Meningitis & Encephalitis

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CNS Infection

- **Meningitis:**
- **Aseptic meningitis:**
- **Encephalitis**
- **Focal suppirative infections of CNS**
- **Para-meningeal infections**
- **Myelitis**

- **Meningitis:**
  - Inflammation of the meninges
  - CSF WBC pleocytosis

- **Aseptic meningitis:**
  - Meningeal inflammation with negative CSF bacterial cultures
  - No prior antibiotic usage
  - Infectious and noninfectious causes .

- **Encephalitis:**
  - Inflammation of the brain
  - Produces neurologic dysfunction:
    - Altered mental status
    - Behavior, or personality changes
    - Motor or sensory deficits
    - Speech or movement disorders
    - Hemiparesis
    - Paresthesias

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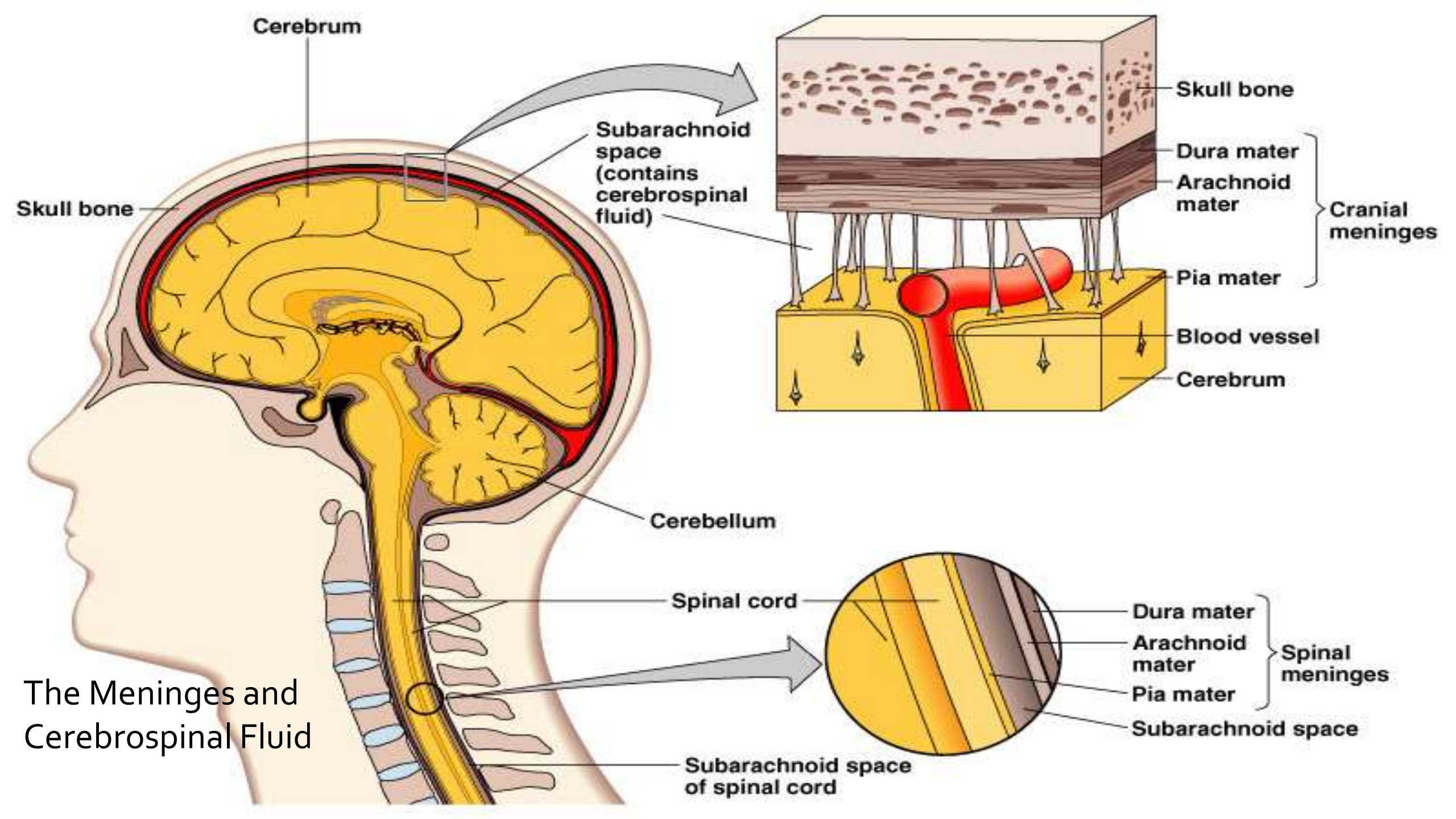
- **Focal suppurative infections of CNS**
  - Brain abscess
  - Subdural or epidural empyema

- **Para-meningeal infections:**
  - Sinusitis
  - Mastoiditis
  - Cranial osteomyelitis

- **Myelitis**
  - Inflammation of the spinal cord
  - Symptoms:
    - flaccid paralysis and reduced or absent reflexes.

Meningitis



The Meninges and Cerebrospinal Fluid

Etiology oF Bacterial Meningitis by age group

Newborn Period

More than 2/3 are caused by:

- Group B streptococcus
- Gram-negative enteric bacilli
  - *E. coli*, Salmonella, Enterobacter
- *Listeria monocytogenes*

Etiology of Bacterial Meningitis by age group

Children 1-23 months

- ***Streptococcus pneumoniae***
- *Neisseria meningitidis*
- Group B streptococcus
- *E. coli*
- *Haemophilus influenza type B*

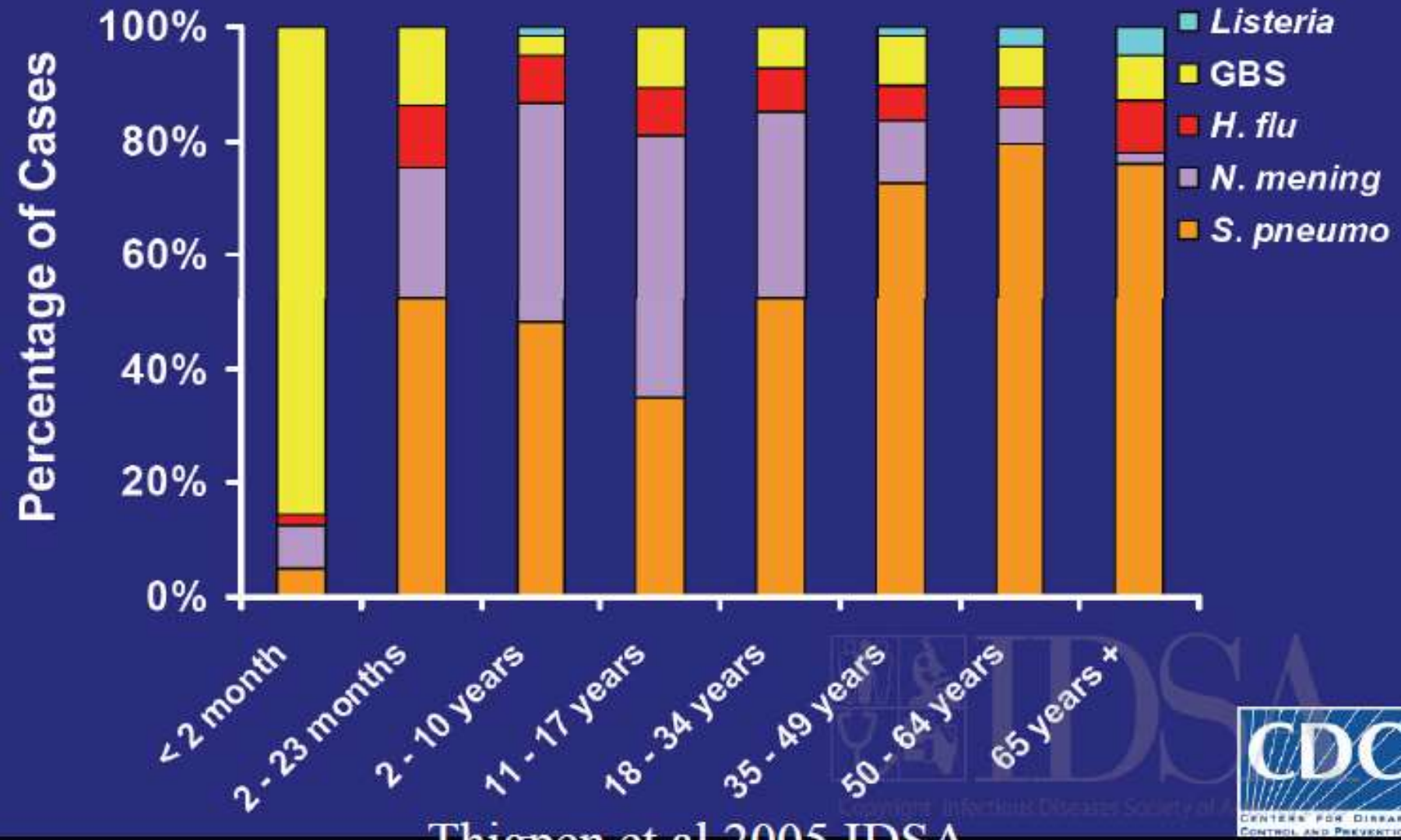
Etiology of Bacterial Meningitis by age group

Children ≥ 2 years

- *Streptococcus pneumoniae*
- *Neisseria meningitidis*

Bacterial Meningitis 2002-2003

By Pathogen, By Age Group



Thigpen et al 2005 IDSA

Bacterial Meningitis

Bacterium	Percentage of Cases	Fatality Rate
Streptococcus pneumoniae	30–50	19–46
Neisseria meningitidis	15–40	3–17
Haemophilus influenzae	2–7*	3–11

Other bacteria causing meningitis account for 6–8% of cases.

