

**The key points!**

- Understand pediatric differences - **Assessment**
- Nursing care with ALOC – **Overarching themes**
  - Increased ICP
  - Seizures
  - DI/SIADH
- Structural abnormalities
  - Hydrocephalus
  - Spina Bifida
- Infections of the Neurological system
- Cerebral Palsy

**Pediatric Differences: Neonatal**

- Dr. Tobar says to keep in mind that the brain and spinal cord are formed very early in embryonic development. Any insult early in gestation is likely to cause congenital malformations.
- 1/3 of congenital malformation in live births = CNS malformations
- 90% are neural tube defects...MOST COMMON!
- Account for 40% deaths in first year of life

**Pediatric Differences: Structure**

- Head proportionately large/ thin bones/ unfused sutures/ fontanel. The head is also heavier in relation to the child's body than in an adults...so if there's a car accident or a fall the head is what makes impact first. Unfused sutures allow for some expansion, meaning there is a little bit of wiggle room.
- Immature muscles/ligaments: The neck is pretty weak and the muscles aren't well developed...combine that with this huge heavy head and you have a high high risk for spinal cord injury in traumas, even if there is no breakage of bone...the neck can still get injured to the point of causing a spinal cord injury.
- Incomplete ossification of vertebral bodies
  - Wedge shaped
  - C1-C2 more lax movement (until age 8 y/o)

**Pediatric Differences: Brain**

- Brain
  - Smaller volume CSF than adults. This means they have less ability to shunt out CSF as a way to keep ICP in balance.
  - Brain growth continues until 12-15 y/o (brain needs fuel!)
  - High metabolic (oxygen/glucose) needs. Children's brains are more sensitive to oxygen deprivation.
- Born with all nerve cells but mature after birth
  - Glial cells and dendrites (receipt of nerve impulses) increase until 4 y/o. The lack of maturity of these nerves is what makes children unable to localize pain.
- Myelination incomplete at birth
  - Presence of primitive reflexes (know when these are supposed to be gone...if they are present or reappear after this time, this is a bad sign for your pt.)

**Cerebral Proportions**

- Infant head = 1/4 total body height, 12% wt
- Adult head = 1/8 total body height, 2% wt

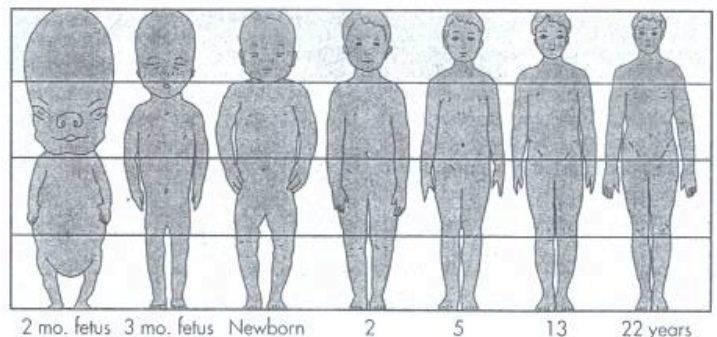


FIG. 5-3 ■ Changes in body proportions from before birth to adulthood. (From Crouch JE, McClintic JR: *Human anatomy and physiology*, ed 2, New York, 1976, John Wiley & Sons.)

**Pediatric Neuro Assessment**

- **Know NORMAL:** Know when a child is expected to reach a milestone, and when a reflex is supposed to be lost. Know what a normal neuro result is for all parts of the assessment.
- **Know Expected:** Know what is expected for that particular child and for that particular situation.
- **Compare to baseline:** Compare to baseline and talk to the parents! Look through the charting and get info from report r/t how that child has been doing throughout this hospitalization.
- LOC, pupils: If child won't let you shine light in their eyes, or you have to engage in a lot of play with them, then they are probably fine in the pupil department.
- VS: Know the ranges and when to be worried.
- Cranial nerves
- Fontanel/sutures: separating sutures is abnormal; a bulging fontanel is abnormal unless child is crying...otherwise it is a sign of increased ICP.
- Cognitive function
- Posture and movement
- Neck stiffness
- Pain

**Assessment: LOC**

- Dr. Tobar says this is kind of hard to do b/c it is very much attached to what is normal for that particular child. Also, the best way to get the info is to observe the child and get as much data as you can before you approach.

