Chapter 17+: Vaccination, Blood & tissue type

Bio 139 General Microbiology
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Vaccinations

★ Principle is simple:
– Expose a person’s immune system to a non-disease causing form of the microbe or its antigens
– Subsequent actual exposure to the pathogen results in a secondary (anamnestic) immune response
  • Secondary response is faster, more vigorous
  • No disease results from infection!

• Usually, vaccination must occur before exposure to work
  • Exceptions: slow-progressing rabies; tetanus

★ Vaccines: Types

• Live, attenuated organism vaccines
  • Measles; mumps; rubella; Sabin polio (oral); smallpox

• Inactivated (dead) organisms
  • Hepatitis A; influenza; rabies; Salk polio (injection)

• Antigenic parts of organisms (subunit vaccines)
  • Hepatitis B; Haemophilus influenzae b (Hib); pneumococcus; meningococcus

• Toxoids
  • Diphtheria; tetanus

Introduction of “universal” vaccination has dramatic effects on disease incidence

Source: cdc.gov

Vaccine types: Problems

★ Live attenuated: example; polio (oral)
  • A microbe that is too “weak” to cause disease in a healthy person can still be a hazard to others
    – Pregnant women (the fetus, specifically)
    – Immunosuppressed people (corticosteroids; AIDS)

• Inactivated:
  • Method of inactivation is important; a “bad batch” can result in “vaccination” with virulent microbes

• Antigenic “parts”:
  • Only certain “parts” confer protective immunity
  • May depend on age of recipient: see conjugates
Vaccine-associated paralytic polio (VAPP)

• Associated with the oral (live) vaccine only
• Mutations in the attenuated live virus cause it to revert to a pathogenic phenotype
• 1979: last case of domestic wild polio in U.S.
  – later cases were all either acquired overseas, or due to vaccination (VAPP)
    • 1/4 of all VAPP occur in immunocompromised individuals
    • 1 per 2,000,000 vaccinations (about 8 cases per year)

Polio vaccine: Which to use?

• Live, attenuated (oral Sabin) vaccine is “better”
  • Gives longer-lasting immunity in more people
  • but it can cause VAPP
• Inactivated (injectable Salk) vaccine is not as effective

★ • If polio were still endemic, then efficacy would be the primary concern
★ • With polio gone from the U.S., VAPP becomes the primary concern

As of 2000, only the inactivated virus (Salk, injectable) vaccine is available in U.S.

Conjugate vaccines

• Exciting new development in vaccine technology (~10 years)
★ Against bacteria with capsules

• Polysaccharide conjugate vaccines
  – Hemophilus influenzae type b (Hib)
  – Streptococcus pneumoniae (pneumococcus)
  – Neisseria meningitidis (meningococcus)

• Encapsulated bacteria are covered by polysaccharides
  • The specific polysaccharides in the capsule vary from one isolate to another

• Polysaccharides (because they are not proteins) are not good antigens
  • Only B cells are activated; T cells require presentation of a peptide (protein-derived) antigen
    – No T activation = no memory B cells
    Children under 2 do not develop protective immunity

• Effective in infants
  • This is especially important for Hib, which causes meningitis in infants, and even with antibiotic treatment has a 5% mortality (other devastating consequences in survivors)

• Most conjugate vaccines are polyvalent
  • They are a mixture of many different polysaccharides to cover a variety of bacterial strains (of the same species)
How do vaccines prevent disease?

1. Immunity
2. Fewer carriers of the pathogen
3. Herd immunity

#1 (immunity) is obvious.
First immunologic exposure to the pathogen’s antigens is in the vaccine.
Subsequent “real” exposure generates a superior anamnestic response.

#2. Decreased carrier rates

• Immunized people are less likely to be carriers of an infection
• Fewer carriers = decreased spread of contagion

#3. Herd Immunity

• Vaccines are not 100% effective
  – Many vaccinated individuals do not develop protective immunity
• In a population where immunization is widely practiced, even unimmunized individuals benefit from the effect called herd immunity
  – For infectious diseases to spread, a chain of transmission is required (from one person to next)
  – If an infected person only encounters immune people, the disease stops there
    – Analogous to a firebreak (area cleared of incendiary material)

Herd Immunity

• By immunizing some significant majority of individuals in a population, the remaining individuals are effectively protected too
  • If the infection appears in the population, it cannot spread widely
  
  – Conversely, if vaccination programs decline, herd immunity falters and infectious disease reappears at rates higher than expected for the drop in vaccination

To vaccinate, or not...

