Meningitis
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I Overview

1) Definitions:
   A) Meningitis - inflammation of the meninges that is identified by an abnormal WBC in the CSF
   B) Bacterial meningitis - meningitis and evidence of a bacterial pathogen in the CSF.
   C) Aseptic meningitis - meningitis in the absence of evidence of a bacterial pathogen
   D) Encephalitis - inflammation of the brain
   E) Meningoencephalitis - inflammation of the brain accompanied by meningitis
   F) Sepsis - clinical evidence of infection + systemic response to the infection
   G) Bacteremia - presence of bacterial pathogen in blood
   H) Infection - presence of microorganism with an immune response but without clinical signs/symptoms

2) Meninges:
   A) Dura mater (pachymeninges): Lies directly beneath and is adherent to the skull
   B) Pia mater: Lies directly over brain tissue
   C) Arachnoid: The middle layer between the dura mater and pia mater

*The pia mater and arachnoid are collectively called the leptomeninges.
*Between the pia mater and the arachnoid is the Subarachnoid Space (SAS)
  - SAS is the conduit for CSF
  - By definition, meningitis is an infection of the SAS

3) Overview of CSF:
   A) Produced by the choroid plexus within the fourth and lateral ventricles at a rate of 0.5 ml/min. (≈ 85%)
   B) CSF flows unidirectional
   C) The vertebral venous plexus and arachnoid villi remove the CSF from the spinal cord
   D) Volume of CSF is age dependent:

<table>
<thead>
<tr>
<th>State of Development</th>
<th>Volume of CSF (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant(&lt;2 yo)</td>
<td>40-60</td>
</tr>
<tr>
<td>Child(&gt;2/&lt;12)</td>
<td>60-100</td>
</tr>
<tr>
<td>Adults(&gt;12 yo)</td>
<td>110-160</td>
</tr>
</tbody>
</table>
II) Viral Meningitis:

1) Overview
   A) Difficult to differentiate from other causes of meningitis
   B) Distinguishing clinical features-
      1. Herpes zoster- dermal lesions
      2. Genital herpes- vesicular lesions
      3. Mumps- parotitis
   C) Typically seasonal disease- peaks in the summer and early fall
   D) Typically a benign disease- young infants may have subtle deficits in language skills.

2) Different Viral Causes:

   A) Enteroviruses- Five groups and 67 different serotypes
      1. Types of Enteroviruses
            1) Accounting for about 14% of the cases
         b. Group B coxsackie – 6 serotypes (B1-B6)
            1) Accounting for about 12% of the cases
         c. Echoviruses – 31 serotypes (1-33, except types 10 and 28)
            1) Most common accounting for 75% of the cases
         d. Polioviruses – 3 serotypes
         e. Newer enteroviruses– 4 serotypes (68-71)

      1. Presentation
         a. Respiratory
            1) Common cold
            2) Pharyngitis
            3) Herpangina
            4) Stomatitis
            5) Pneumonia
            6) Pleurodynia
         b. Gastrointestinal
            1) Vomiting
            2) Diarrhea
            3) Abdominal Pain
            4) Hepatitis
         c. Eye- acute hemorrhagic conjunctivitis
         d. Heart- Myopericarditis
         e. Skin- Exanthem
         f. Neurologic
            1) Aseptic meningitis
            2) Encephalitis
            3) Paralysis

      2. Epidemiology
         a. Most common viral meningitis (85-95%)
         b. Seasonal- July to December (late summer to fall)
         c. RNA viruses present in the GI tract
1) Viral shedding and transmission can continue several weeks after onset of infection
d. Fecal-oral route of transmission (possibly oral-oral)
e. Typically effects ages < 1 yo (but not limited to)

B) Mumps virus- paramyxovirus
1. Clinical presentation
   a. Swelling of the salivary glands
   b. Meningitis occurs in 10-30% of the cases
   c. Encephalitis is rare (1 in 6,000 cases)

2. Epidemiology
   a. Second most common viral meningitis (10-20%)
   b. Parotitis- precedes symptoms of meningitis by 3-10 days (may not develop in all cases)
   c. Peak between late winter to early spring
   d. Benign and self limiting disease
   e. Humans are the only natural known hosts
   f. Spread via direct contact via the respiratory route