One way to assess LOC	Infant LOC	Pediatric Glasgow
Alert: responsive to parent; coos/babbles/smiles	Quality of cry	Best eye opening: Spont = 4 To speech = 3 To pain = 2 None = 1
Verbal: response to verbal stimulation	Strong suck with feeding	Best verbal: Coos, Babbles = 5 Irritable = 4 Cries to Pain = 3 Moans to Pain = 2 None = 1
Pain: responsive to pain only	Coordinated suck/swallow	Best motor: Normal spont movements = 6 Withdraw to touch = 5 Withdraw to pain = 4 Abnormal flexion = 3 Abnormal extension = 2 None = 1
Unresponsive to pain	Presence of appropriate reflexes	

**Vital Signs**

- VS changes w/ ICP (should make sure these aren't due to another cause such as crying or pain)
  - Increased systolic B/P
  - Widened pulse pressure
  - Bradycardia
- Airway assessment
  - Check for gag/cough reflex
  - Respiratory pattern and rate

Nerve	Name of Cranial Nerve	How to Test
I	Olfactory (smell)	Infant: not tested Child: familiar odor (such as orange)
II	Optic (visual acuity)	Infant: child should blink when you shine a bright light, also will have dorsal head flexion Child: eye chart as appropriate for age
III, IV, VI	Oculomotor Trochlear Abducens	Infant: see if they will focus and follow a light Child: move object through 6 cardinal pts (play!) All: check for eyelid droop and PERL
V	Trigeminal	Infant: check for root/suck reflex Child: observe chewing; touch face with cotton ball
VII	Facial	Look for facial symmetry
VIII	Acoustic	Infant: response to loud noise Child: whisper a word, have them repeat it
IX, X	Glossopharyngeal Vagus	Infant: coordinated swallow Child: gag reflex
XI	Spinal accessory	Infant: not tested Child: shrug shoulders, turn head against resistance
XII	Hypoglossal	Infant: suck/swallow are coordinated Child: stick out tongue, speech

**Neuro Assessment, cont**

- Cognitive Exam:
  - Behavior
  - Facial expressions
  - Gestures
  - Communications
  - Activity
  - LOC
- Cerebellar Exam:
  - Balance
  - Coordination
  - Gait
  - Should not have a hand preference before age 2.
- Primitive Reflexes to know!
  - Palmar grasp is gone at 3 months
  - Startle is gone at 6 months
  - Plantar grasp is gone at 8 months
  - Babinski is gone between 12-16 months

**Assessment in summary**  
 KNOW NORMAL FOR CHILD  
 KNOW BASELINE  
 Identify changes  
 Irritability – lethargy  
 Coordination of suck/swallow  
 Response to stimuli  
 Engagement in play

**Question: What test might you anticipate in infant presenting with ALOC?**  
 CBC to check electrolytes, oxygen saturation levels...

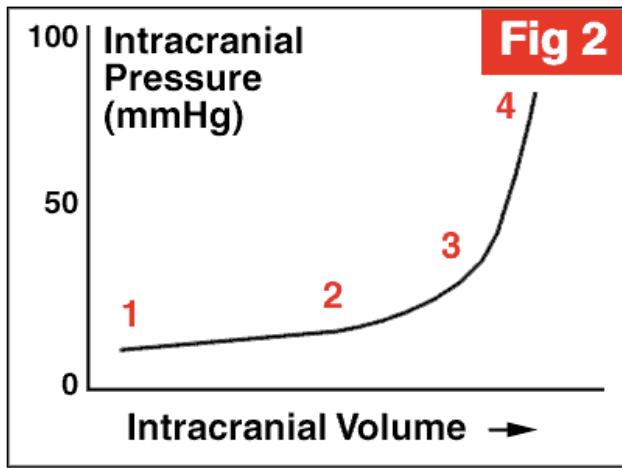
**Overarching Themes**

- Need to know the signs and what to do in these cases:
  - Increased ICP
  - Seizures
  - Metabolic disorders

**Intracranial Pressure**

- Definition = ICP is the pressure within the intracranial space
- Normal = 3 – 15 mm Hg (adults), 0 – 10 mm Hg (babies)
- Accept values < 20 mm Hg
- Cerebral Perfusion Pressure is the blood pressure gradient across the brain
  - $CPP = MAP - ICP$ . When MAP goes up, the CPP goes down and you don't get as much perfusion to the brain.
  - CPP should be between 50 to 70-ish
- The Monro - Kellie Hypothesis
  - Once sutures have fused, the skull is a rigid compartment filled to capacity with essentially non-compressible contents:
    - brain 80%
    - blood 10% (we don't want the blood to leave the skull...that would be bad)
    - CSF 10% (not much wiggle room here if CSF is the only thing that should fluctuate)
- If one component increases in volume, another component must decrease or ICP will rise.

