Topic 15: Diseases of the Nervous System

About the Nervous System
- Divided into two parts
  - Central nervous system (CNS)
  - Peripheral nervous system (PNS)

Structure of the Nervous System
- Artist's Conception

Structure of the Nervous System
- Structures of the Central Nervous System
  - Composed of the brain and spinal cord
  - Brain has several main parts
    - Cerebrum controls voluntary muscles, perception, and “thinking”
    - Cerebellum controls many involuntary body movements
    - Brain stem controls breathing, heart rate, blood pressure
  - Spinal cord
    - Extends from the brain stem to the lumbar region
Structure of the Nervous System

- **Structures of the Peripheral Nervous System**
  - Composed of nerves that transfer commands from CNS to muscles and glands
  - Cranial nerves extend from the brain through holes in the cranial bones
  - Spinal nerves extend from the spinal cord through gaps between the vertebrae
  - Three types of nerves
    - Sensory nerves – carry signals toward the CNS
    - Motor nerves – carry signals away from the CNS
    - Mixed nerves – carry signals toward and away from the CNS

Structure of the Nervous System – Main Cell Types

- **Cells of the Nervous System**
  - Two basic cell types
    - Neuroglia
      - Provide support, insulation, nutrients, phagocytize microbes
    - Neurons
      - Carry nerve impulses
      - Nucleus lies in a region called the cell body
      - A collection of many neurons' cell bodies is called a ganglion
    - Dendrites and axons extend from the cell body

How do they get in?

- **Portals of Infection of the Central Nervous System**
  - CNS is an axenic environment
    - It has no normal microbiota
  - Pathogens may access the CNS several ways
    - Breaks in the bones and meninges
    - Medical procedures
    - Traveling in peripheral neurons to the CNS
    - Infecting and killing cells of the meninges resulting in meningitis
How do they cause disease?

• Bacteria cause disease in two ways
  – Infect cells of the nervous system
    – Meningitis
    – Leprosy
  – Bacteria growing elsewhere release toxins that affect neurons
    – Botulism
    – Tetanus

Bacterial Diseases of the Nervous System

• Bacterial Meningitis
  – Signs and symptoms
    – Sudden high fever and severe meningeal inflammation
    – Inflamed cranial meninges – severe headache, vomiting, pain
    – Inflamed spinal meninges – stiff neck, altered muscle control
    – Infection of the brain, or encephalitis, can result in behavioral changes, coma, and death
    – All may develop rapidly

Bacterial Diseases – Bacterial Meningitis

• Bacterial Meningitis
  – Pathogens and virulence factors
    – Five species cause 90% of bacterial meningitis cases
      – *Streptococcus pneumoniae* – leading cause in adults
      – *Neisseria meningitidis* – due to fimbria, capsule, and lipooligosaccharide
      – *Haemophilus influenzae* – leading cause prior to vaccine
      – *Listeria monocytogenes* – disease in fetuses, pregnant women, and immunocompromised individuals
      – *Streptococcus agalactiae* – causes most cases of newborn meningitis
Bacterial Diseases of the Nervous System – Strep Pneumonia

[Image]

Bacterial Disease – Neisseria Diplococci

• Fimbrae

[Image]

Bacterial Diseases – Haemophilus Influenza

• Pleomorphic Bacteria

[Image]
Bacterial Diseases of the Nervous System

- Listeria Invasion – evading the cell

Bacterial Diseases of the Nervous System

- Bacterial Meningitis
  - Pathogenesis
    - *S. agalactiae* acquired during birth
    - *Listeria* transmitted via contaminated food
    - Other species transmitted via respiratory droplets
  - Epidemiology
    - *S. pneumoniae* present in throat of 75% of humans without causing harm
    - Not spread by casual contact
    - Meningococcal meningitis is the only form that becomes epidemic

Bacterial Diseases of the Nervous System

- Bacterial Meningitis
  - Diagnosis, treatment, and prevention
    - Diagnosis made based on symptoms and culturing of bacteria from CSF from a spinal tap
    - Treat with various antimicrobial drugs
    - Vaccines available for *S. pneumoniae*, *H. influenzae* type b, and *N. meningitidis*
    - Individuals at risk for listeriosis should avoid high-risk foods (milk, cheeses, undercooked meat)
Hansen’s Disease (Leprosy)

- Signs and symptoms manifest in two forms
  - Tuberculoid leprosy – nonprogressive
  - Lepromatous leprosy – progressive tissue destruction
- Pathogen and virulence factors
  - *Mycobacterium leprae* is the causative agent
    - Gram-positive bacillus with mycolic acid in cell wall
- Pathogenesis
  - *M. leprae* grows best in cooler regions of the body
Bacterial Diseases of the Nervous System