*Before introduction of Hib vaccine, H. influenzae accounted for about 45% of cases of bacterial meningitis; about 70% of these cases occurred in children under age 5.

SOURCE: Adapted from E.J. Phillips and A.E. Simor, "Bacterial Meningitis in Children and Adults," Postgraduate Medicine 103 (3):104 (1998).

Haemophilus influenzae Meningitis

- Occurs mostly in children (6 months to 4 years)
- Gram-negative aerobic bacteria, normal throat microbiota
- Capsule antigen type b
- Prevented by Hib vaccine

Haemophilus influenzae Meningitis

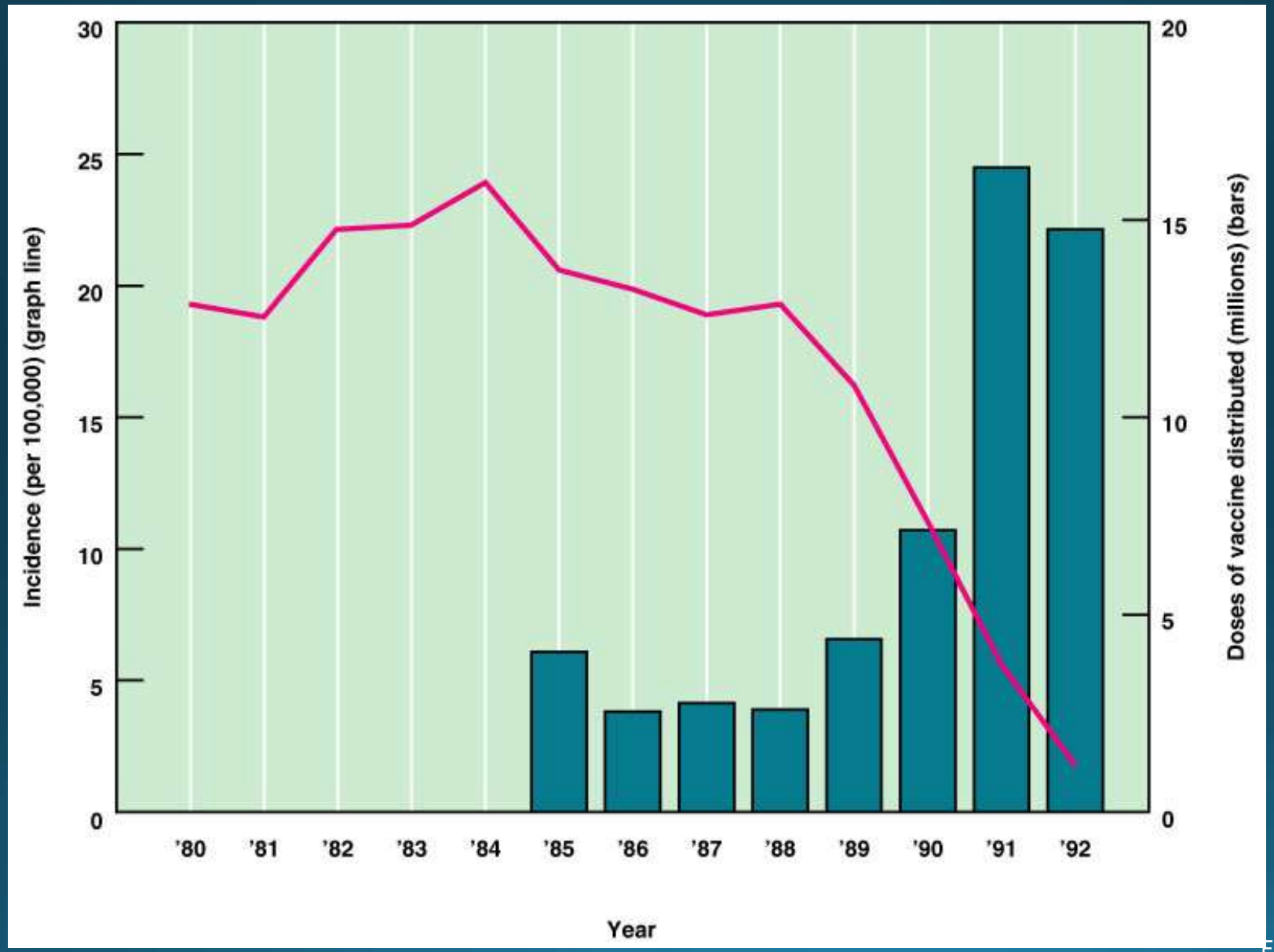
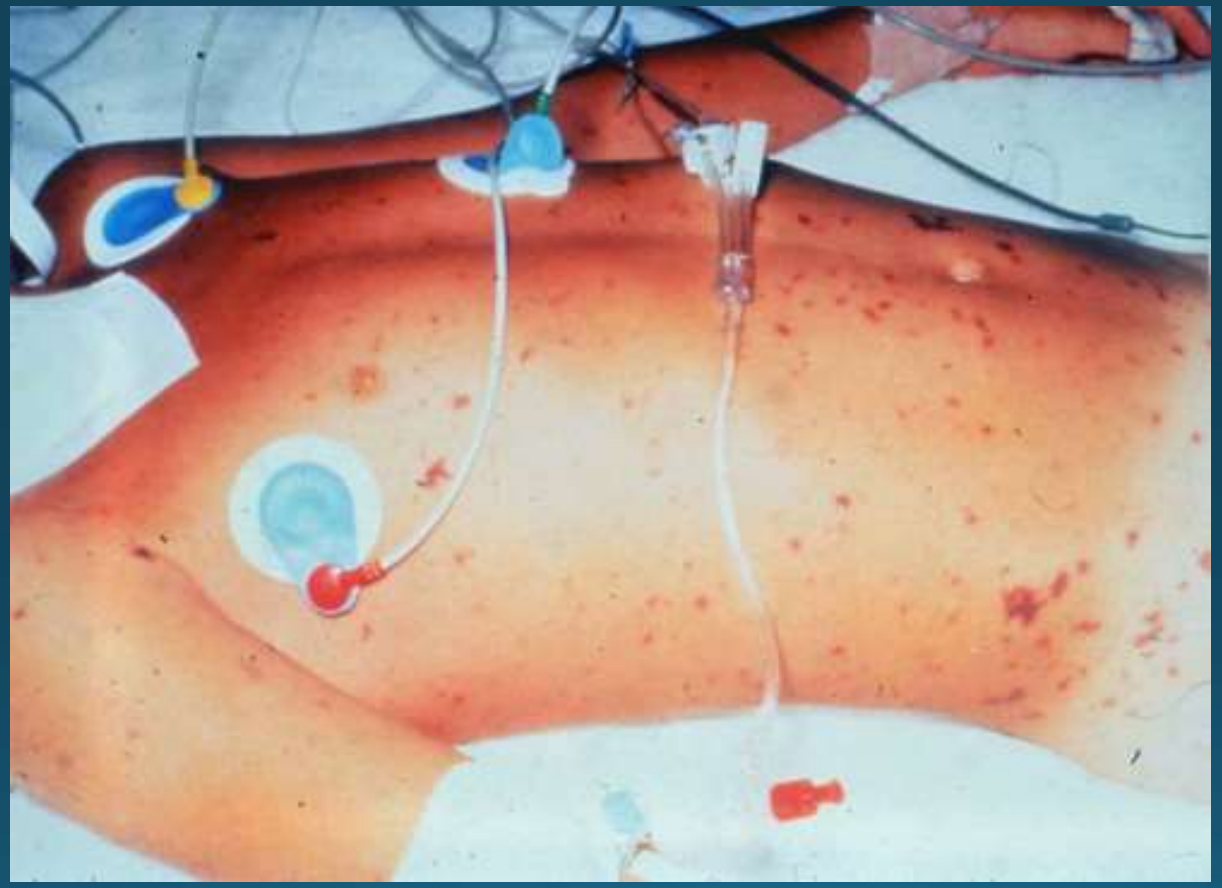


