Principles of vaccination

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Epidemiology NUR404

Fall semester

5th week

4/11/2023

Outline

- Immunity
  - Passive immunity & Active immunity
  - Antigen & Antibody
- Classification of vaccines
  - Live attenuated
  - Inactivated
- Vaccination schedule in Iraq
- Contraindications and adverse effects

Objectives

- To describe the different types of vaccine.
- To familiarize students with the vaccination schedule in Iraq

Immunity

- Immunity is the ability of the human body to eliminate foreign material.
- Immunity provides protection from infectious diseases
  - most microbes are identified as foreign materials by the immune system
- Immunity to an infectious agent is usually indicated by the presence of antibody to that organism.
- Immunity is generally specific to a single organism or group of closely related organisms.

Passive and active immunity

The basic mechanisms for acquiring immunity;

Passive Immunity

- Protection transferred from another human or animal
- Temporary protection that disappears with time

Active Immunity

- Protection produced by the person's own immune system
- Usually, permanent

Antigen & Antibody

Antigen

- A live or inactivated substance (e.g., protein, polysaccharide) of infectious agent capable of producing an immune response

Antibody

- Protein molecules (immunoglobulin) produced by B lymphocytes to help eliminate an antigen

Passive Immunity

- Transfer of antibody produced by one human or another animal to another.
- Passive immunity provides protection against some infections, but this protection is temporary.
- The antibodies will degrade during a period of weeks to months, and the recipient will no longer be protected.

Passive Immunity

Sources of Passive Immunity

1. From mother

2. Blood or blood products

3. Immune globulin

4. Hyperimmune globulin

5. Antitoxin

Passive Immunity

2. Blood or blood products

- Many types of blood products contain variable quantities of antibodies

Three major sources of antibody used in human medicine:

3. Immune globulin

- Produced by pooling IgG fractionating antibodies from thousands of donors.
- Use: post-exposure prophylaxis for hepatitis A and measles

4. Hyperimmune globulin

- Contain high titers of a specific antibody donated from plasma of humans with high levels of this particular antibody.
- Use: post-exposure prophylaxis for hepatitis B, rabies, tetanus

5. Antitoxin

- Products from animals (horses) containing only one antibody against one antigen.
- Use: treatment of botulism and diphtheria.

Active Immunity

- Stimulation of the immune system to produce antigen-specific antibodies.
- This leads to immunity lasting for years if not life-long.

Two mechanisms:

1. Natural disease

- Immunity following natural disease
- Leads to production of memory B-cells
- These cells continue to circulate in the body, leading to immunologic memory.
- Upon re-exposure to the natural disease antigen, these memory cells begin to replicate and produce antibodies very rapidly.

2. Vaccination

- Vaccines simulate the natural disease leading to the same immunologic response without subjecting the recipient to the complication of the disease.

Classification of vaccines

- **Live attenuated**
  - Viral - Bacterial
- **Inactivated**
  - **Whole**
    - Viruses - Bacteria
  - **Fractional**
    - Protein-based
      - Toxoid (inactivated bacterial toxin) - Subunit
    - Polysaccharide-based
      - Pure - Conjugate

Live Attenuated Vaccines

Characteristics

- Attenuated (weakened) form of the virus or bacterium
- Must replicate to be effective
- Immune response similar to natural infection
- Usually does not cause illness
- Usually produce immunity with one dose (except those administered orally)

Live Attenuated Vaccines

Characteristics (negative)

- Possibility of severe reactions
- Interference from circulating antibody, e.g. in children with mother's antibody
- Fragile - should be stored and handled carefully

Live Attenuated Vaccines

Examples

- Viral - measles, mumps, rubella, yellow fever, rotavirus, oral polio

- Bacterial – BCG, oral typhoid

Inactivated Vaccines

- Inactivated vaccines are produced by growing the bacterium or virus in culture media, then inactivating it with heat and/ or chemicals (usually formalin).

Two types:

1. **Whole cell**

2. Fractional vaccines

- The organism is further treated to purify only those components to be included in the vaccine (e.g., the polysaccharide capsule of pneumococcus).

Inactivated Vaccines

Features:

- Cannot replicate
- Generally, require 3-5 doses
- Immune response mostly humoral with little or no cellular immunity.
- Cannot cause disease from infection, even in immunodeficient persons.
- Are less affected by circulating antibody than live agents, so they may be given when antibody is present in the blood
    - E.g., in infancy or following receipt of antibody-containing blood products.

Inactivated Vaccines

Features (cont.):

- Inactivated vaccines always require multiple doses.
- In general, the 1st dose does not produce protective immunity. A protective immune response develops after the 2nd or 3rd dose.
- Antibody titers against inactivated antigens diminish with time.
  - Some inactivated vaccines may require periodic supplemental doses to increase, or "boost," antibody titers.