• Botulism
  – Signs and symptoms
    – Caused by intoxication from ingested toxin
  – Three forms
    – Food-borne botulism – progressive paralysis of all voluntary muscles
    – Infant botulism – bacteria grow in the intestines, producing non-specific symptoms
    – Wound botulism – symptoms like those of food-borne botulism
  – Pathogen and virulence factors
    – Clostridium botulinum is the causative agent
    – Different strains produce one of seven neurotoxins

Bacterial Diseases of the Nervous System - Botulism

• How Botulism Toxin Works

Clostridium

• Botulism
  – Epidemiology
    – Rare, roughly 50 cases of food-borne and wound botulism per year in U.S.
    – Infant botulism most common form in U.S.
  – Diagnosis, treatment, and prevention
    – Three approaches to treatment
      – Washing of intestinal tract to remove Clostridium
      – Administration of botulism immune globulin
      – Treatment with antimicrobial drugs
    – Prevention involves destroying endospores in contaminated food through proper canning techniques
Bacterial Diseases: Clostridium Botulinum (Flaccid Paralysis)

- Bacterial spores are ingested or ingested in food or water
- Germination produces hundreds of vegetative cells
- Invade the body with enteric flora
- Produces gangrene or partial paralysis
- Develops into a clostridial bacteria known as "Flappy baby syndrome"

Causes:
- Excessive crying
- Poor feeding
- Weakness
- Loss of control
- Loss of movement
- Insidious onset
- Insidious period
- Insidious spread

Treatment: Treatment includes: Strepococcus, diphtheria, tetanus, and diphtheria toxoids

Prevention: Do not feed honey to infants under one year of age.

Bacterial Diseases -- Typical Clostridium Spores

LM 10 μm

Bacterial Diseases of the Nervous System: Tetanus

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Viral Diseases of the Nervous System – In General

• Viruses more readily cross the blood-brain barrier
• Viral infections of the nervous system occur more frequently than bacterial and fungal infections
• Viral diseases of the nervous system include meningitis, polio, rabies, and encephalitis

Viral Diseases - Viral Meningitis

- Signs and symptoms
  - Similar to bacterial meningitis
  - Usually milder than bacterial or fungal meningitis
- Pathogens and virulence factors
  - 90% of cases caused by viruses in the genus Enterovirus
- Pathogenesis
  - Damage to cells in the meninges triggers meningitis
Viral Diseases - Viral Meningitis (cont)

- Epidemiology
  - More common than bacterial and fungal meningitis
  - Spread via respiratory droplets and feces
- Diagnosis, treatment, and prevention
  - Characteristic signs and symptoms that occur in the absence of bacteria in the CSF
  - No specific treatment exists

Viral Diseases – Polio

- Poliomyelitis
  - Signs and symptoms – four conditions may result
    - Asymptomatic infections – almost 90% of cases
    - Minor polio – nonspecific symptoms
    - Nonparalytic polio – muscle spasms and back pain
    - Paralytic polio – produces paralysis
- Pathogen and pathogenesis
  - Poliovirus is the causative agent
  - Transmitted most often by drinking contaminated water

Viral Diseases – Polio Iron Lung Ward
Viral Diseases 

Polio World Map – Look! India is now Polio-Free!

• World Wide Polio Cases

2012- Eradicated!

Viral Diseases & Polio Vaccines

• Comparison of Vaccines

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Characteristics</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral vaccine</td>
<td>Inactivated</td>
<td>Effective, no side effects</td>
<td>Requires booster doses</td>
</tr>
<tr>
<td>Oral vaccine (OPV)</td>
<td>Live attenuated</td>
<td>Effective, stable during transport and storage</td>
<td>Requires higher dose and contact with other diseases</td>
</tr>
<tr>
<td>Oral vaccine (OPV)</td>
<td>Oral administration</td>
<td>Effective, no side effects</td>
<td>Requires higher dose and contact with other diseases</td>
</tr>
</tbody>
</table>

Viral Diseases – Rabies- TEM

• Rabies Virus
Viral Diseases – Rabies (cont.)

- Rabies
  - Pathogen and virulence factors
  - Rabies virus
  - Pathogenesis
    - Virus replicates in muscle cells and then moves across neuromuscular junctions into neurons
  - Epidemiology
    - Zoonotic disease
      - Transmitted via bite or scratch from an infected animal

Viral Diseases Rabies Distribution

[Map showing the distribution of rabies in the United States, with areas marked in red indicating high incidence.]