Figure 22.3



Neisseria Meningitis

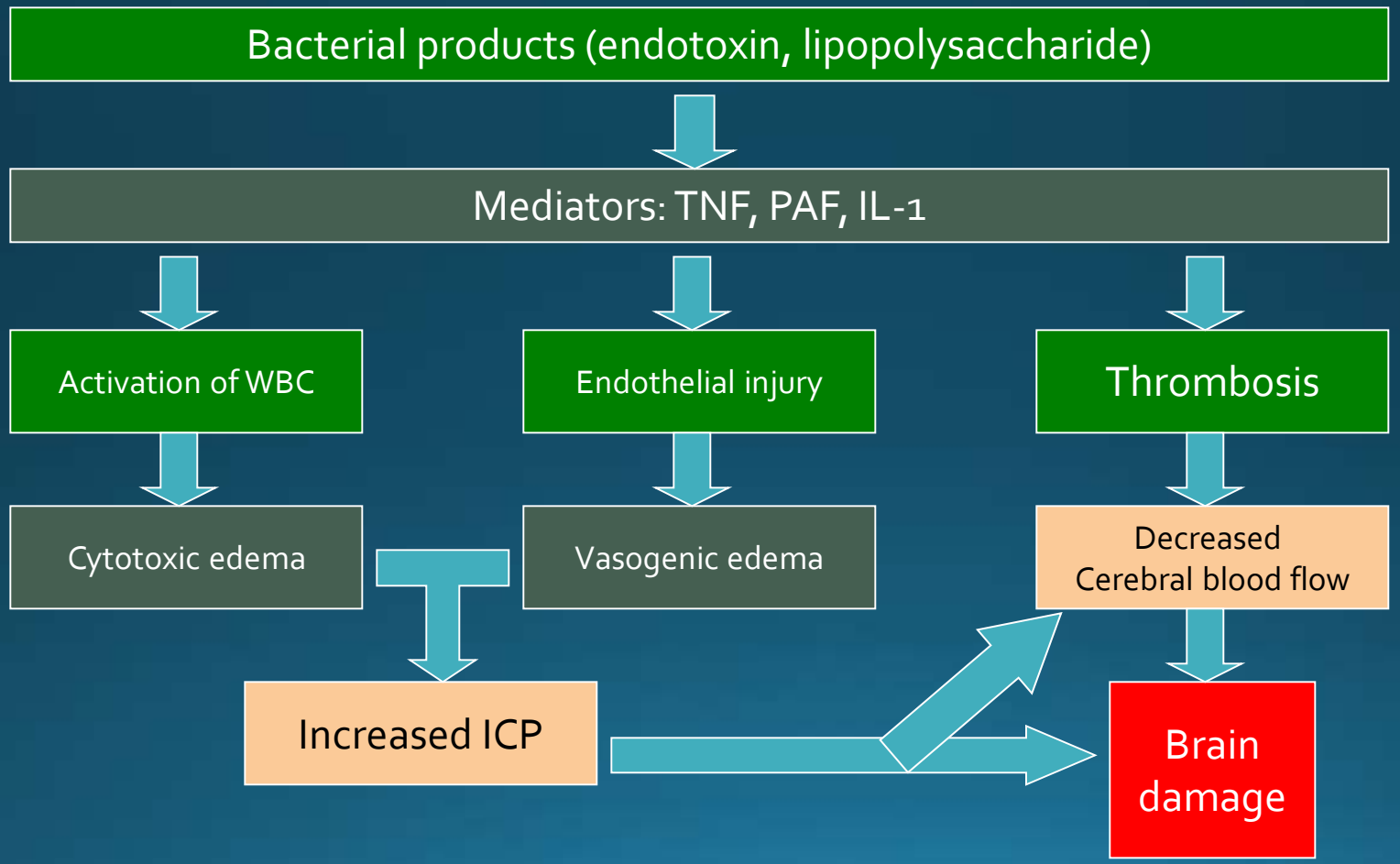
(Meningococcal Meningitis)

- *N. meningitidis*
- Gram-negative aerobic cocci, capsule
- 10% of people are healthy nasopharyngeal carriers
- Begins as throat infection, rash
- Serotype B is most common in the U.S.

Streptococcus pneumoniae Meningitis

- Gram-positive diplococci
- 70% of people are healthy nasopharyngeal carriers
- Most common in children (1 month to 4 years)
- Mortality: 30% in children, 80% in elderly
- Prevented by vaccination (Pneumococcal Conjugated Vaccine, PCV)

Pathogenesis



Meningitis

Learn the Symptoms – Meningitis can Kill in 24 Hours

INFANTS


Fever, possibly with cold hands & feet


Refusing feeds or vomiting


High pitched moaning cry or whimpering


Dislike of being handled or fretful


Neck retraction with arching of back


Blank & staring expression


Child is difficult to wake, lethargic


Pale, blotchy complexion

Floppy or stiff or jerking movements

CHILDREN/ADULTS


Stiff neck *


Headache


Fever


Vomiting


Light sensitivity*


Drowsiness or confusion


Joint pain


Fitting

Symptoms can appear in any order, & may not all be present.

*Young children with meningitis may not have a stiff neck *Young children with meningitis may not be light sensitive

Clinical Manifestations of Bacterial Meningitis

- Young infants
  - Proceeded by URTI
  - Irritability
  - Somnolence
  - Fever
  - bulging fontanelle and diastasis of sutures in the infant.

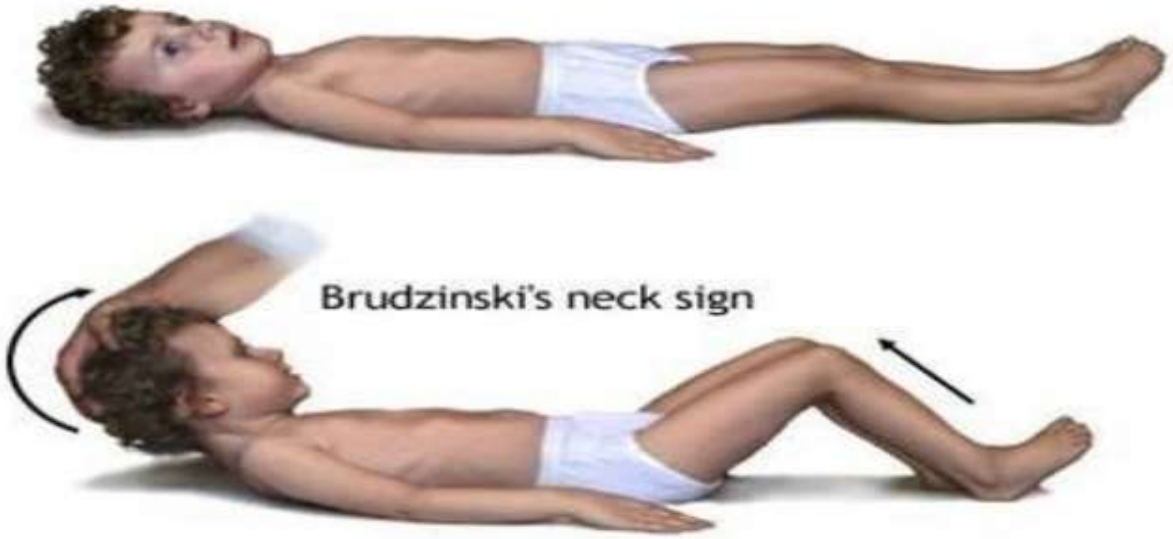
Clinical Manifestations of Bacterial Meningitis

- Older Children:
  - Increased intracranial pressure is the rule:
    - Vomiting, irritability, anorexia, headache, confusion, photophobia and nuchal rigidity
    - Nuchal rigidity, positive Kernig and Brudzinski signs

Physical Examination

Brudzinski`s Sign

- A Positive Brudzinski`s sign occurs when flexion of the Neck causes involuntary flexion of the Knee and Hip Joints.



Seizures in Bacterial Meningitis

- 20% of patients have seizures prior to admission
- 32% of patients have seizures prior to or during 1st 48 hours of hospitalization
- Early, generalized or multifocal seizures of short duration and minimal frequency are related to "toxic encephalopathy" associated with bacterial toxins, hypoperfusion and metabolic derangements; EEG usually not helpful. Usually controlled easily and have no prognostic implications

Seizures in Bacterial Meningitis

- Seizures which are difficult to control, which persist beyond the 3rd hospital day or which develop initially after the 3rd hospital day may be associated with permanent sequelae.

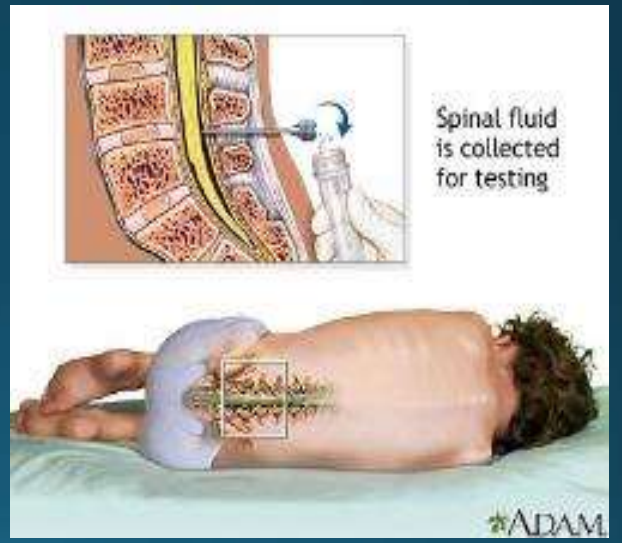
- Persistent focal seizures or recurrent seizures of varying focality imply:
  - venous or arterial thrombosis
  - infarction
  - subdural effusion.

