Vaccines

Lecture 16 – Dr. Gary Mumaugh

Vaccines

- A vaccine is a form of antigen (substance which stimulates an immune response) used to create a barrier of immunity against a specific disease.
- The term derives from Edward Jenner's reliance upon cowpox ("vacca" means cow in Latin) to provide protection against smallpox. This was a concept and practice studied and utilized by the founder and father of bacteriology, Louis Pasteur, et al.
- The process of mass administering vaccines is referred to as 'vaccination.'

Vaccines [Background]

- Vaccine comes from the Latin word “vacca” which pertains to “cows”
- Based on the practice of *variolation* which was inoculating healthy individuals with weak forms of smallpox
- 1st Vaccine (1796): Edward Jenner inoculated milkmaids with cowpox to confer protective immunity against smallpox.
- 1st Attenuated Vaccine (1885): Louis Pasteur developed a vaccine to protect against rabies; vaccine is made from viable virus with reduced virulence (lower degree of pathogenicity).
- Most damage to a cell is done too early before any clinical symptoms of disease appear. Treatment becomes difficult, therefore, *prevention* is preferred over post-exposure vaccines.
- The Main Idea: Vaccines contain a weak form of a virus/microbe that is not pathogenic
- Vaccines are used to protect a large number of people – fight against epidemics and pandemics.
- Good vaccines elicit a secondary immune response that will eliminate the pathogen.

The Immune System & Response

- Once vaccinated, the immune system takes a week and upwards to begin fighting off the organism.
- *Immunity* is conferred once the immune system is “trained” to resist a certain disease a vaccine is developed for
- Artificially Acquired Immunity is provided
- Childhood vaccinations are highly encouraged against:
    - Measles, Mumps, Rubella, Polio, Hepatitis A & B, Diptheria, Pertussis, Tentanus, Chicken Pox, HIB, Rotavirus, Meningococcal disease, and Influenza.
- Macrophages: white blood cells that detect and engulf viral antigens; microbes are carried to lymphocytes

The Immune System & Response - continued

- Within lymph nodes, T and B cells are activated
    - *T cells:* able to recognize virus infected cells early in infection period and release cytotoxins to destroy them
    - *B cells:* secrete antibodies that bind antigens on the virus surface. This coats the virus and prevents infection. B-cells can also recognize virus infected cells late in infection
- Ideally, good vaccines evoke both T and B cells
- Antibodies will activate macrophages to “eat” viral antigens
- Elimination of the disease will leave many T and B cells to convert into memory cells
- Recovering from the infection leaves you with a supply of memory cells that will protect against future infection

Vaccines: Achieving Immunity

- Whether your natural immunity system provides you with suitable amounts of protection or you derive it from vaccines, the point is that once you are assured of immunity to specific disease-causing organisms, you are much safer against becoming ill, thus free to go about your daily life.

Vaccines: Natural Immunity

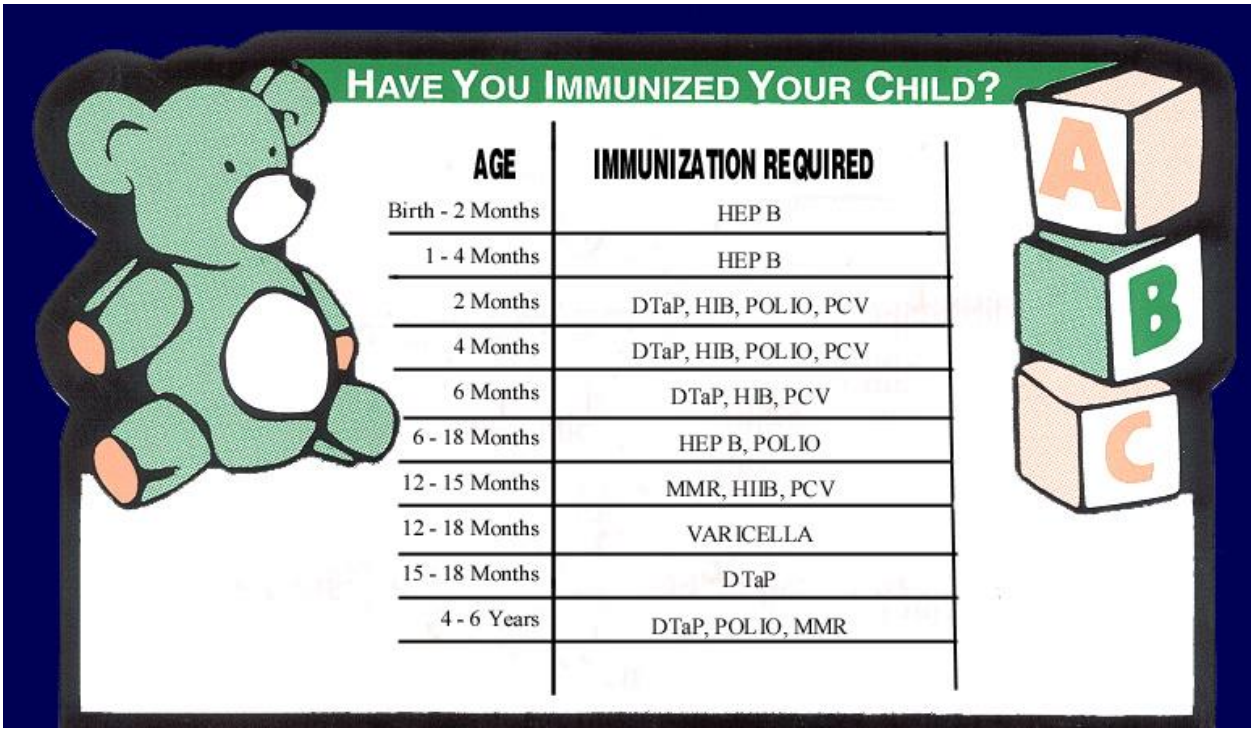
- Natural immunity develops after one has been either singularly or repeatedly exposed a certain organism.
- Your immune system, quite sophisticated in this sense, is able to ensure you do not become ill when you once again come into contact with that same virus or bacterium.
- Exposure to a foreign invader stimulates the production of select white blood cells in your body called 'B-Cells'.
- The 'B-Cells' produce plasma cells, which, in turn, produce antibodies purposefully created to fight the particular invader.
- The next time that invader enters the body, the antibodies are trained to recognize and destroy it.