Viral Diseases – Cell changes due to Rabies in Cerbellum

[Image showing cell changes with Negri bodies.]
Viral Diseases -- Arboviral Encephalitis

In General:

– Arboviruses are arthropod-borne viruses
  – Transmitted via blood-sucking arthropods (ex. mosquitoes)
  – Mosquito-borne arboviruses cause various types of arboviral encephalitis
  – As zoonotic diseases they rarely affect humans
  – Arboviruses usually cause mild, cold-like symptoms
  – Arboviruses that cross the blood-brain barrier can cause encephalitis with symptoms similar to meningitis

Table 20.2  Characteristics of Arboviral Encephalitis Diseases and Viruses in the United States

Viral Diseases – Overview of Arboviral Encephalitis in the US

Viral Diseases -- Togavirus TEM (false color)
Viral Diseases – Transmission of Encephalitic Arboviruses

Viral Diseases – Incidence of Human West Nile Virus in the US

Viral Diseases -- Arboviral Encephalitis – How to…

- **Diagnosis** based on signs and symptoms and positive test for antibodies against specific arboviruses in the CSF
- **Treatment** is supportive
- **Prevention** involves limiting contact with mosquitoes
  - Use netting and insect repellants
  - Reduce mosquito numbers by eliminating stagnant water
- **Vaccines** for horses available against EEE, WEE, VEE, and WNV
Mycoses of the Nervous System – What are they?

- Mycoses are fungal diseases
- Mycoses may spread from the lungs to the CNS via the blood
- Poisoning from mushroom toxins can produce neurological problems and hallucinations
- Fungi may also produce fungal meningitis

Mycoses – Cryptococcus Neoformans in Brain

- Capsules
- In Brain
Protozoan Diseases of the Nervous System

- Protozoan infections of the nervous system are rare
- Two diseases caused by protozoa
  - African sleeping sickness
  - Meningoencephalitis

Protozoan Diseases – Trypanosomiasis

- African Sleeping Sickness
  - Signs and symptoms – three clinical stages
    - Site of bite becomes lesion with necrotic tissue
    - Parasites in the blood create fever, lymph node swelling, and headache
    - Meningoencephalitis upon invasion of the CNS
  - Pathogen and virulence factors
    - Caused by the trypanosome Trypanosoma brucei
    - Evades host's immune system by changing surface glycoproteins

Protozoan Diseases – Trypanosoma brucei Life Cycle

- T. brucei
- Tsetse fly
- rhythmic
Protozoan Diseases – Trypanosomiasis how to...

- **African Sleeping Sickness**
  - *Diagnosed* from microscopic observation of trypanosomes in the blood, lymph, or spinal fluid, or by tissue biopsy
  - *Treatment* includes various drugs that are administered based on how the disease has progressed
  - *Insecticide application* can help reduce occurrence

Protozoan Diseases – Amoebic Infection

- **Primary Amebic Meningoencephalopathy** – what is it?
  - Signs and symptoms
    - Same as for meningitis and encephalitis caused by bacteria, viruses, and fungi
  - Pathogen, pathogenesis, and epidemiology
    - Caused by *Acanthamoeba* and *Naegleria*
    - Enter host through cuts or scrapes on the skin, the eyelid, or through inhaling contaminated water
  - Diagnosis, treatment, and prevention
    - Drugs have limited success
    - Prevent by avoiding possibly contaminated water supplies

Prion Disease – what are they?

- A *prion* is an infectious protein
- *Spongiform encephalopathies* – A class of diseases that includes scrapie and mad cow disease
  - Leave the brains of victims full of holes
  - Humans can contract by eating meat from infected cattle
Microbial Diseases of the Eye

- Senses are important part of the nervous system
- Vision comprises almost half of the function of the cerebrum

Microbial Diseases of the Eye -- Trachoma

- Pathogen, treatment, and prevention
  - Caused by Chlamydia trachomatis that multiplies in the conjunctiva
  - Results in discharge and deformed eyelids
  - Can lead to blindness
  - Typically affects children, but certain strains can affect adults
- Diagnosis, treatment, and prevention
  - Diagnose by identifying bacteria at site of infection
  - Treat with antimicrobials and surgery
Microbial Diseases – Trachoma (Chlamydia trachomatis)

Other Microbial Diseases of the Eye

- Bacterial infections of the skin and reproductive tract can affect the eyes
- Styes – infections of the sebaceous glands near the eye
- Ophthalmic neonatorum – inflammation of the conjunctiva and cornea of a newborn
- Conjunctivitis – inflammation of the conjunctiva
  - *Haemophilus influenzae* is common bacterial cause
- Keratitis – inflammation of the cornea