Clinical Manifestations of Bacterial Meningitis

- Papilledema is an uncommon finding in acute meningitis.
- When papilledema is observed:
  - venous sinus occlusion
  - subdural empyema
  - brain abscess

EVALUATION

- Hx
- Physical examination
- Investigation
  - CBC , KEF , ELECTROLYTES
  - CRP , ESR
  - Blood Culture.
  - Lumber puncture and CSF analysis
  - Imaging study (brain CT)



Lumbar Puncture or Spinal Tap

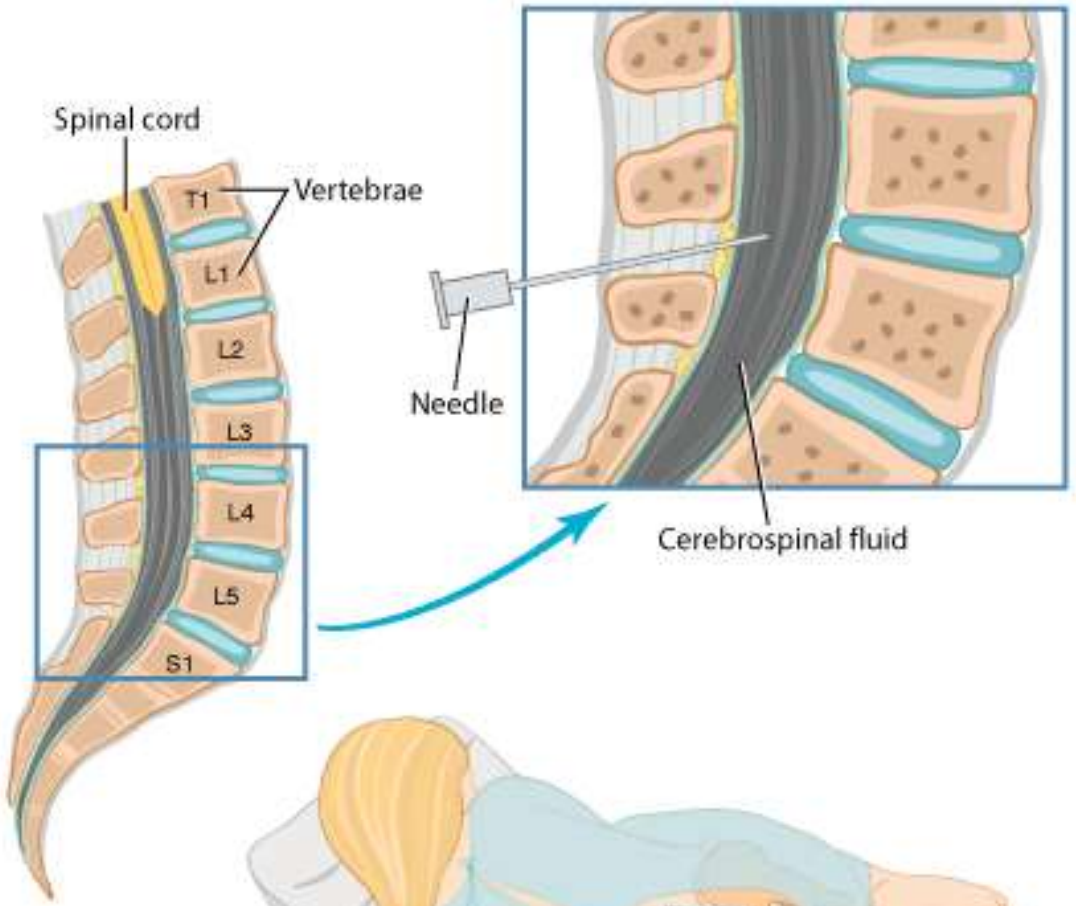
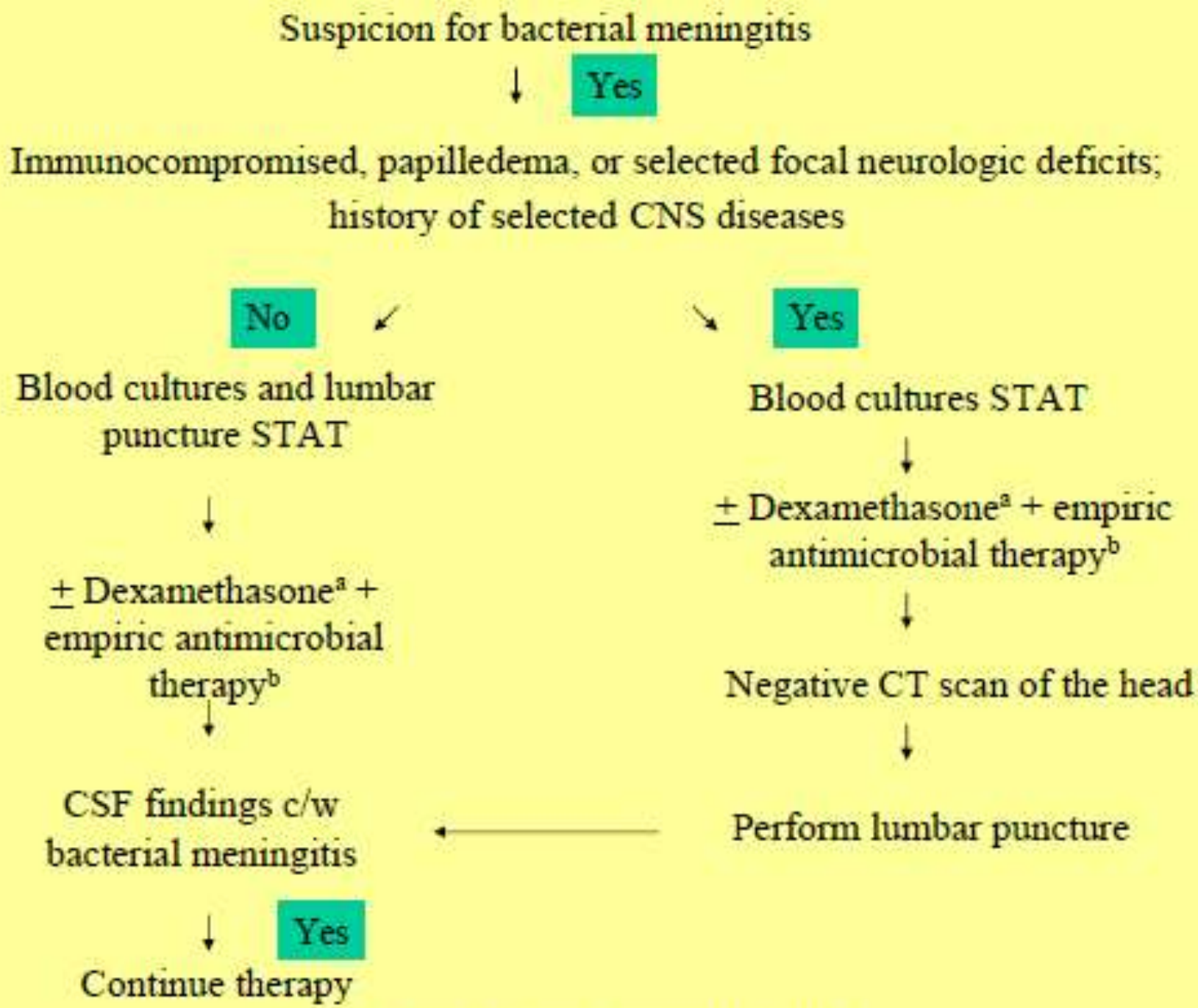


Figure 5. Spinal tap procedure.



IDSA Guidelines *Clin Infect Dis* 2004

Neuroimaging(CT brain)

- Indications for imaging before LP in children with suspected bacterial meningitis include
  - Coma
  - Papilledema
  - Focal neurologic deficit
  - The presence of a CSF shunt
  - History of hydrocephalus
  - Recent history of CNS trauma or neurosurgery

Contraindication for LP

- Suspected brain abscess or subdural empyema (20% herniation)
- Bleeding disorders
- Skin infection at site of LP
- Papilledema? (1-6% herniation after LP)

Cell count, differential and chemistry

	Normal newborn	Normal children	Bacterial meningitis	Viral meningitis	TB/fungal meningitis
WBC (mm^3)	0-30	0-6 in >3months 0-9 in 1-3 months	>1000	100-500	100-500
PMN (%)	**2-3**	**0**	>50*	<40	<50
Protein (mg/dl)	20-150	15-45	>100	50-100	100-1000
Glucose (mg/dl)	30-120	40-80	<30	normal	low-normal
CSF/blood glucose(%)	40-250	60-90	<50	normal	low-normal

*10% of bacterial meningitis presents with lymphocyte predominance.

Interpretation of CSF

- WBC:
  - WBC >6 cells is abnormal(>3 months)
  - WBC >9 cells is abnormal(1-3 months)
  - WBC > 30 cells is abnormal (birth-1 month)

Interpretation of CSF

- The presence of a single neutrophil in the CSF is considered abnormal (except in newborns)
- Glucose: <40 mg/dL or ratio of the CSF to blood glucose concentration is usually depressed (<0.5)
- Traumatic LP: should be treated presumptively for meningitis pending results of CSF culture.