Features of vaccines

Live Attenuated Vaccines	Inactivated Vaccines
Attenuated (weakened) virus or bacterium	Killed bacteria or virus
Usually does not cause illness	Cannot cause disease even in immunodeficient persons
Immune response similar to natural infection	Immune response mostly humoral with little or no cellular immunity
Must replicate to be effective	Cannot replicate
Usually produce immunity with one dose	Generally require 3-5 doses
Interference from circulating antibody	Are less affected by circulating antibody
Possibility of severe reactions	Severe reaction very rare
Fragile - should be stored and handled carefully	Less fragile

Inactivated Vaccines

Examples

Whole-cell vaccines

- Viral - polio, hepatitis A, rabies, influenza
- Bacterial - pertussis, typhoid, cholera

Fractional

1. Protein-based

- Subunit (single protein molecule) - hepatitis B, influenza, acellular pertussis
- Toxoid (inactivated bacterial exotoxin) - diphtheria, tetanus

2. Polysaccharide-based

- Pure polysaccharide - Pneumococcal, Meningococcal
- Conjugate polysaccharide - HiB, pneumococcal

Inactivated Vaccines - Fractional

2. Polysaccharide Vaccines

- Composed of long chains of sugar molecules from the surface capsule of bacteria.
- The immune response is typically T-cell independent
  - Able to stimulate B cells without the assistance of T-helper cells.
- Not consistently immunogenic in children younger than 2 years of age because of immaturity of the immune system.
- There is no booster response

Inactivated Vaccines

Conjugation: Polysaccharide is chemically combined with a protein molecule.

- Immunogenicity will be improved
- The immune response will be changed from T-cell independent to T-cell dependent, leading to
  - Increased immunogenicity in infants
  - Antibody booster response to multiple doses of vaccine.

Vaccination schedule in Iraq

Vaccine	Age
• BCG, Hepatitis B, Oral polio	24 hrs
• Oral polio, Rota virus, Hexavalent vaccine (diphtheria, tetanus, acellular pertussis (DTaP), hepatitis B, IPV and Haemophilus influenzae B (Hib)), Pneumococcal	2 months
• Oral polio, Rota virus, Hexavalent vaccine (diphtheria, tetanus, acellular pertussis (DTaP), hepatitis B, IPV (injectable polio vaccine) and Haemophilus influenzae B (Hib)), Pneumoccocal	4 months
• Oral Polio, Hexavalent vaccine (diphtheria, tetanus, acellular pertussis (DTaP), hepatitis B, IPV (injectable polio vaccine) and Haemophilus influenzae B (Hib)), Pneumococcal	6 months
• Measles, Vitamin A	9 months
• MMR	15 months
• Oral Polio, Pentavalent (diphtheria, tetanus, acellular pertussis (DTaP), IPV (injectable polio vaccine) and Haemophilus influenzae B (Hib)), Vitamin A	18 months
• Oral Polio, Quadrivalent (diphtheria, tetanus, acellular pertussis (DTaP) and IPV (injectable polio vaccine). • MMR, Vitamin A	4-6 years

Contraindications to vaccination

- There are few absolute contraindications to the use of the vaccines.

- Delaying a vaccination because of an intercurrent illness;
  - Child might not return again and the opportunity is lost.

False contraindications

- Fever, respiratory tract infection, diarrhea and malnutrition are not contraindications for vaccination.

True contraindications

- Immunosuppression is a contraindication to the administration of live vaccines.
  - Individual with high doses of corticosteroid – at least 3 months after treatment is stopped.
  - Chemotherapy – after 6 months
- Live vaccine should be avoided during pregnancy

Simultaneous administration of vaccines

- To reduce the number of contacts required to complete the immunization series, as many antigens as possible are given at a single visit.
- All the EPI antigens can be administered on the same day.
- Combination vaccines are increasingly used
  - DPT with HiB conjugate (quadrivalent)
  - DPT with HiB conjugate and hepatitis B (Pentavalent type 1)
  - DPT with HiB conjugate and IPV (Pentavalent type 2)
  - DPT, hepatitis B, IPV and Hib (Hexavalent)

Adverse Effects

Adverse effects are rare

- **Local reactions**
  - Erythema, warmth at the injecting site, most common following DPT.
- **Systemic reactions**
  - Fever
  - Rash, allergic reactions, arthritis/arthralgia.
- **Neurological reactions**
  - The most serious form, but the rarest.
  - Febrile or afebrile convulsions, encephalitis, encephalopathy, paralysis, Guillain-Barre syndrome, peripheral neuritis or neuropathy.

References

- **Control of communicable diseases manual**, by Heymann DL, American Public Health Association, 19th edition, 2008.
- **Park's textbook of preventive and social medicine**, by Park K, Banarsidas Bhanot Publishers, 21st edition, 2011.