHOOD IMMUNIZATIONS PART 1:
Introduction to the Immune System and Types of Vaccines

Developed by Kristen Timm and Dr. Sarah Forgie for PedsCases.com.
September 6, 2017.

Introduction

Hello, my name is Kristen Timm and I am a medical student at the University of Alberta. This PedsCases podcast was developed with Dr. Sarah Forgie, a pediatric infectious disease specialist at the Stollery Children's Hospital in Edmonton and Professor of Pediatrics at the University of Alberta.

This is a three-part PedsCases podcast series on childhood immunizations. In this podcast, I will be presenting an overview of how vaccines and immunizations work and the different types of vaccines. In Part Two I will review vaccines used in the routine immunization schedule in Canada, and in Part Three I will present answers to some frequently asked questions from vaccine-hesitant parents.

Learning Objectives

At the end of this podcast the listener should be able to:
1. Outline the components of the immune response
2. Define innate and adaptive immune response
3. Define passive and active immunity
4. List the various types of vaccines and contrast the advantages and disadvantages of each
5. Give an example of each vaccine type

Introduction to the Immune System

Everyday we are surrounded by pathogens including bacteria, viruses, and fungi that have the potential to infect us and cause disease; however, our bodies have an amazing ability to fight these infectious diseases through the immune system. Let's start by talking briefly about how the immune system fights infections before we talk about how vaccines help our immune systems protect us from getting sick.

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If the physical barrier of the skin becomes damaged, bacteria may start multiplying locally in the wound using nutrients from the body. As growth continues, bacteria damage the surrounding tissue and may invade further. To prevent this bacterial invasion, the immune system provides several layers of defense. The first line of defense is macrophages, which ingest and destroy the bacteria. Macrophages also induce an inflammatory response, which leads to the cardinal symptoms of pain, heat, swelling, and redness around the wound. The macrophages send out messenger proteins called cytokines to recruit neutrophils. Neutrophils trap and kill more bacteria. Dendritic cells are also activated by the macrophages. Dendritic cells transport pieces of the bacteria (or antigens) to the lymph nodes where T cells become activated. When the helper T cells are activated, they multiply and take on several roles. Some travel through the body to the site of the infection, some form memory T cells to create long term immunity, and some go on to activate B cells. The activated B cells produce antibodies, which are proteins designed to attach to the surface of the offending bacteria. Once the antibodies have attached to the bacteria, they make it easier for other immune cells to destroy the bacteria. Eventually the infection is cleared and many of the immune cells that were involved in the attack self-destruct. However, memory helper T cells and memory B cells remain in the body, ready to attack if the same type of bacteria should ever return.

Now let's clarify a few terms.

The immune system has both **innate** and **adaptive** defenses that help protect us. The innate immune system is a first line defence against invading pathogens and includes external components such as our skin and mucous membranes and internal components such as macrophages and neutrophils. The innate immune response is non-specific and helps protect us against all different kinds of pathogens. In comparison, the adaptive immune response "learns" to target and attack *specific* pathogens as the body is exposed to these pathogens. B and T cells are key players in the adaptive immune response. The adaptive immune system responds to pathogen exposure from a variety of sources such as stepping on a rusty nail in a field, having someone sneeze in your face, or getting vaccinated. We will come back to the third scenario in a minute.

Adaptive immunity may be either **passive** or **active**. Passive immunization occurs when a person is given already-formed antibodies from external sources. For example, babies acquire passive immunity against some pathogens because maternal antibodies are transferred across the placenta during pregnancy and in breast milk during breastfeeding. This protection is temporary because antibodies have a defined half-life and once passive antibody levels drop, the protection is lost. Another example is patients who present with animal bites. If there is a concern that the animal may have had rabies, the patient will be given rabies immunoglobulin, passive rabies immunization with pooled antibodies from donors who are immune to rabies. This offers short-term protection against rabies. Active immunization, on the other hand,

occurs when the body is exposed to a pathogen or part of a pathogen and the adaptive immune system is activated to produce immunity to that illness. In some cases, active immunity will be acquired as a person recovers from an illness. For example, if a healthy child had measles, they are likely to be immune from ever developing measles again because they have immunological memory, and their immune system is ready to produce the appropriate cellular and antibody response if the virus were ever to be detected again. However, thanks to the advances of vaccine development, we can offer people active immunization against specific diseases such as measles, chicken pox, polio, and many others without people ever having to experience these illnesses.