Gram's stain

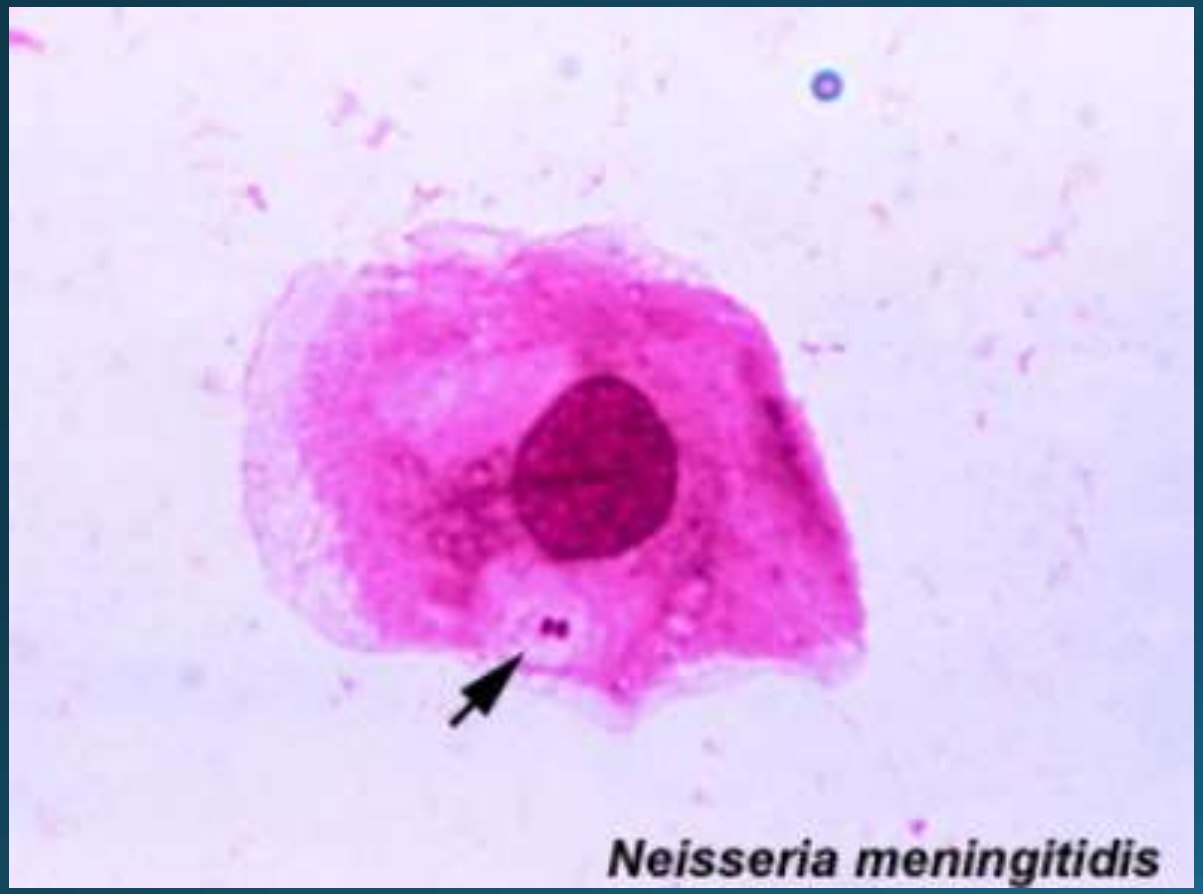
- Positive in 60-90% of untreated patients
- Positive in 97% of cases with organisms > 10^5 CFU/ml
- Positive in pneumococcus > H. influenzae > N. meningitidis >gram-neg bacilli > Listeria
- 90 % pneumococcal M , 80% meningococcal M , 50% G- bacillary M ,30% listeria M
- The yield is lower by 20% in those with prior antibiotic therapy.
- As sensitive as (or better than) antigen detection test.

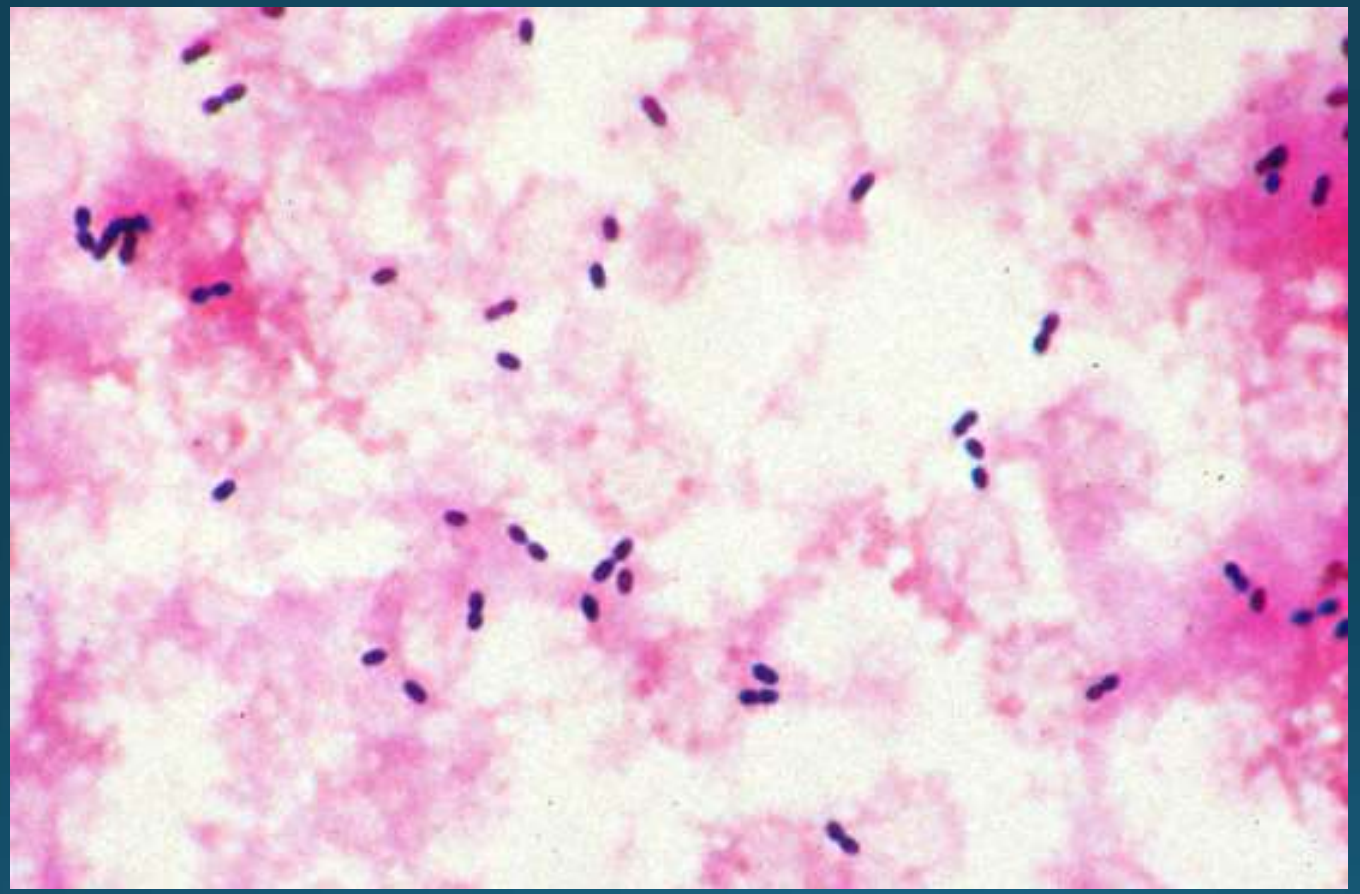
Bacterial culture

- Prompt culture to avoid loss of organisms such as *Neisseria meningitides*
- CSF cultures are positive in 85% of untreated patients