Vaccines: Induced Immunity

- Vaccine-induced immunity, on the other hand, is the result of receiving a vaccine.
- The vaccine triggers your immune system's infection-fighting ability and memory without exposing it to the actual disease-producing germs.
- As a whole, vaccines contain either a killed or weakened form or derivative of the infectious germ.
- When given to healthy people, the vaccine triggers an immune response.
- Because the vaccine 'tricks' your body into thinking that it is being invaded by a specific organism, your immune system revs up to destroy the invader and prevent it from infecting you again.

Vaccines: Induced Immunity

- If exposed to a disease for which a vaccine has already been administered, the invading germs will be faced with antibodies sent to destroy them.
- In comparing natural immunity with vaccine-induced methods, the two prove to be quite similar.
- The major difference is that it is not always practical to rely solely upon natural measures for if you do you may not be fully protected against all possible invaders.
- Quantities in which vaccines need to be taken vary depending upon the type of vaccine and make-up of the individual.
- For example, several doses of a vaccine may be needed for a full immune response whereas with others only one dose may be required for complete coverage.
- Though some people may fail to achieve full immunity after the initial dose of vaccine, they may favorably respond to subsequent doses.
- And, though traditionally, vaccines have been viewed as only needing to be administered for lifetime, coverage; this 'belief' is not necessarily true.
- Rather, its re-upping quality is based upon the type of vaccine and nature of the disease.



Live (Attenuated) Vaccines

- consist of a live form of the virus that has been artificially weakened; select for mutants that will cause wild-type infection without onset of disease
- Usually only takes 1 or 2 doses to confer life-long immunity (childhood vaccines).
- Must be careful of the small chance of reversion to a more virulent form
- Elicit good immune response, inexpensive, but must be cautiously stored to maintain viability

Vaccines – a method of prevention

- Influenza
  - Nearly 40,000 deaths and 115,000 hospitalized yearly in US
  - Educated guess on most probable form of virus
  - Also comes in nasal spray of attenuated form
  - New vaccines must always be produced due to high antigenic variation
  - At risk individuals (elderly, immunodeficient) should be vaccinated
- HPV – Human Papillomavirus
  - Genital HPV most common sexually transmitted infection in US
  - Cause of cervical cancer, genital warts, anal & penile cancer
  - By the age of 50, 80% of women will have contracted at least 1 strain of the virus
  - Fortunately, many strains can be cleared by immune system before symptoms occur
  - HPV vaccine is a preventative measure against initial infection
  - Types 16 and 18 cause 70% of the cases of cervical cancer and types 6 and 11 cause 90% of genital warts
  - HPV Vaccine, Gardasil, protects against these strains
  - Pap smears are still recommended since there are over 100 HPV strains identified, many of which can also cause cancer

Vaccines – a source of controversy

- Some health critics say vaccination benefits are exaggerated. Claim that vaccines are not solely responsible for reducing mortality rates of any one disease.
- Opponents find that even vaccinated individuals still contract disease
- Adverse effects (although RARE) can be worse than the naturally occurring disease
- Some diseases and conditions (leukemia, MS, SIDS) have increased with the use of vaccinations
  - Some vaccines contain mercury, formaldehyde, neomycin, and other toxic chemical components

Diseases for which vaccination is routinely recommended

- Diphtheria , *Haemophilus influenzae type b (Hib)*, Hepatitis A & B
- Herpes zoster (shingles) , Human papillomavirus (HPV), Influenza
- Measles , Meningococcal disease, Mumps , Pertussis , Pneumococcal disease
- Polio , Rotavirus, Rubella , Tetanus , Varicella (chickenpox)

Diphtheria: This is a picture of the throat of a child who has diphtheria. If not treated, this child could die from suffocation.

Haemophilus influenzaetype b: This girl is hospitalized with Haemophilus influenzaetype b (Hib) infection shown here involving deep tissue of this girl's face. Hib disease can also lead to brain damage, seizures, paralysis, hearing loss, and death.

Hepatitis A: Hepatitis A infection has caused this man's skin and the whites of his eyes to turn yellow. Other symptoms of hepatitis A can include loss of appetite, abdominal pain, nausea or vomiting, fever, headaches, and dark urine.

Herpes Zoster (shingles): A dangerous complication of shingles infecting the eye which can lead to loss of vision. Without vaccination, approximately 30% of all people who have been infected with chickenpox will later develop shingles.

- **Human Papillomavirus(HPV):**
- HPV is the most common sexually transmitted infection in the United States. Approximately 20 million people are currently infected with HPV.
- At least 50% of sexually active men and women acquire genital HPV infection at some point in their lives.
- Persistent infection with high-risk types of HPV is associated with almost all cervical cancers.

Shows how influenza germs spread through the air when someone coughs

Measles rash covering child's arms and stomach

Child's face displaying diffuse lymphedema of the neck due to a mumps virus infection of the parotid salivary glands

- Child has pertussis; it is difficult for him to stop coughing and to get air