Types of Vaccines

Now that we have reviewed some basic principles of how the immune system works, let's talk about some different types of vaccines. Vaccines are classified based on two essential elements. First, which part of the pathogen we choose to present to the immune system, and second, how that part has been treated or modified before being used in a vaccine.

Live vaccines contain a whole, living microbe. When we hear the phrase "live *attenuated* vaccine," we know that the microbe has been weakened in the lab so it does not cause severe infection as you would see with the natural agent. The advantage of these vaccines is that they can elicit a strong immune response and often provide life-long immunity after only one or two doses. While there are some bacterial infections that have a live attenuated vaccine (for example, the Bacille Calmette-Guerin or BCG vaccine for tuberculosis), most live attenuated vaccines licensed for use in Canada are targeted against viruses such as influenza, rotavirus, mumps, measles, varicella, yellow fever, or rubella. One disadvantage to live vaccines is that they usually require refrigeration for storage, which can be problem in developing countries. Another disadvantage is that they are contraindicated during pregnancy or in patients with weakened immune systems because of a small risk that the live microbe could cause a symptomatic infection.

Inactivated vaccines contain a whole microbe that has been killed using methods such as heat, chemicals, or radiation. The advantage of inactivated vaccines is that they are more stable and usually do not require special storage such as refrigeration. Another advantage is that there is less chance of the microbe causing disease. The disadvantage of inactivated vaccines is that they lead to an overall weaker immune response, so they usually require multiple doses before they provide adequate, long-lasting immunity. Examples of inactivated vaccines include the whole-cell pertussis vaccine and the inactivated polio virus vaccine.

Inactivated component (or subunit) vaccines do not contain a whole microbe; instead, they include only a small part of the microbe, that is an antigen (or sometimes

multiple antigens), which will stimulate the adaptive immune system. The antigen could be based on a protein or polysaccharide subunit of the microbe. In some cases, polysaccharide subunits will be *conjugated*, which means that the sugar antigen from the microbe is attached to a carrier protein to induce a stronger response from the immune system. The polysaccharide on its own can activate B-cells without the assistance of T-helper cells, called a "T-cell independent response," which will ultimately result in memory B cells that will provide some immunity, but no memory T cells. By adding a protein to the antigen, the response is "T-cell dependent" and both memory B cells *and* memory T cells are produced. For example, the conjugated pneumococcal vaccine that protects against *Streptococcus pneumoniae* combines polysaccharide sugars from the bacterial capsule with a non-toxic protein from diphtheria.

Toxoid vaccines are designed to protect us against bacteria such as tetanus, that cause severe symptoms with toxins. The spores of *Clostridium tetani* enter the body through contaminated wounds. Under anaerobic conditions in the body (such as deep in a wound where there is crushed tissue and reduced blood flow), the spores germinate. Once actively growing, the bacteria produce a protein-based toxin that affects neurons and causes rigidity and spasms of skeletal muscles. The vaccine that protects against these effects of tetanus is a toxoid vaccine. Essentially, the tetanus toxin is altered to become a harmless "toxoid" that will induce an immune response to the toxin. So even if a deep wound is infected with *Clostridium tetani* and toxin is produced, the person will be immune to the effects of the toxin.

Summary

Alright, let's review what we just covered.

- The immune system has innate components such as the skin and mucous membranes that are non-specific and protect against pathogens in general. The immune system also has adaptive components that work to target specific pathogens after the body has had exposure to these pathogens.
- The adaptive immune system may be passive or active depending on whether the antibodies are formed externally and then introduced to the body or the antibodies are formed within the body.
- Without vaccines, the adaptive immune system builds defenses against certain diseases only after the offending pathogen has caused an illness. However, we take advantage of the adaptive immune system using vaccines in order to build up defenses against certain pathogens before they have the chance to cause disease.
- Vaccines are classified based on the type of antigen that is presented to the immune system and on how this antigen is modified. Currently licensed vaccines in Canada include live attenuated vaccines, inactivated vaccines, inactivated component (AKA subunit) vaccines, conjugated vaccines, and toxoid vaccines.

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- Regardless of the type of vaccine, all vaccines help educate the immune system and provide it with the ability to start fighting pathogens as soon as they are detected.

Thank you for listening. Please join me for the follow-up PedsCases podcast on Childhood Immunizations Part 2 for an overview of vaccines routinely used in Canada.

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