C) Lymphocytic choriomeningitis virus- arenavirus
1. Clinical presentation
   a. Nonspecific (prodrome) Sx’s:
      1) Fever
      2) Malaise
      3) Myalgia
      4) Retro-orbital headache
      5) Photophobia
      6) Anorexia
      7) Nausea
   b. Meningitis

2. Epidemiology
   a. Chronic infection of the common house mouse
   b. Transmission via infected rodent
      1) Inhalation or ingestion of dust or food contaminated with the virus from urine, blood, feces, or nasopharyngeal secretions from the infected mouse
      2) No documented case of human to human transmission
   c. More common in winter
   d. RNA virus

D) Herpes simplex 1 and 2 (HSV)- Type 1 more meningoencephalitis and type 2 meningitis
1. Only treatable type of viral meningitis
   a. Type 2:
      1) Neonates- pass through birth canal but Sx's do not show for 1-3 weeks
      2) Sexually active adults- during or after an attack of genital or rectal herpes
3) **Treatment of Aseptic Meningitis**:
   A) Supportive care- fluids, electrolytes, oxygen
   B) Seizure control
   C) Management of cerebral edema and increased ICP- hyperventilation mannitol, dexamethasone, pentobarb comas
   D) Acyclovir (10 mg/kg q8°) for Herpes virus
   E) All patients should be started on antibiotics until cultures are back

**III) Bacterial meningitis:**

1) **Introduction**

   A) Incidence:
      1. 0.2-2.9 cases/100,000/yr (1986)
      2. 0.2-1.1 cases/100,000/yr (1995)
   B) Disease of the very young and very old
   C) 80% caused by *Haemophilus influenzae* (1986)
      1. 1990: Routine administration of hemophilus b conjugated vaccine
         a. 85% reduction since 1990 with vaccine
         b. Biggest reduction between the ages of 1 to 23 months old
   D) Mortality greatest in patients < 2 months and > 60 years old
      1. Mortality has not changed much in the last 3 decades
   E) Significant sequelae occur in 10-30% of children and are highest with pneumococcal meningitis
      1. Unilateral or bilateral hearing impairment or complete hearing loss 10%
         Seizures, focal neurological deficits, learning/behavior disabilities ≤ 5%

2) **Morbidity / Mortality**

<table>
<thead>
<tr>
<th>Organism</th>
<th>% of Total Cases</th>
<th>Annual Incidence (cases/100,000)</th>
<th>Fatality Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Haemophilus influenzae</em></td>
<td>45</td>
<td>7</td>
<td>2.9</td>
</tr>
<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td>18</td>
<td>47</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Neisseria meningitidis</em></td>
<td>14</td>
<td>25</td>
<td>0.9</td>
</tr>
<tr>
<td>Grp B streptococci</td>
<td>5.7</td>
<td>12</td>
<td>0.4</td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>3.2</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td>other</td>
<td>15</td>
<td>1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