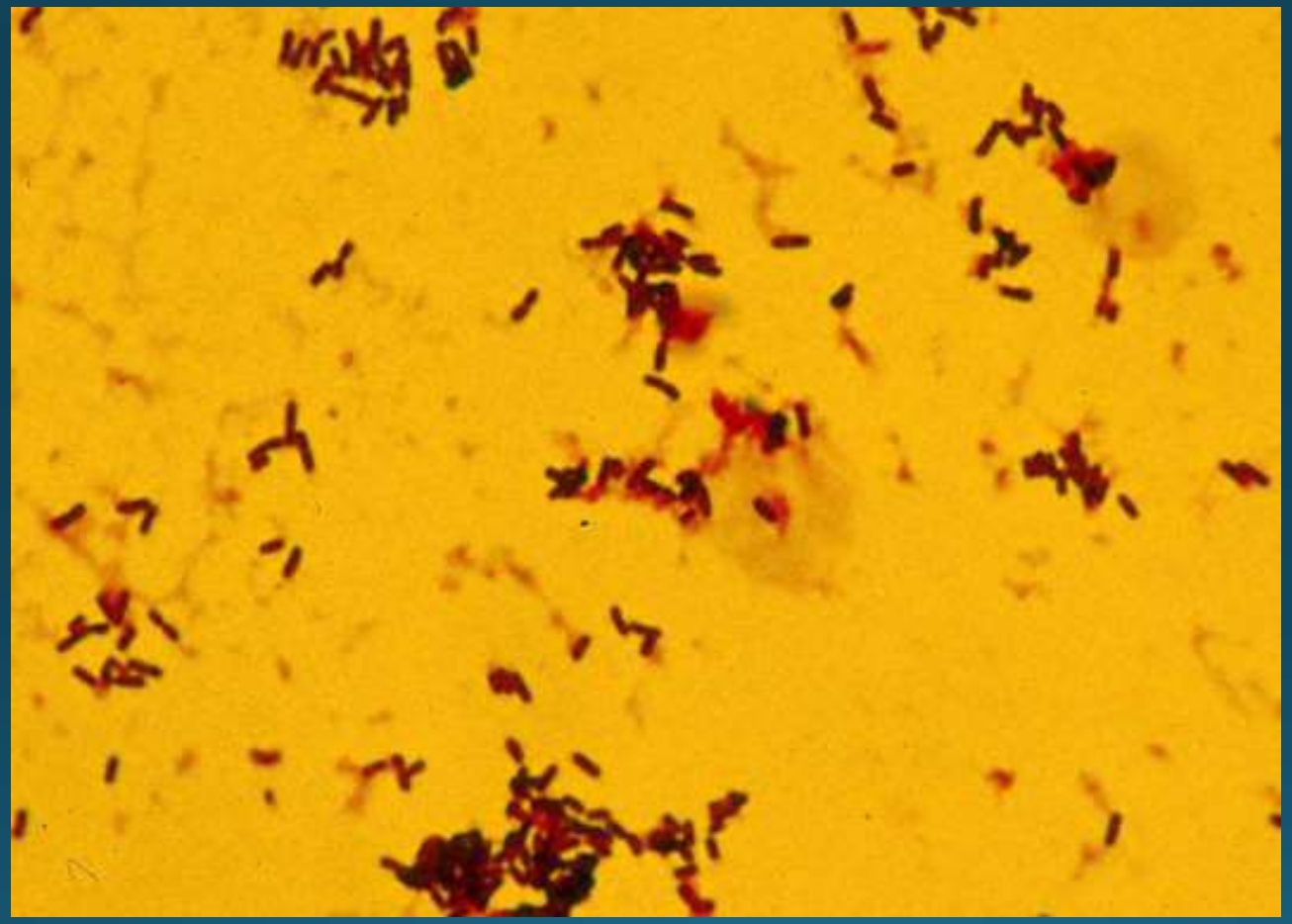
Latex agglutination

- Not better than gram's stain
- High false-positive.
- Maybe most useful in pretreated patients


Neisseria meningitidis



Streptococcus pneumoniae



Listeria monocytogenes

Bacterial Meningitis
Normal Child Greater than One Month Old

Expected Organisms:

Streptococcus pneumoniae
Neisseria meningitidis
Haemophilus influenzae type b

Empiric therapy*:

Ceftriaxone or Cefotaxime + Vancomycin
(Ampicillin + Gentamicin for newborns)

Management of Pneumococcal Meningitis

Repeat lumbar puncture

- No improvement after 36-48 h
- penicillin resistant strep pneumoniae meningitis PRSP
  - (Isolate with MIC > 2 to cefotaxime/ceftriaxone)

Follow-up for sequelae (25-30%)

- Hearing test
- Neurodevelopmental evaluation

Dexamethasone for Bacterial Meningitis

- Dexamethasone may be beneficial for treatment of infants and children :
  - with Hib meningitis:
  - to diminish the risk of neurologic sequelae including hearing loss
  - if given before or concurrently with the first dose of antimicrobial agent(s)
  - There probably is no benefit if dexamethasone is given more than 1 hour after antimicrobial agent(s).

- Red Book

Management of Pneumococcal Meningitis

- Initial regimen for children > 1 mo with possible bacterial meningitis regardless of pneumococcal vaccination:

Vancomycin 60 mg/kg/day

+

ceftriaxone 100 mg/kg/day

(or cefotaxime 300 mg/kg/day)

- Dexamethasone is controversial
- Treatment duration is 10-14 days

Duration of treatment Bacterial Meningitis

Depended on causative organism and the clinical course:

- S. pneumoniae: 10-14 days
- N. meningitidis: 5-7 days
- Hib: 7-10 days
- *L. monocytogenes* – 14 to 21 days
- *S. aureus* – at least 2 weeks
- Gram –ve: 3 weeks

Causes of Prolonged or Recurrent Fever in children with Bacterial Meningitis

- Inadequate Treatment
- Nosocomial Infection
- Phlebitis
- Immune mediated arthritis
- Drug Fever
- Unknown
- Suppurative complication: Pericarditis, Pneumonia, Pyogenic arthritis, Subdural empyema
- Discontinuation of Dexametahsone

Indications for Repeat Lumbar Puncture

- Patient not responding clinically after 48 h of appropriate therapy.
- Pneumococcal isolate resistant (MIC >2 µg/ml) to cefotaxime/ceftriaxone
- Neonate with Gram-negative meningitis

Indications for Neuroimaging of Head in Bacterial meningitis

- Persistent focal neurologic findings
- Persistently positive CSF cultures despite appropriate therapy
- Persistent elevation in CSF PMN % after >10 days of therapy
- Recurrent meningitis

Neuroimaging

- Cerebral edema
- Transient ventricular dilatation/hydrocephalus
- Ventriculitis
- Subdural effusion/empyema
- Cerebral infarct
- Brain abscess
- Venous sinus thrombosis
- Hemorrhagic stroke
- Spinal cord infarction

Poor prognostic factors:

- ≥2 days of symptoms before admission.
- Etiology: Bacterial, especialy pneumococcal.
- The number of organisms.
- CSF sugar < 20 mg / dl at admission.
- Delayed sterilization of CSF : > 24 hours
- Coma
- Seizure after 72 hrs of admission, prolonged, or difficult to control
- Malnutrition
- Focal neurologic deficits
- SIADH

Neurologic Sequelae of Bacterial Meningitis

- mental retardation
  - language delay
  - learning disorders
- behavior disorders
- delayed or abnormal motor development
- hemiparesis
- hearing handicap
- ataxia
- seizure disorder
- blindness
- hydrocephalus
- Hypothalamic dysfunction

Sensorineural Hearing Loss in Bacterial Meningitis

- Unilateral or bilateral loss
  - *S. pneumoniae* 30%
  - *H. influenzae* type b 6-15%
  - *N. meningitidis* 5-10%
- Ataxia commonly associated with deafness
- Hearing loss appears to occur early (present at or near admission)

PREVENTION

- **Vaccines** (primary prevention)**.**
- **Isolation :**
  - standard precautions + droplet precautions for 24 hours into treatment
- **Chemoprophylaxis:**
  - Rifampicin to contacts of patients with meningococcal and Hib
- **Patient Education.**

Prognosis

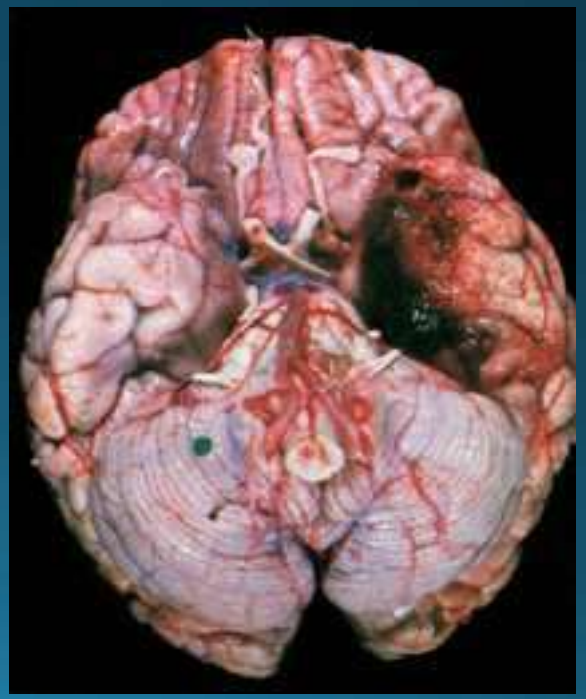
- Mortality: 5%in developed countries and 8 %in developing countries.
- Neurological sequele:15 % to 25 %
  - Deafness : 11 %
  - Mental retardation :4 %
  - Spasticity and/or paresis : 4 %
  - Seizures : 4%

Encephalitis in Children

Marwan Shalabi, MD

Definition of Encephalitis in Children

- Acute CNS dysfunction with radiographic or laboratory evidence of brain inflammation.
- CNS dysfunction:
  - Seizures
  - Focal neurologic findings
  - Alteration in mental status.



How do they get there?

- Arboviruses: bloodstream infection➔enter the CNS via endothelial cell infection
- HSV, rabies, and possibly poliovirus: retrograde transport in neurons.
- Amoeba *Naegleria fowleri*: through the olfactory mucosa.

Where do they stay there?

- HSV : temporal lobe (herpes could cause high RBC in CSF)
- Rabies : pons, medulla, cerebellum, and hippocampus
- Japanese encephalitis virus: brainstem and basal ganglia.