**Volume Pressure Relationship**



Just small changes in volume cause dramatic increases in pressure!

1 and 2 are the compensation phase  
3 and 4 are the decompensation phase

**S/S of Increased ICP**

Timing of Indicator	Sign
Early	HA, visual disturbance, N/V, dizzy, slight pupil and VS changes, slight changes LOC - irritable to inconsolable
Signs specific to infants	Tense and bulging fontanel, wide sutures, increased OFC, high pitched cry
Late signs	LOC to lethargy to non responsiveness Seizures Cushing's Triad Fixed, dilated pupils

### Nursing Care of child with Increased Intracranial Pressure

- Support of ABC
  - Maintain airway, CO2 low/normal
  - Maintain CO
- Maintenance of CPP
  - Actions to maintain low ICP (don't want to do too much at one time, but also want to provide periods of rest)
  - Sedation/seizure control
  - CSF drainage via drains and proper alignment
  - Environmental control
    - Keep the room dim and quiet, parents talking gently and pleasantly at bedside
- Balance supply/demand for glucose and oxygen (not sure how you do that?)

### Seizures

Caused by malfunctions of brain's electrical system

Determined by site of origin

Most common neurologic dysfunction

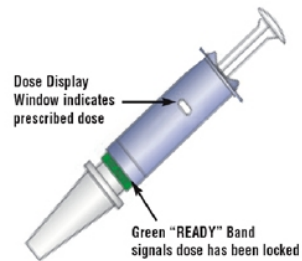
Occur with wide variety of CNS conditions

Major Causes of Seizures

Birth injuries [anoxia] or congenital defects of CNS

Acute infections in late infancy and early childhood

Usually idiopathic in children >3 yrs



in kids

in Children

### Seizures etiology

- Infantile Spasms
  - 4-8mo – 2 y/o (but can continue to cause developmental delay)
  - Genetic, Inborn Error Metabolism, hypoxia
  - Clusters of 5-150/day
  - Increase in intensity over time
  - High risk DD, intractable seizures
  - The child will have acute flexion where they arch back (almost doubled over backwards). Can last 30 seconds to 2 mins...they can cluster and have from 5 - 150 in any given day.
  - More common in males than females
- Lennox-Gastaut Syndrome
  - More likely in males
  - 1-5 years of age
  - Atonic/Akinetic (child just “goes down”)
  - Idiopathic often but may be r/t gray matter degenerative diseases
  - Associated with developmental delays
  - No good treatment for this.

### Seizure Types

- Lots of different types...so ask parents what their child's seizure looks like, what happens before, what happens after, how long do they last, and does he ever stop breathing?
- Partial seizures are a result of a focal abnormality of the brain. Can be d/t an abscess, vascular problem, trauma...
  - Simple: usually don't have loss of consciousness, no aura, no post-ictal, one part of their body doesn't work right...may be lip-smacking, eye-blinking, their hand...can be anywhere! Can progress into whole body seizure (but not super common in kids)
  - Complex: do tend to have aura, do have post-ictal period, some impairment of consciousness
- Generalized
  - Tonic-Clonic: usually has abrupt onset, may or may not have aura, does have a post-ictal period.
  - Absence: 3-12 years of age, more often female, they do have an alteration in LOC, do not always fall down, tends to be a much more subtle form of motor response like staring or eye blinking. This can become an issue with kids is that this can happen multiple times a day, end up missing out on class and can have learning disabilities.

- Akinetic: maintain muscle tone, but freeze for a period of time
- Atonic: drop seizures...lose muscle tone and just drop to the floor. Can be misdiagnosed as a cardiac problem.

