Principles of Immunization

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Session Objectives

1. Understand the types of acquired immunity
2. Differentiate between the different types of vaccines used in preventing illness
3. Understand the type of vaccine, its mode of delivery, and schedule for important immunizable diseases; TB, Pertussis, Rubella, Diphtheria, Measles, Tetanus, Hepatitis, Meningitis, Rabies, Polio
4. Define and understand the cold chain and its importance

Session Overview

- Types of immunity.
- Types of vaccines.
- Specific types of vaccine, their mode of delivery, and schedule for important immunizable diseases.
- The cold chain

Types of acquired immunity

Introduction

Objectives of Understanding of the basic function of the immune system:

- Understand how vaccines work.

Immunity

The ability of the human body to tolerate the presence of material indigenous to the body ("self"), and to eliminate foreign ("non-self") material.

- This discriminatory ability provides protection from infectious disease, since most microbes are identified as foreign by the immune system.

Introduction

- Immunity to a microbe 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.
- There are two basic mechanisms for acquiring immunity:
  - Active
  - Passive.

Types of Immunity

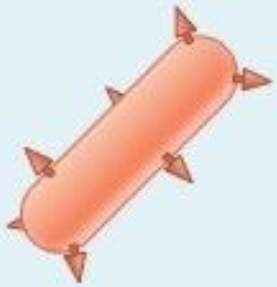
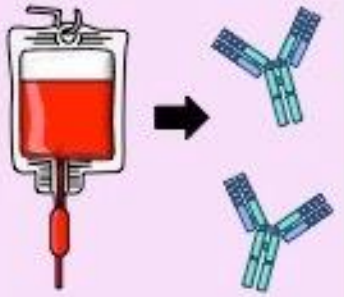
Active Immunity

- Immunity develops as a result of infection or by specific immunization.
- Stimulation of the immune system to produce antigen-specific humoral (antibody) and cellular immunity.
- Takes time to develop.
- usually lasts for many years, often for a lifetime

Passive Immunity

- Transfer of antibody produced by one human or other animal to another.
- Provides protection against some infections, but this protection is temporary.
- The antibodies will degrade during a period of weeks to months
- E.g. Antibodies are transported across the placenta from mother to infant (transplacental)

Types of Immunity

ACTIVE IMMUNITY		PASSIVE IMMUNITY	
Natural	**Artificial**	**Natural**	**Artificial**
			
Infection	Vaccination	Maternal antibodies	Monoclonal antibodies

Advantages of active immunity compared to passive immunity:

- Long-lasting protection
- Sever reactions are rare.
- Higher protective efficacy
- Less expensive.

Types of Immunity

Herd immunity (Community immunity)

- When vaccination of a portion of population (or herd) provides protection to unprotected individuals.
  - Higher number of immune individuals, the lower likelihood that a susceptible person will come in contact with an infectious agent.
- Provides an immunological barrier to the spread of disease in the human herd.
- On-going immunization programme will keep the herd immunity at a very high level.

Ways for acquiring active immunity

1. Following clinical infection
   - once persons recover from infectious diseases, they will have lifelong immunity to that disease
   - E.g. chickenpox, rubella and measles
2. Following immunization with an antigen
   - Vaccines interact with the immune system and produce an immune response similar to that produced by the natural infection, but they do not subject the recipient to the disease and its potential complications.