3) Most Common Cause of Meningitis for Specific Age Groups

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Most likely organism</th>
<th>Less likely organism</th>
<th>Risk factors for all ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn-3 mo</td>
<td><em>E. coli</em>&lt;br&gt;Klebsiella sp&lt;br&gt;Enterobacter sp&lt;br&gt;Group B Strep.</td>
<td><em>L. monocytogenes</em>&lt;br&gt;Herpes Simplex Virus</td>
<td>Respiratory tract infection&lt;br&gt;Otitis media</td>
</tr>
<tr>
<td>3 mo-4yo</td>
<td><em>N. meningitidis</em>&lt;br&gt;<em>S. pneumoniae</em>&lt;br&gt;<em>H. influenzae</em></td>
<td>Viruses</td>
<td>Mastoiditis&lt;br&gt;Head trauma</td>
</tr>
<tr>
<td>5-17yo</td>
<td><em>N. meningitidis</em>&lt;br&gt;<em>S. pneumoniae</em></td>
<td>Viruses</td>
<td>Alcoholism&lt;br&gt;Splenectomy</td>
</tr>
<tr>
<td>18-29yo</td>
<td><em>N. meningitidis</em>&lt;br&gt;<em>S. pneumoniae</em></td>
<td>Viruses</td>
<td>Sickle cell disease&lt;br&gt;High-dose steroids&lt;br&gt;Immunosuppression&lt;br&gt;Immunoglobulin deficiency</td>
</tr>
<tr>
<td>30-70yo</td>
<td><em>N. meningitidis</em>&lt;br&gt;<em>S. pneumoniae</em></td>
<td><em>L. monocytogenes</em>&lt;br&gt;GNB&lt;br&gt;Viruses</td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td><em>S. aureus</em>&lt;br&gt;<em>S. epidermidis</em>&lt;br&gt;GNB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed Head Trauma</td>
<td><em>H. influenzae</em>&lt;br&gt;<em>S. pneumoniae</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Head Trauma</td>
<td><em>S. aureus</em></td>
<td>GNB: <em>Klebsiella</em>&lt;br&gt;<em>E. coli</em></td>
<td></td>
</tr>
</tbody>
</table>

4) Pathogenesis

A) Routes of transmission
   1. Hematogenous spread
   2. Parameningeal seeding
   3. Direct inoculation

B) Pathogenic virulence factors overcome host defense mechanisms

**BACTERIAL PATHOGENESIS**

- Nasopharyngeal Colonization
  - Adhesive lectins, pili
  - IgA protease secretion
- Local Invasion
- Bacteremia
  - Capsule
- Meningeal Invasion
  - Adhesive pili
- Bacterial Replication in CSF
- Subarachnoid Space Inflammation

**HOST DEFENSES**

- Secretory IgA
- Ciliary activity
- Mucosal epithelium
- Complement
  - (Alternate Pathway)
- Cerebral endothelium
- Poor opsonic activity
C) Mediators of the inflammatory process in CSF.

1. Bacterial Components
   a. Endotoxin/Lipopolysaccharide
   b. Peptidoglycan
   c. Lipoteichoic acid

2. Release of inflammatory mediators by astrocytes, microglial/endothelial cells
   a. TNF $\alpha$
   b. IL-1

3. Pathophysiology
   a. Reduced cerebral perfusion secondary to edema
   b. Cerebral ischemia secondary to thrombosis
   c. Vasculitis
   d. Alteration of cerebral blood flow
   e. Direct neuronal cell damage secondary to bacterial elements activated leukocytes, cytokines, and other inflammatory mediators
f. Vasogenic edema - cytokines act on endothelial cells to damage the BBB

g. Cytotoxic edema - direct damage to cells allowing buildup of intracellular water

h. Interstitial edema - obstruction of CSF flow and removal

i. Brain herniation

5) Clinical Presentation and Diagnosis

A) Age Groups

1. Neonates and infants:
   a. Fever/hypothermia
   b. Lethargy
   c. Poor feeding
   d. Seizures
   e. Apnea

2. Older children and adults:
   a. Fever
   b. Headache
   c. Malaise
   d. Chills
   e. Photophobia
   f. Stiffness of neck/back

3. Elderly:
   a. Altered mental state

* Not all patients will present with positive Brudzinski's and Kernig's signs

B) Physical Exam

1. Nuchal rigidity
2. Positive Brudzinski's sign
3. Positive Kernig's sign

C) Laboratory studies

1. Lumbar puncture
   a. CSF cell count
   b. CSF chemistries
   c. CSF Gram's stain
      1) 50% of the time positive
   d. CSF culture
      1) Positive in 85% of the cases
   e. Rapid antigen tests- 69% accurate when (+) cultures
      1) Counterimmunoelectrophoresis (CIE)- encapsulated organisms
      2) Enzymeimmunoassay (EIA)
      3) Latex coagglutination and latex fixation
      4) Limulus amebocyte lysate test- GN endotoxin