### **Pediatric Diagnosis of Seizure Disorders**

- Ascertain type of seizure
  - History, observation. Take a log of the seizures at the bedside (what time does it start, where does it start, what does it look like, does it change or progress, how long does it last, etc...)
- Determine the cause of the event
  - Diagnostics
    - EEG: often done over 24 hour period, b/c different seizures come on at different times. You are trying to catch the seizure on the EEG...so you try to bring on a seizure.
    - MRI
    - Labs: glucose, lytes, BUN, Ca<sup>++</sup>
    - LP (lumbar punctures)

### **Epilepsy**

- Definition:  $\geq 2$  "unprovoked" seizures
- Idiopathic epilepsy: cause unknown... "it just happens."
- Seizures are indispensable characteristic of epilepsy

### **Nursing Management of Epilepsy**

- Sz precautions
  - padded side rails, oxygen at bedside, bed low
- Medications: If pt gets up to 3 meds and still has seizures, then may try a ketogenic diet.
- Ketogenic diet: High fat, low carb. This can be a problem b/c most pediatric meds are mixed with sugar...so need to get the syrup-free versions. This causes a state of ketosis...the ketones act on the brain as an anti-seizure tx. You don't stop meds when you go on this diet, you do the diet in addition to meds.
- Education for the family

### **Nursing Interventions**

- Observe and document episode
  - Protect from injury
  - Stay calm
  - Remain with child
  - Privacy if possible

### **Pharmacologic Management**

- Goal is to have child just on ONE drug...they have a lot of side effects!
- Monitor therapeutic levels
- Increase dosage as child grows
- Monitor for known side effects
- Avoid abrupt discontinuation—gradual dose reduction
- Only going up to 3 drugs..then it's time for the ketogenic diet.
- Kids will have to be on multivitamins and Ca replacement...a SE of the drugs is that they leach calcium and kids get osteoporosis.



- Monotherapy is treatment of choice for pediatric patients
- Gradual increase of dose until seizure control or signs of toxicity
- Polypharmacy if uncontrolled with one drug

### **When to Discontinue Pharmacologic Management**

- When seizure free for 2 years
- Child will be hospitalized during this period

- Normal EEG
- Avoid during puberty (stress) or when subject to frequent infections
- Recurrence possible within first year

**Home Management of Seizures**

- CPR training for family members
- Rectal diazepam available for intractable seizures (see pictures). Has a dial where you dial in the dose...the green window tells you it's ready. This is a med they get when they seize more 5 minutes. Teach them to watch child's breathing. They need to also call 911!
- Activity restriction on individual basis and what type of seizures they have. If child has aura and can sit himself down...they won't have restrictions necessarily.
- Safety devices—helmets, no swimming alone, awareness of school, other caregivers, no baths alone (take showers!)

**Common Pediatric Seizure Triggers**

- Changes in dark-light patterns (camera flashes, headlights, rotating fan blades, reflections off snow or water)
- Sudden loud noises
- Extreme temperature changes
- Dehydration
- Fatigue

**Status Epilepticus**

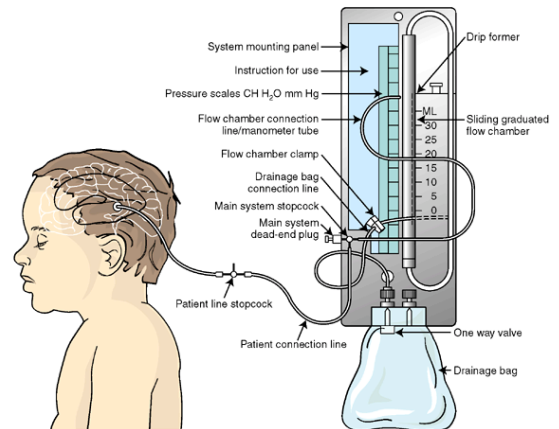
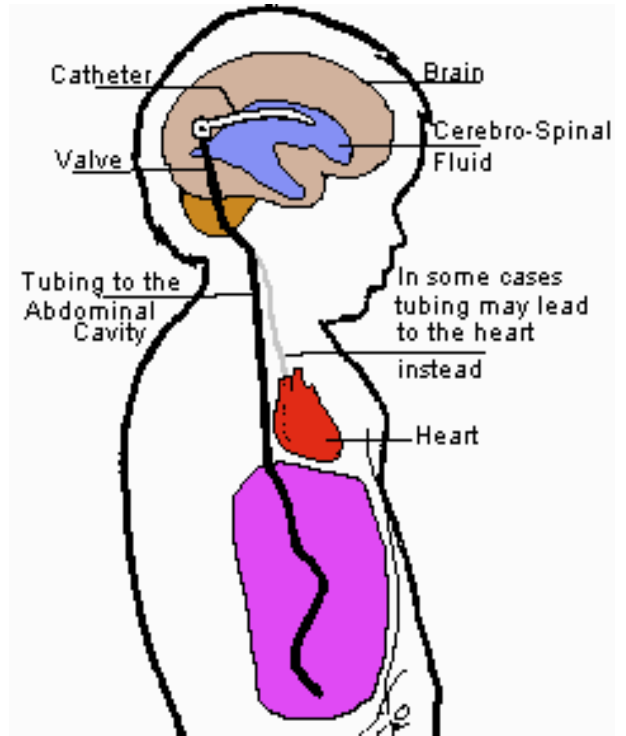
- Definition: seizure lasting >30 minutes or series of seizures without regaining premorbid level of consciousness
- Safety = ABCs!
  - A = airway: position, secretions
  - B = breathing: oxygen, RR
  - C = circulation: IV, POC glucose
  - D = disability: stop the seizure via meds...watch breathing!!!