Types of Active Immunity

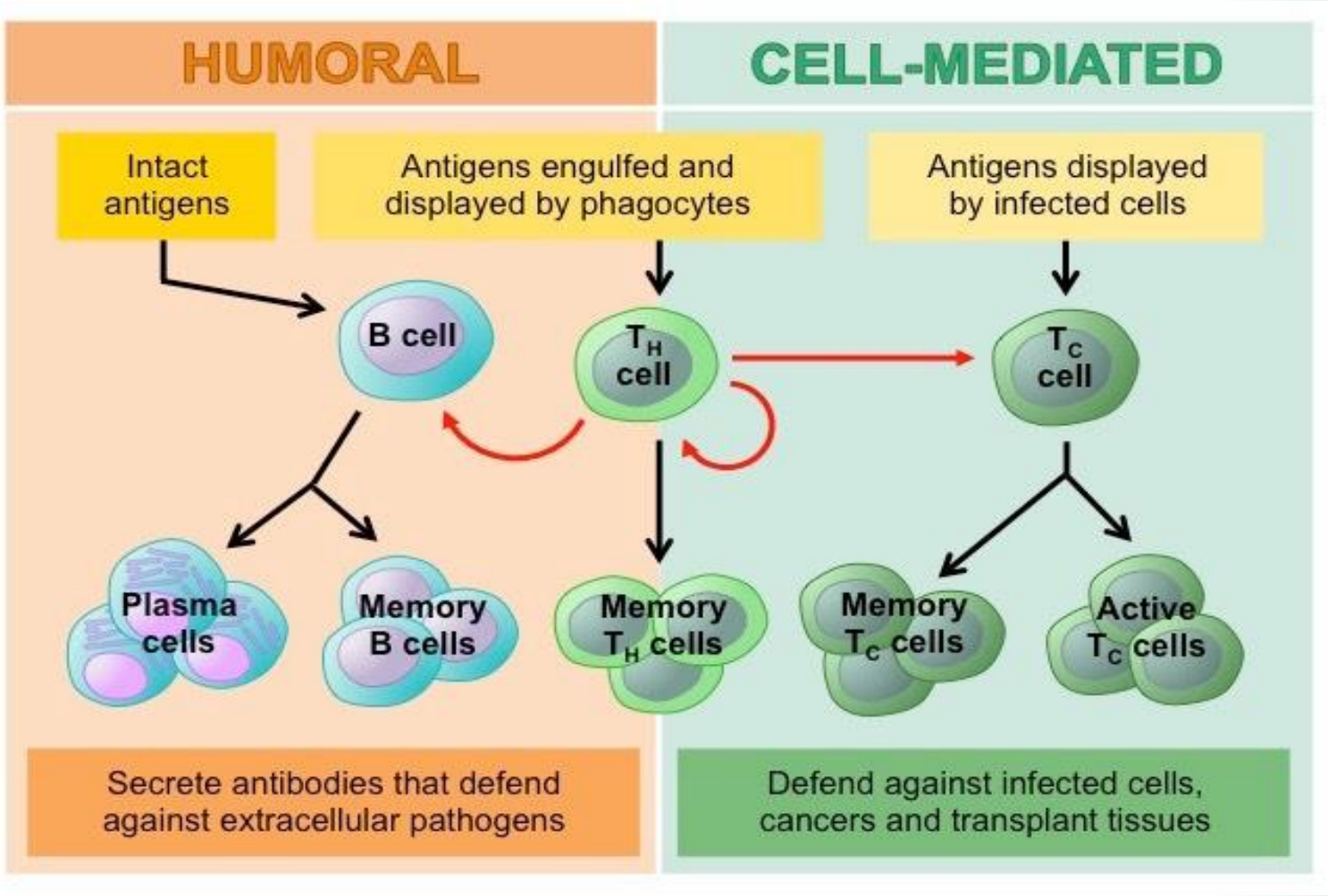
Humoral Immunity

- From B-cells (B-lymphocyte)
- Produce specific antibodies against foreign antigen.
- Immunoglobulins classes: IgG, IgM, IgD, IgA, IgE
- Antibodies are specific → not provide protection against more than one antigen

Cellular Immunity

- From mainly T-cells (T-lymphocyte)
- Recognition of antigen and initiation of a chain of responses e.g. activation of macrophage, release of cytotoxic factors, secretion of immunological mediators…
- Responsible for immunity against many diseases such as Tuberculosis and Brucellosis.

Types of Active Immunity



Classification of Vaccines

Vaccines

Vaccine

- Immuno-biological substance designed to produce specific protection against a given disease.
- It stimulates the production of protective antibody and other immune mechanisms.
- Vaccination is the most effective medical strategy to control infectious diseases.

Types of Vaccines

Vaccine may be prepared from:

- Live modified organisms
- Inactivated or killed organisms
- Extracted cellular fractions
- Toxoid
- Combination of these

Live Vaccines

- Prepared from live or wild organisms (modified in laboratory)
- These organisms lost their capacity to induce full disease but retain their immunogenicity.
- More potent immunizing agents.
  - Multiply in the host → large antigenic dose
  - Have all antigenic components.
- Contraindications for administrating live vaccine:
  - Immunocompromised persons (leukemia, lymphoma or cancer)
  - Persons with immune deficiency disease.
  - Pregnancy

Live Vaccines

- Prepared from live or wild organisms (modified in laboratory)
- These wild viruses or bacteria are attenuated, or weakened, in a laboratory, usually by repeated culturing.
- These organisms lost their capacity to induce full disease but retain their immunogenicity.
- To produce an immune response, live attenuated vaccines must replicate (grow) in the vaccinated person.
- More potent immunizing agents.
  - Multiply in the host → large antigenic dose
  - Have all antigenic components.