2. Blood culture
3. Sputum culture
4. Peripheral CBC
5. Peripheral electrolytes
### Differential Diagnosis of the CSF:

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>WBC/mm3</th>
<th>Cell type</th>
<th>Glucose (mg/dL)</th>
<th>Protein (mg/dL)</th>
<th>Gram Stain</th>
<th>Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm (normal)</td>
<td>0-25.4</td>
<td>Lymphocytes</td>
<td>24-63</td>
<td>65-150</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
<tr>
<td>Term (normal)</td>
<td>0-22.4</td>
<td>Lymphocytes</td>
<td>34-119</td>
<td>20-170</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
<tr>
<td>&gt;1 month (normal)</td>
<td>0-4</td>
<td>Lymphocytes</td>
<td>40-80 (&lt;40)</td>
<td>5-40</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
<tr>
<td>Adult (normal)</td>
<td>&lt;5</td>
<td>Lymphocytes</td>
<td>&gt;40 (or 60% of periph)</td>
<td>&lt;50</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
<tr>
<td>Bacterial Meningitis</td>
<td>&gt;500 (usually &gt;1000)</td>
<td>Neutrophils</td>
<td>&lt;40</td>
<td>&gt;50 (&gt;100)</td>
<td>Pos. (70-90%)</td>
<td>Pos.</td>
</tr>
<tr>
<td>Viral Meningitis</td>
<td>&lt;500</td>
<td>Neutrophils-early Lymphocytes-late</td>
<td>&gt;40</td>
<td>&lt;100</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Tuberculous Meningitis</td>
<td>&lt;500</td>
<td>Lymphocytes</td>
<td>&lt;40</td>
<td>50-500</td>
<td>Rarely AFB Pos.</td>
<td>AFB Pos.</td>
</tr>
<tr>
<td>Syphilitic Meningitis</td>
<td>200-500</td>
<td>Lymphocytes</td>
<td>&gt;40</td>
<td>40-200</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
<tr>
<td>Brain Abscess</td>
<td>&lt;100</td>
<td>Neutrophils-early Lymphocytes-late</td>
<td>&gt;40</td>
<td>Early ≤500 Late-norm</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
<tr>
<td>Neoplasm</td>
<td>&lt;100</td>
<td>Lymphocytes</td>
<td>40-80</td>
<td>50-1000</td>
<td>Neg.</td>
<td>Neg.</td>
</tr>
</tbody>
</table>

### 6) Pathogen specific characteristics

**A) Haemophilus influenzae**

1. Peak incidence: 6-12 months of age: declines after 24 months of age
2. Deafness = 6%
3. Coma and seizures, if present, occur early in course
4. Sterile, subdural effusions are common with this pathogen only
5. Close contacts are 200-1000 x risk
6. Resistance pattern is growing throughout the U.S
7. Dramatic reduction in the amount of cases caused by serotype B
   a. 87-94% reduction
   b. Other types include serotypes F, A, and E
5) Encapsulated groups are A-F
B) *Neisseria meningitidis*

1. More prevalent in winter and spring
   a. Group B primarily responsible for isolated cases
   b. Groups A and C primarily associated with epidemics
   c. Y pneumonia
   d. A prominent in Africa/Asia
   e. Petechiae and purpura occur in 50%
3. May present with a characteristic immune reaction 10-14 days after infection
   a. Fever, arthritis, pericarditis
   b. Treat with NSAID’s
4. 50% die within the first 24 hrs
5. Deafness = 10.5%
6. Close contacts are 500-1000 x risk
7. No penicillin resistance detected in the Twin Cities yet; few nationally

C) *Streptococcus pneumoniae*

1. Gram positive diplococci
2. “Pneumococcus”
3. Deafness = 31%
4. Specific risk factors
5. Common cause of recurrent meningitis secondary to fractures of the cribriform plate, sinuses, or mastoid
6. Seizures more common
7. Resistant strains throughout the United States and the Twin Cities
   a. Sensitive:
      Penicillin MIC < 0.06 µg/mL
      Ceftriaxone MIC < 0.5 µg/mL
   b. Intermediate Sensitive
      Penicillin MIC of 0.1-1 µg/mL
      Ceftriaxone MIC 0.5-2 µg/mL
   c. Resistant
      Penicillin MIC of >1 µg/mL
      Ceftriaxone MIC > 2 µg/mL