Acute Viral Encephalitis

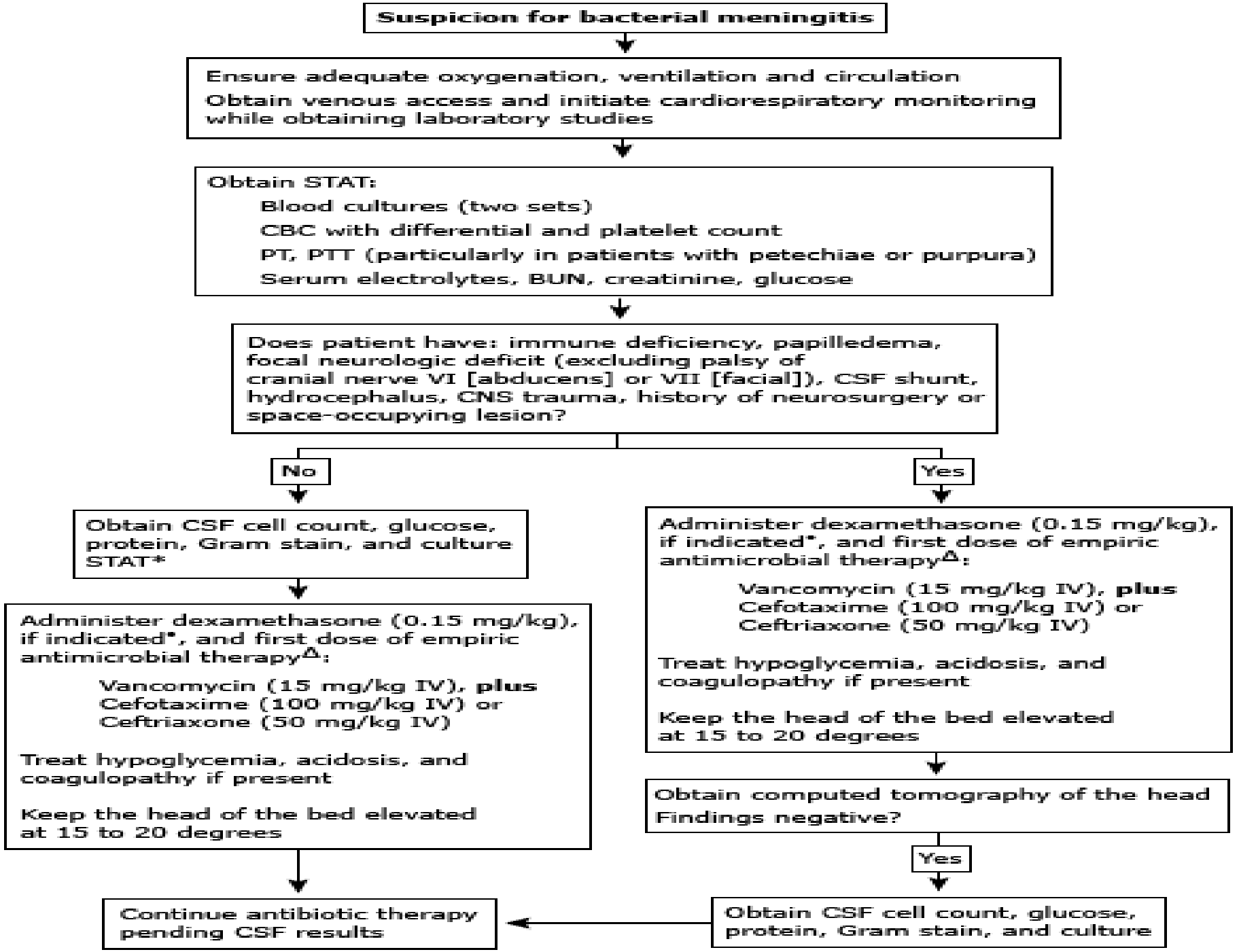
- Children, elderly & the immunocompromised most commonly affected
- More than 100 different viruses can cause encephalitis
- In the USA, the most frequently reported causes are:
  - Enteroviruses
  - HSV1 and HSV2
  - Arthropod-borne viruses (Arbo Viruses)
  - The majority of cases have an unknown cause.

Virus	Treatment
Herpes simplex viruses 1 and 2	Acyclovir 10 mg/kg dose IV every 8 hours × 14 to 21 days
	Higher doses for neonatal encephalitis (20 mg/kg dose IV every 8 hours for 21 days)
	Oral acyclovir, famciclovir, valacyclovir for meningitis associated with primary genital herpes simplex virus
Varicella-zoster virus	Acyclovir 20 mg/kg dose IV every 8 hours
	?Famciclovir, valacyclovir
Cytomegalovirus	Ganciclovir
	Foscarnet
Epstein-Barr virus	Acyclovir (limited effectiveness)
Enterovirus	Pleconaril (compassionate release only)
	IV immunoglobulin (for hypogammaglobulinemic patients and neonates with sepsis syndrome)
La Crosse virus	? Ribavirin
Measles virus	Ribavirin
West Nile virus	Under study: IV immunoglobulin with high titer to West Nile virus, interferon, antisense nucleotides

IV = intravenous.

Antiviral Agents for viral CNS Diseases

Thank you


Suspicion for bacterial meningitis
Ensure adequate oxygenation, ventilation and circulation
Obtain venous access and initiate cardiorespiratory monitoring while obtaining laboratory studies
Obtain STAT:
Blood cultures (two sets)
CBC with differential and platelet count
PT, PTT (particularly in patients with petechiae or purpura)
Serum electrolytes, BUN, creatinine, glucose
Does patient have: immune deficiency, papilledema, focal neurologic deficit (excluding palsy of cranial nerve VI [abducens] or VII [facial]), CSF shunt, hydrocephalus, CNS trauma, history of neurosurgery or space-occupying lesion?
No
Yes
Obtain CSF cell count, glucose, protein, Gram stain, and culture STAT*
Administer dexamethasone (0.15 mg/kg), if indicated*, and first dose of empiric antimicrobial therapy△:
Vancomycin (15 mg/kg IV), plus Cefotaxime (100 mg/kg IV) or Ceftriaxone (50 mg/kg IV)
Treat hypoglycemia, acidosis, and coagulopathy if present
Keep the head of the bed elevated at 15 to 20 degrees
Administer dexamethasone (0.15 mg/kg), if indicated*, and first dose of empiric antimicrobial therapy△:
Vancomycin (15 mg/kg IV), plus Cefotaxime (100 mg/kg IV) or Ceftriaxone (50 mg/kg IV)
Treat hypoglycemia, acidosis, and coagulopathy if present
Keep the head of the bed elevated at 15 to 20 degrees
Obtain computed tomography of the head
Findings negative?
Yes
Obtain CSF cell count, glucose, protein, Gram stain, and culture
Continue antibiotic therapy pending CSF results

Characteristic features of common causes of bacterial meningitis

Organism	Site of entry	Age range	Predisposing conditions
Neisseria meningitidis	Nasopharynx	All ages	Usually none, rarely complement deficiency
Streptococcus pneumoniae	Nasopharynx, direct extension across skull fracture, or from contiguous or distant foci of infection	All ages	All conditions that predispose to pneumococcal bacteremia, fracture of cribriform plate, cochlear implants, cerebrospinal fluid otorrhea from basilar skull fracture, defects of the ear ossicle (Mondini defect)
Listeria monocytogenes	Gastrointestinal tract, placenta	Older adults and neonates	Defects in cell-mediated immunity (eg, glucocorticoids, transplantation [especially renal transplantation]), pregnancy, liver disease, alcoholism, malignancy
Coagulase-negative staphylococci	Foreign body	All ages	Surgery and foreign body, especially ventricular drains
Staphylococcus aureus	Bacteremia, foreign body, skin	All ages	Endocarditis, surgery and foreign body, especially ventricular drains; cellulitis, decubitus ulcer
Gram-negative bacilli	Various	Older adults and neonates	Advanced medical illness, neurosurgery, ventricular drains, disseminated strongyloidiasis
Haemophilus influenzae	Nasopharynx, contiguous spread from local infection	Adults; infants and children if not vaccinated	Diminished humoral immunity

Major causes of aseptic meningitis in children

	Common	Uncommon	Rare
Infectious causes			
Viruses	Enteroviruses: Polioviruses Echoviruses Coxsackieviruses Numbered enteroviruses	Mumps HIV	Respiratory viruses: Adenovirus Influenza Parainfluenza
	Herpes simplex virus type 2*		Lymphocytic choriomeningitis virus
	Arboviruses: Eastern and Western equine encephalitis St. Louis encephalitis La Crosse (California) encephalitis West Nile		Measles Parvovirus B19 Rotavirus Herpes viruses: Herpes simplex virus type 1 Human herpes virus 6 Epstein-Barr virus Varicella zoster Cytomegalovirus Arboviruses: Powassan virus
Bacteria	*Borrelia burgdorferi* (Lyme disease)* Partially treated bacterial meningitis*	*Mycobacterium tuberculosis** Parameningeal infection (epidural, subdural abscess)*	*Bartonella* sp (cat scratch disease)* Syphilis* *Leptospira* sp* *Brucella** *Mycoplasma pneumoniae** *Rickettsia**
Fungi		*Cryptococcus** *Coccidioides** *Histoplasma** *Blastomyces**	*Candida* spp* *Aspergillus* spp* *Sporothrix schenckii**
Parasites			*Taenia solium* (cysticercosis)* *Trichinella spiralis** *Toxoplasma gondii**
Noninfectious causes			
Drugs	Ibuprofen Trimethoprim-sulfamethoxazole Other NSAIDS Pyridium (phenazopyridine) Anti-CD3 monoclonal antibody Azathioprine		
Malignancy	Lymphoma* Leukemia*		
Autoimmune	Sarcoid* Behcet's disease* Systemic lupus erythematosus*		
Other causes	Epidermoid cyst* Postvaccination Heavy metal poisoning* Intracranial hemorrhage*		

* Treatable cause.