Live Vaccines

- Live attenuated vaccines produce immunity in most recipients with one dose, except those administered orally
- A small percentage of recipients do not respond to the first dose of an injected live vaccine (such as MMR or varicella) and a **second dose is recommended to provide a very high level of immunity** in the population
- Contraindications for administrating live vaccine:
  - Immunocompromised persons (leukemia, lymphoma or cancer)
  - Persons with immune deficiency disease.
  - Pregnancy

Live Vaccines

- Live attenuated vaccines are **fragile** and can be damaged or destroyed by heat and light. They must be handled and stored carefully.

Examples:

- **Viral vaccines**
  - Measles, mumps, rubella, varicella, zoster, yellow fever, rotavirus, and influenza (intranasal).
  - Oral polio vaccine
- **Bacterial vaccines**
  - Bacille Calmette-Guérin (BCG)
  - Oral typhoid

Inactivated or Killed Vaccines

- Produced by growing the bacterium or virus in culture media, then inactivating it with heat and/ or chemicals (usually formalin).
- Not alive and cannot replicate.
- Cannot cause disease from infection, even in an immunodeficient person.
- Always require multiple doses.
  - In general, the first dose “primes” the immune system.
  - A protective immune response develops after the second or third dose.

Inactivated or Killed Vaccines

- Some inactivated vaccines may require periodic supplemental doses to increase, or "**boost**," antibody titers.
- Usually administrated by **subcutaneous** or **intramuscular** route
- More stable than live vaccine.
- **Contraindication:**
  - Sever local or general reaction to a previous dose.
- **Example:**
  - Polio, Hepatitis A, Rabies
  - Pertussis, Typhoid, Cholera, Plague

Subunit Vaccines

- Vaccine made of single or multiple **antigenic components** of a microorganism that are capable of stimulating a specific immune response sufficient to protect from the relevant pathogen infection or from the clinical manifestation of the disease.
  - Toxoids
  - Protein vaccines
  - Recombinant protein vaccines
  - Polysaccharide-based vaccines
  - Combinations

Toxoids

- Certain organisms produce exotoxins, e.g., diphtheria and tetanus bacilli.
- The toxins produced by these organisms are **detoxicated** and used in the preparation of vaccines.
- In general, toxoid preparations are highly efficacious and safe immunizing agents.

Protein Vaccines

- Proteins can be purified from in-vitro cultures of a pathogenic microorganism.
- Pertussis vaccines currently available contain from two to four different proteins purified from B. pertussis and are able to confer protection against whooping cough comparable to that obtained with the whole cell vaccine.
- The influenza vaccine

Polysaccharide-based Vaccines

- Stimulation of an antibody response against the surface polysaccharide of pathogenic bacteria is a strategy for the development of vaccines against **capsulated** bacteria.
- The chemical structure or capsular polysaccharides varies between different strains within a single species → As a consequence, a limitation of polysaccharide-based vaccine is that the **immune responses they elicit are often serotype specific**.
- **Examples**: S. pneumoniae, Hib, and Salmonella

Combinations Vaccines

- If more than one kind of immunizing agent is included in the vaccine it is called a mixed or combined vaccine.
- The aims of combined vaccines are to
  - Simplify administration
  - Reduce costs
  - Minimize the number of contacts of the patient with the health system,
  - Reducing the storage cost
- Usually **does not** increase the risk of adverse reactions

Combinations Vaccines

Examples:

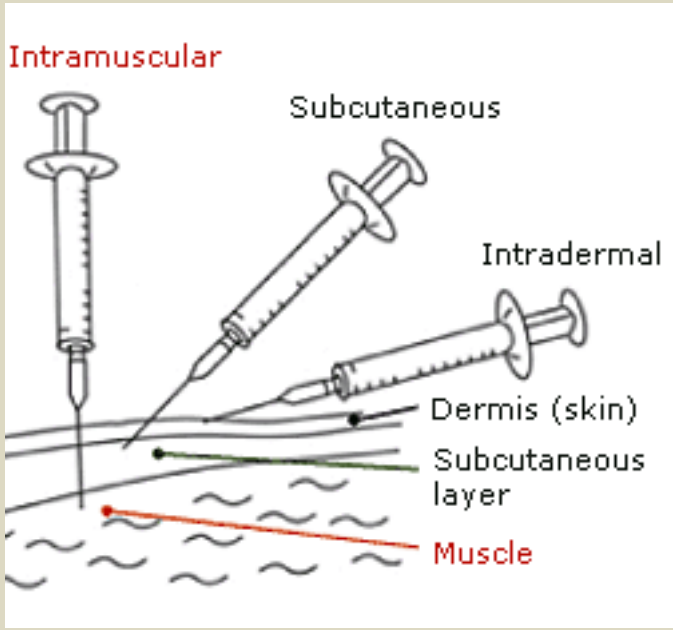
- DPT (Diphtheria-pertussis-tetanus)
- MMR (Measles, mumps and rubella)
- DPTP (DPT plus inactivated polio)
- DPT-Hep B-Hib (Diphtheria, pertussis, tetanus, hepatitis Band haemophilus influenza type B).