**Febrile Seizures**

- Connection with fever w/o intracranial infection
- 6mo-3y/o; familial tendency; 30-40% repeat
- Don't usually treat with anti-seizure meds b/c the meds are so risky.
- Kids tend to outgrow this
- Generally treat by treating the fever early and aggressively

**Syndrome of Inappropriate ADH Secretion**

- Action of antidiuretic hormone...too much ADH! It is secreted from the pituitary.
  - Increased H<sub>2</sub>O reabsorption in renal tubules
- SIADH
  - Decreased serum osmolality (<275)
  - Decreased serum Na (<110mEq/L)
  - Increased urine osmolality (>1200)
  - Increases cerebral edema
- Specific gravity (Urine > 1.030)...urine is very concentrated.
- Irritability, anorexia, nausea, cramps, lethargy, stupor, convulsions



### SIADH Monitoring & Tx

- Restrict fluids (75% - 50% maintenance)
- Hypertonic saline. Look for the fluid shift after you give this!
- Monitor electrolytes q 6 hours during acute periods.
- Accurate I/O
- Urine specific gravity
- Daily Wt
- Neuro checks
- Sz precautions

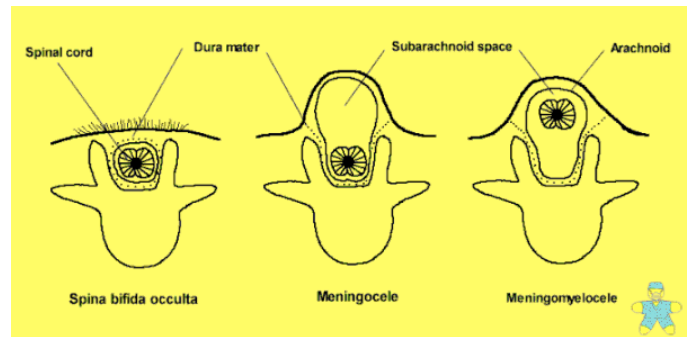


### Diabetes Insipidus

- Insufficient ADH
  - Central (neurogenic)
  - Nephrogenic
- Uncontrolled diuresis
- Decreased urine osmolality & specific gravity (urine is basically just water)
- Increased serum osmolality & Na
- Insatiable thirst
- Dehydration

### Question

Your patient with DI wants to drink continuously. Do you limit intake? DO NOT LIMIT INTAKE!



### DI Monitoring & Tx

- Fluid replacement
- Strict I/O
- Daily weights
- Urine specific gravity
- Urine & serum osmolality
- Monitor electrolytes
- **Desmopressin** (DDAVP)...replaces ADH (aka Vasopressin). This doesn't work if the problem is nephrogenic (the kidneys not responding to ADH).