Clinical clues to viral infections of the central nervous system in children

Etiology	Frequency of meningitis versus encephalitis*		Potential clinical clues
	Meningitis	Encephalitis	
Enteroviruses			
Coxsackie A and B viruses	Common	Rare	Herpangina, hand-foot-mouth disease, conjunctivitis, pharyngitis, pleurodynia, myopericarditis, rash
Echoviruses	Common	Rare	Rash
Polioviruses	Common	Rare	Flaccid paralysis
Arthropod-borne viruses (arboviruses)			
West Nile virus	Infrequent	Common	Rash; mosquito exposure
St. Louis encephalitis virus	Common	Common	Mosquito exposure
La Crosse (California) encephalitis virus	Common	Common	Mosquito exposure
Eastern equine encephalitis virus	Rare	Common	Mosquito exposure
Western equine encephalitis virus	Common	Common	Mosquito exposure
Powassan virus	Uncommon	Common	Tick exposure
Herpesviruses			
Herpes simplex type 1	Rare	Common	Oral lesions
Herpes simplex type 2	Common	Rare	Genital lesions, sacral radiculopathy (urinary retention, constipation, paresthesia, weakness)
Cytomegalovirus	Infrequent	Common	Immunocompromised host
Varicella zoster virus	Common	Infrequent	Vesicular rash; shingles
Epstein-Barr virus	Infrequent	Common	
Other viruses			
Human immunodeficiency virus	Common	Common	Intravenous drug use, risky sexual behavior
Rabies virus	Rare	Common	Animal exposure; prodrome of nonspecific symptoms (fever, headache, malaise, myalgia, cough, sore throat, nausea, vomiting)
Lymphocytic choriomeningitis virus	Common	Infrequent	Rodent pets or contact with rodent droppings or urine
Influenza virus	Rare	Common	Classic influenza symptoms: fever, cough, vomiting, headache, diarrhea
Mumps virus	Common	Infrequent	Painful parotitis; occurs in unvaccinated or incompletely vaccinated individuals
Measles virus	Common	Rare	Conjunctivitis, coryza, cough; occurs in unvaccinated or incompletely vaccinated individuals

* The terms common, infrequent, and rare refer to the propensity of a viral CNS infection to result in either

Table 603-1 Cerebrospinal Fluid Findings in Central Nervous System Disorders

CONDITION	PRESSURE (mm H_2O)	LEUKOCYTES (mm^3)	PROTEIN (mg/dL)	GLUCOSE (mg/dL)	COMMENTS
Normal	50-80	<5, ≥75% Lymphocytes	20-45	>50 (or 75% serum glucose)	
COMMON FORMS OF MENINGITIS					
Acute bacterial meningitis	Usually elevated (100-300)	100-10,000 or more; usually 300-2,000; PMNs predominate	Usually 100-500	Decreased, usually <40 (or <50% serum glucose)	Organisms usually seen on Gram stain and recovered by culture
Partially treated bacterial meningitis	Normal or elevated	5-10,000; PMNs usual but mononuclear cells may predominate if pretreated for extended period of time	Usually 100-500	Normal or decreased	Organisms may be seen on Gram stain Pretreatment may render CSF sterile. Antigen may be detected by agglutination test
Viral meningitis or meningoencephalitis	Normal or slightly elevated (80-150)	Rarely >1,000 cells. Eastern equine encephalitis and lymphocytic choriomeningitis may have cell counts of several thousand. PMNs early but mononuclear cells predominate through	Usually 50-200	Generally normal; may be decreased to <40 in some viral diseases, particularly mumps (15-20% of cases)	HSV encephalitis is suggested by focal seizures or by focal findings on CT or MRI scans or EEG. Enteroviruses and HSV infrequently recovered from CSF. HSV and enteroviruses may be

UNCOMMON FORMS OF MENINGITIS					
Tuberculous meningitis	Usually elevated	10-500; PMNs early, but lymphocytes predominate through most of the course	100-3,000; may be higher in presence of block	<50 in most cases; decreases with time if treatment is not provided	Acid-fast organisms almost never seen on smear. Organisms may be recovered in culture of large volumes of CSF. *Mycobacterium tuberculosis* may be detected by PCR of CSF
Fungal meningitis	Usually elevated	5-500; PMNs early but mononuclear cells predominate through most of the course. Cryptococcal meningitis may have no cellular inflammatory response	25-500	<50; decreases with time if treatment is not provided	Budding yeast may be seen. Organisms may be recovered in culture. Cryptococcal antigen (CSF and serum) may be positive in cryptococcal infection
Syphilis (acute) and leptospirosis	Usually elevated	50-500; lymphocytes predominate	50-200	Usually normal	Positive CSF serology. Spirochetes not demonstrable by usual techniques of smear or culture; dark-field examination may be positive
Amebic (*Naegleria*) meningoencephalitis	Elevated	1,000-10,000 or more; PMNs predominate	50-500	Normal or slightly decreased	Mobile amebas may be seen by hanging-drop examination of CSF at room temperature

CSF
Bact

CSF Penetration by Vancomycin in Children Receiving Dexamethasone-Bacterial Meningitis

	CSF Concentration	Serum Concentration	CSF/Serum
Vancomycin	n =9	n=10	
Level-mean ± SD	3.3 ± 1.1*	17.5 ± 6.7	.21 ± .06
Range	(2-5.9)	(7.1 - 30.7)	(.14 - .26)

*ug/ml

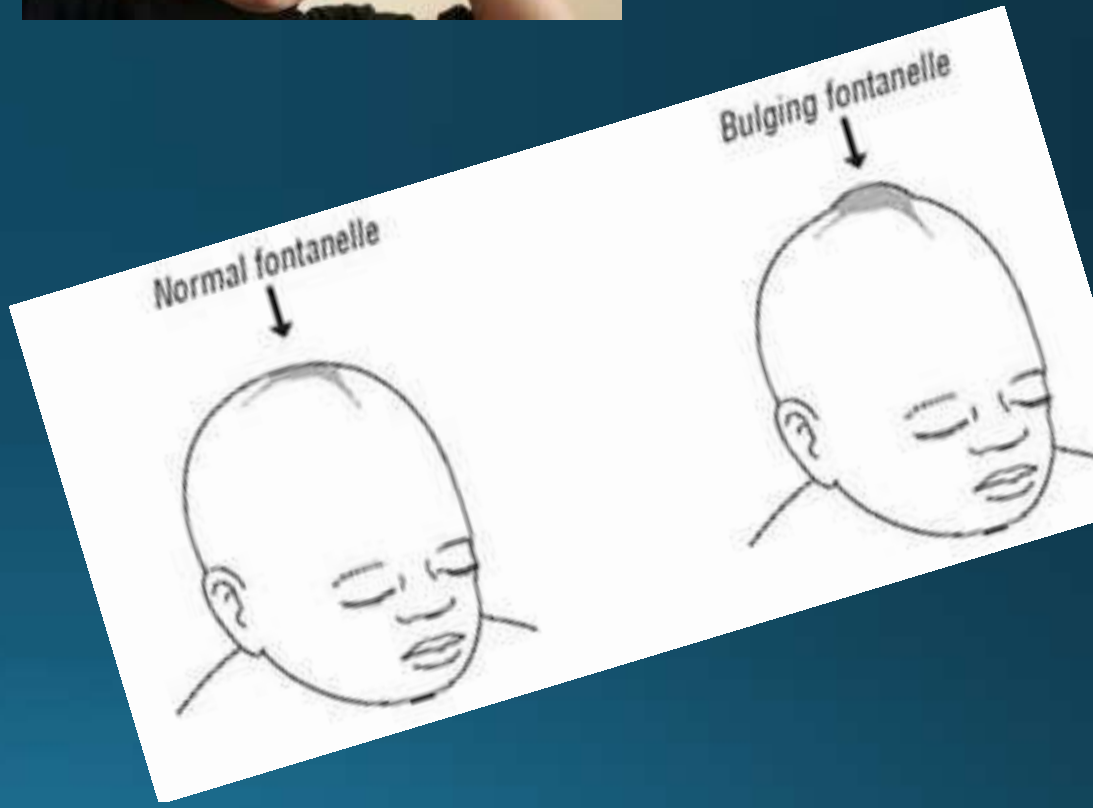
Vancomycin Dose: 60 mg/kg/day + 4 doses dexamethasone dose: 0.6 mg/kg/day

Klugman et al AAC 1995

Increased ICP

S&S of high ICP:

- headache, emesis,
- bulging fontanel or diastasis (widening) of the sutures,
- oculomotor (anisocoria, ptosis) or abducens nerve paralysis,
- hypertension with bradycardia,
- apnea or hyperventilation,
- decorticate or decerebrate posturing, stupor, coma, or signs of
- herniation.



Causes Encephalitis in Children: Viruses

- Adenovirus
- Arboviruses
- Enteroviruses
- Hepatitis A, B
- Herpesvirus group
- —HSV 1 and 2
- —Varicella-zoster virus
- —Epstein-Barr virus
- —Cytomegalovirus
- —Human herpesvirus 6
- —Herpesvirus B
- Influenza
- Lymphocytic choriomeningitis virus
- Measles
- Mumps
- Parainfluenza
- Parvovirus
- Rabies
- Rotavirus
- Respiratory syncytial virus
- Rubella
- Smallpox
- Vesicular stomatitis virus

Causes: Bacteria

- *Actinomyces* sp
- *Bartonella henselae*
- *Brucella* sp
- *Chlamydia* sp
- Ehrlichia (aka *Anaplasma*) sp
- *Listeria monocytogenes*
- Mycoplasma pneumoniae
- *Norcardia* sp
- Q fever
- *Rickettsia* sp
- Spirochetes
- —*Treponema pallidum*
- —*Leptospiria* sp
- —*Borrelia* sp
- Whipples bacillus

Causes: Fungi

- *Coccidiodes immitis*
- *Cryptococcus neoformans*
- *Histoplasma capsulatum*

Causes: Protozoa

- *Acanthamoeba* sp
- *Balamuthai mandrillaris*
- *Malaria* sp
- *Naegleria fowleri*
- *Toxoplasma gondii*
- *Trypanosoma* sp

- Parasites
—*Baylisascaris procyonis*
—*Cysticercosis*
—*Schistosoma* sp
—*Strongyloides stercoralis*
—*Trichinella spiralis*