D) *Listeria monocytogenes*

1. Peak incidence in summer/early fall
2. Gram positive rod (coccobacilli)
3. Most common ages < 3 months or > 60 yo
4. Susceptible to ampicillin
   a. Enhanced bactericidal activity with the edition of gentamicin
7) Treatment

A) Antimicrobial therapy

1. Factors enhancing antimicrobial penetration
   a. Small molecular weight
   b. Unionized at physiologic pH
   c. Highly lipid soluble
   d. Large free fraction in serum (low protein binding)

2. Factors that reduce the activity of the antibiotic
   a. Low pH of fluid
   b. High concentration of protein in fluid
   c. High temperature of fluid

3. Penetration of antimicrobial agents into the CSF

   Therapeutic concentrations without inflamed meninges:
   
   a) Chloramphenicol
   b) Rifampin
   c) INH
   d) Sulfonamides
   e) Trimethoprim
   f) Triazole antifungals- fluconazole, itraconazole

   Therapeutic concentration with inflamed meninges:
   
   a) Penicillin G
   b) Ampicillin
   c) Carbenicillin
   d) Ciprofloxacin
   e) Ticarcillin(clavulanic acid)
   f) Quinolones
   g) Piperacillin(tazobactam)
   h) Cefuroxime
   i) Ceftizoxime
   j) Ceftazidime
   k) Mezlocillin
   l) Imipenem
   m) Aztreonam
   n) Vancomycin

   Nontherapeutic concentrations regardless of inflammatory status: (Aminoglycosides)
   
   a) Amikacin
   b) Streptomycin
   c) Gentamicin
   d) Kanamycin
   e) Tobramycin
   f) Polymyxin
### B) Empiric antibiotic therapy

<table>
<thead>
<tr>
<th>Age</th>
<th>Standard</th>
<th>Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1 month</td>
<td>ampicillin plus 3rd generation cephalosporin</td>
<td>ampicillin plus aminoglycoside</td>
</tr>
<tr>
<td>Older children and healthy adults</td>
<td>3rd generation cephalosporin plus vancomycin</td>
<td>ampicillin plus chloramphenicol</td>
</tr>
<tr>
<td>Elderly</td>
<td>ampicillin plus 3rd generation cephalosporin</td>
<td>ampicillin plus aminoglycoside</td>
</tr>
</tbody>
</table>

### Suggested Parental Antibiotics for Treatment of Bacterial Meningitis:

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>First</th>
<th>Second</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Streptococcus (Group B)</strong></td>
<td>Penicillin G</td>
<td>Chloramphenicol</td>
</tr>
<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td></td>
<td>Cefotaxime</td>
</tr>
<tr>
<td>Penicillin-sensitive</td>
<td></td>
<td>Cefetizoxime</td>
</tr>
<tr>
<td>Penicillin- Intermediate resistant</td>
<td></td>
<td>Ceftriaxone</td>
</tr>
<tr>
<td>Penicillin MIC &gt; 0.06 µg/mL</td>
<td>Penicillin G or ampicillin</td>
<td>Chloramphenicol</td>
</tr>
<tr>
<td>Ceftriaxone MIC &lt; 0.5 µg/mL</td>
<td>Third generation cephalosporin</td>
<td>Cefuroxime</td>
</tr>
<tr>
<td>Penicillin-resistant Ceftriaxone MIC &gt; 1 µg/mL</td>
<td>Third generation cephalosporin + Vancomycin</td>
<td>—</td>
</tr>
<tr>
<td><strong>Staphylococcus epidermidis</strong></td>
<td>Penicillinase-resistant penicillin’s</td>
<td>Vancomycin</td>
</tr>
<tr>
<td>Penicillin-resistant</td>
<td>Vancomycin</td>
<td>—</td>
</tr>
<tr>
<td><strong>Staphylococcus aureus</strong></td>
<td>Penicillin G</td>
<td>Vancomycin</td>
</tr>
<tr>
<td>Penicillin-sensitive</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Penicillin-resistant</td>
<td>Nafcillin or oxalic</td>
<td>Vancomycin</td>
</tr>
<tr>
<td>Methicillin-resistant</td>
<td>Vancomycin</td>
<td>—</td>
</tr>
<tr>
<td><strong>Neisseria meningitidis</strong></td>
<td>Penicillin G or ampicillin</td>
<td>Chloramphenicol</td>
</tr>
<tr>
<td><strong>Hemophilus influenzae</strong></td>
<td>Cefotaxime</td>
<td>Cefuroxime</td>
</tr>
<tr>
<td><strong>Enterbacteriaceae</strong></td>
<td>Cefotaxime</td>
<td>Ceftriaxone</td>
</tr>
<tr>
<td><strong>Pseudomonas aeruginosa</strong></td>
<td>Ceftazidime and Tobramycin</td>
<td>Piperacillin plus aminoglycoside</td>
</tr>
<tr>
<td><strong>Listeria monocytogenes</strong></td>
<td>Penicillin G or ampicillin plus an aminoglycoside</td>
<td>Trimethoprim-sulfamethoxazole</td>
</tr>
</tbody>
</table>
B) Steroid therapy