• In the U.S., vaccination is nearly, but not quite, mandatory
  – Proof of vaccination is required by all schools & daycare facilities, but parents can legally gain exemption for their child
• Many parents are choosing to delay or entirely skip certain (or all!) vaccines for their children

Do you even know what diphtheria is?
Have you ever met someone paralyzed by polio?

To vaccinate, or not...

• Vaccines become victims of their own success
  • As people forget the dread of the diseases, they lose sight of the benefits of vaccination
  • Rare complications of vaccination (some real, some imagined) become the focus: risks loom large in people’s minds

Any medical intervention (whether a pill, a shot, an operation) has benefits AND risks.
The decision to use that intervention must be based on rational consideration of risk vs. benefit.
Vaccine risks

- Each vaccine has a particular profile of potential side effects
  - Fever, pain at injection site, joint aches, rash, etc. are relatively common
  - Severe side effects caused by vaccines currently in use are exceedingly rare, but real
  - All vaccine side effects are reportable and are tracked by CDC

- Association is NOT proof of cause:
  - Because vaccines are given to millions of people, often all in the same age group, it is statistically expected that recent vaccination will correlate with the appearance of many causally unrelated medical problems
  - People look for a cause, a reason, why Johnny has autism, why Suzie died of crib death...hey, what about that shot last month???
    - Threat of costly litigation impedes vaccine development

Rotavirus vaccine

- Diarrheal disease affecting infants
  - U.S. and developing countries, >500,000 deaths/year
- 1st vaccine (Rotashield) was approved summer 1998
- By summer 1999, 15 cases of intussusception (a severe, unusual type of bowel disease) were reported to the Vaccine Adverse Event Reporting System;
  - About 1 per 10,000 vaccinations
  - The vaccine was withdrawn
- Two new rotavirus vaccines (RotaTeq in U.S.; RotaRix in E.U.) are now available (spring 2006)
  - both are live, attenuated (oral) vaccines
  - neither is associated with intussusception

To vaccinate, or not...

- Popular media fans parents’ fears
  - Benefit of vaccines is emotionally unclear
    - The diseases are gone from collective memory
  - Risk, no matter how small, feels big
    - Not my child!!!

Unspoken irony of public health:

If everyone else vaccinates their kids, there is no reason to vaccinate mine.

Loose ends: Transfusion reactions

Red blood cells (RBCs) that carry foreign (non-self) surface antigens of the ABO group are lysed by IgM antibodies

- ABO group mismatches cause immediate transfusion reactions, the first time
  - IgM antibodies against A & B blood antigens are already present; sensitization is not required
  - Anti-A or Anti-B IgM are present because of cross reactivity with natural antigens on gut bacteria & elsewhere
- IgM is very good at fixing complement, etc.
- ABO transfusion reactions are sudden & severe
Rh (D) antigen incompatibility

- Natural (pre-existing) antibodies against Rh group antigens do not exist
  - Sensitization (exposure to Rh+ blood) is necessary
- Exposure to Rh+ blood in a Rh- person promotes IgG production
- Unlike IgM, IgG can cross the placenta

Hemolytic disease of the newborn

- Rh- mother carrying Rh+ fetus
  - First pregnancy: no anti-Rh antibodies, no problem
- During birth, enough fetal RBCs enter the maternal circulation to promote an immune response
  - IgG against Rh antigens are produced
- Second pregnancy: maternal IgG crosses the placenta and attacks fetal RBCs

At birth, all Rh- mothers are offered/given Rhogam (anti-Rh IgG antibodies)

- This passive immunization destroys the baby’s RBCs before the mother’s immune system becomes sensitized
- Subsequent pregnancies are safe

Transfusions & hemolytic disease of the newborn (Rh). Ch. 18. p. 514-515