Route of adminstartion of Vaccines

Routes of Administrating Vaccines

- The route of administration is the path by which a vaccine is brought into contact with the body.
- This is a critical factor for success of the immunization.

1. Intramuscular route
2. Subcutaneous route
3. Intradermal route
4. Oral route



Intramuscular (IM) injection

- Administers the vaccine into the muscle mass.
- Vaccines containing adjuvants should be injected IM to reduce adverse local effects.

Subcutaneous (SC) injection

- Administers the vaccine into the subcutaneous layer above the muscle and below the skin.

Intradermal (ID) injection

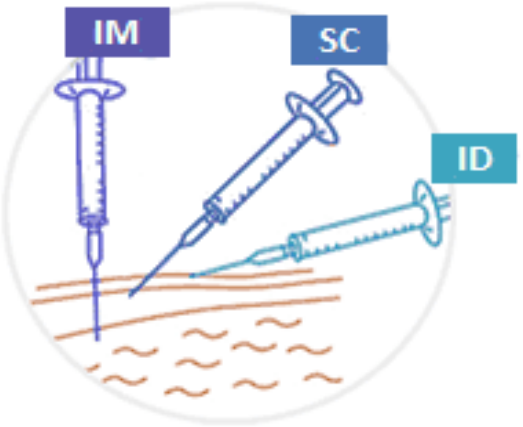
- Administers the vaccine in the topmost layer of the skin.
- BCG is the only vaccine with this route of administration.
- Intradermal injection of **BCG** vaccine reduces the risk of neurovascular injury.

Oral administration

- Oral administration of vaccine makes immunization easier by eliminating the need for a needle and syringe.

Routes of Administrating Vaccines

- **Oral**
  - OPV
  - Rotavirus
- **Intramuscular (IM)**
  - DTwP, DTaP, DT, Td, TT
  - Hepatitis B
  - IPV
  - Hib
  - PCV-7
- **Subcutaneous (SC)**
  - Measles
  - Yellow fever
- **Intradermal (ID)**
  - BCG



Immunization Schedules

BCG	–	Birth – 2 weeks
OPV	–	Birth; 6 weeks, 10 weeks and 14 weeks; 16–18 months, 5 years
DPT	–	6 weeks, 10 weeks and 14 weeks; 16–18 months and 5 years
Hepatitis B	–	Birth, 6 weeks and 14 weeks *or* 6 weeks, 10 weeks and 14 weeks
Hib Conjugate	–	6 weeks, 10 weeks and 14 weeks
Measles	–	9 months, 16–24 months
MMR	–	15 months
Typhoid	–	2 years, 5 years, 8 years, 12 years
TT/Td	–	10 years, 16 years
TT	–	2 doses one month apart for pregnant women, or booster dose if previously immunized.

Vaccines that can be given after discussion with parents

Varicella	–	15 months (or after 1 year)
Hepatitis A	–	high-risk selected infants, 18 months, and 6 months later
Pneumococcal conjugate vaccine	–	6 weeks
Influenza vaccine	–	6 months of age to high risk selected infants anually

Examples of Currently Used Vaccines

Vaccine	Type	Mode of administration
Measles	Live attenuated	Subcutaneous
Rubella	Live attenuated	Subcutaneous
Mumps	Live attenuated	Intramuscular
Diphtheria	Toxoid	Intramuscular
Pertussis	whole-cell pertussis vaccines and acellular pertussis vaccines	Intramuscular

The “Cold Chain”

The “Cold Chain”

- A system of storage and transport of vaccines at low temperature from the manufacturer to the actual vaccination site.
- Important to avoid the “vaccine failure”
- **The success of national immunization programme** is highly dependent on supply chain system for delivery of vaccines and equipment, with a functional system that meets **6 rights** of supply chain (The right vaccine in the right quantity at the right place at the right time in the right condition (no temperature breaks in cold chain) and at the right cost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