1. Advantages
   a. Reduces inflammatory reaction
   b. Reduces neurologic sequelae

2. Disadvantages
   a. GI bleeds
   b. Antibiotic penetration
      1) Significant reduction of vancomycin/BBB penetration
      2) Somewhat lower CSF concentrations of ceftriaxone
   c. Ischemia

3. Recommendations
   a. 0.15 mg/kg dexamethasone IV q6hr X 4 days or 0.4 mg/kg q12hr x 4 days
   b. Administer steroid before first dose of antibiotic
   c. Use in children who have GNB on gram stain
   d. Monitor hemoglobin and stool guaiac

4. Actions
   a. Blocks TNFα and IL-1 release
   b. ↓ ICP, CNS edema, fever duration, and CSF lactate and protein levels
   c. ↑ CSF glucose
   d. ↓ Neurological complications and hearing loss (50%)

8) Prevention

A) Neisseria meningitidis

1. Prophylaxis for close contacts of index case is recommended:

<table>
<thead>
<tr>
<th>Drug</th>
<th>Age Group</th>
<th>Dosage</th>
<th>Duration and route of administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rifampin</td>
<td>&lt;1 mo</td>
<td>5 mg/kg q12hr</td>
<td>2 days, PO</td>
</tr>
<tr>
<td></td>
<td>&gt;1 mo - 12 yr</td>
<td>10mg/kg q12h</td>
<td>2 days, PO</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>600mg q12hr</td>
<td>2 days, PO</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>Adults</td>
<td>500 mg</td>
<td>Single dose, PO</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>Children&lt;15yo</td>
<td>125 mg</td>
<td>Single dose, IM</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>250 mg</td>
<td>Single dose, IM</td>
</tr>
</tbody>
</table>

2. Prevention: vaccination of limited use. Available vaccine covers serogroups A, C, Y, and W-135; however, sporadic cases are most often due to group B. Typically vaccine has been useful during epidemics (type C), high risk patients, and consider use in college freshman.

B) Streptococcus pneumoniae

1. Prophylaxis not recommended

2. Prevention:
   a. Pneumococcal polysaccharide vaccine useful in high-risk patients
   b. Conjugate vaccine part of childhood vaccinations. (Starting at 2 months old)
C) *Haemophilus influenzae* type b

1. Prophylaxis of close contacts is recommended when at least one member of the same household as the index case is less than 4 years of age and not fully immunized:

<table>
<thead>
<tr>
<th>Drug</th>
<th>Age Group</th>
<th>Dosage</th>
<th>Duration and route of administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rifampin</td>
<td>&lt;1 mo</td>
<td>10 mg/kg qd</td>
<td>4 days, PO</td>
</tr>
<tr>
<td></td>
<td>&gt;1 mo - 12 yr</td>
<td>20 mg/kg qd</td>
<td>4 days, PO</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>600mg q12hr</td>
<td>4 days, PO</td>
</tr>
</tbody>
</table>

2) Prevention: several available vaccines, recommended routinely as part of childhood vaccinations. (Starting at 2 months old)