### Structural Disorders

- Hydrocephalus: ventricles filling up with fluid, ICP goes up, CPP goes down, cells don't get oxygen and glucose, you get brain damage..
- Neural tube defects

### Types of Hydrocephalus

- Obstructive/Noncommunicating
  - Blockage of CSF pathways through the ventricular system
    - Blocked aqueduct of Sylvius/foramen of Monro
    - Arnold-Chiari malformation
    - Ventricular occlusion (blood, infection, tumors, granulomas)
- Communicating
  - Impaired absorption of CSF within the subarachnoid space
  - Infection or inflammation (membrane/meninges)

### Hydrocephalus: S & S

- Increased head circumference, bulging fontanel, separated sutures if a slow process
- S/S increased ICP
- Enlarged ventricles on CT & MRI



### **Hydrocephalus: Monitoring**

- H.C. (F.O.C.)
- Fontanel tension
- Serial ultrasounds—ventricle size
- CT scan – ventricle size, midline shift (have to get CT with older kids)

### **Hydrocephalus: Initial Management**

- Treatment of excessive CSF (shunt)
  - Ventriculoperitoneal (VP) ... most common
  - Ventriculoatrial (VA) ... pretty uncommon
  - Typically these are set for a certain pressure...newer ones can be set with a magnet. Anything that increases abdominal pressure is going to decrease pressure (such as heavy-duty constipation). Also worry about infection...especially abdominal. Other big issue is drainage...we want the shunt to last as long as possible...the drain coils around when child is small and the drain is supposed to uncoil as child grows. This doesn't always work.
- Externalized ventricular drain (EVD is temporary)
  - Treatment of complications d/t surgery and shunt (do this for a child with a shunt infection...clear the infection while on the EVD, then child goes back to the shunt).
  - Potential issues: teach parents not to move bed, infection, clogs or kinks in tubing
  - Manage problems related to psychomotor development

### **VP Shunt**

- Shunt Malfunction
  - This is an emergency!!!
  - Increased ICP
  - Worsening neurologic status/altered LOC
- Infection
  - Shunt malfunction
  - Fever and inflammation of tract
  - Abdominal pain
  - WBC increase
  - Cloudy CSF

### **Case #1:**

- 18 month old with EVD @ 3 cm above external auditory canal (also with an internal shunt)
- Order to clamp overnight in anticipation of internalization of shunt. Why? To see how he's reabsorbing with just the internal shunt.
- What assessment parameters will you monitor?
  - Worried about increasing ICP.
- Patient with following changes:
  - LOC – previously GCS 15, now responds to stimulation with cry but then lethargic
  - Pupils equal but sluggish
  - HR previously 110-130, now at 85
  - SBP previously 100 – now 130's
  - What do you do?: Call doc...this kid has increased ICP!

### **Myelodysplasia = Spinal Bifida**

- A defect in the development of any part of the spinal cord.
- Failure of neural tube closure during first 6 weeks of embryonic development; may be related to folate deficiency
- Increase incidence in families
- Affects 0.4-1 in 1000 births
- Spina bifida occulta

- Spina bifida cysta: meningocele
- Spina bifida cystica: myelomeningocele
- Clinical Manifestations:
  - Prenatal detection: Ultrasound, increased AFP
  - Superficial evidence: spinal area skin depression, dimple, port-wine/hairy/lipomatous nevi
  - What happens to baby depends on where it is...the higher up the spinal cord the more problems you have.
  - Hydrocephalus in 85% (primarily ACM which is Arnold-Chiari malformation) because the 4th ventricle is not in correct position and this blocks the outflow of CSF.
  - GU: Neurogenic bladder (spastic or flaccid)
  - GI: Loss of control (+/-)
  - M/S: club foot; DDH (Developmental Dysplasia of the Hip); Scoliosis

Arnold-Chiari malformation (ACM) is a congenital anomaly in which parts of the brain protrude through the opening in the base of the skull into the spinal column.

### Treatment of Spina Bifida

- Surgical
  - Repair of meningocele (keep child off back after surgery)
  - Shunt for related hydrocephalus (ACM)
  - Tethered cord release...cords get tethered (stuck) causing compression of nerve roots and more CNS problems. The treatment is to have the cord released.
  - Potential for genitourinary surgery. Many of these children will be on long-term catheters. The goal is self-catheterization...usually a stoma at the umbilicus for easy self-catheterization.
- Support for mobility
- Support for Growth and Development

### Latex Allergy...spina bifida kids usually develop latex allergy

- Research estimates that 50-70% of individuals with SB suffer from an allergy to natural rubber latex
- All patients with SB should be treated as if they have latex allergy
- Many products contain rubber latex:
  - catheters, gloves, tubing, tape, tourniquets
  - glue, toys, handles, tires, balloons, elastic

### Infectious Disorders

- Bacterial Meningitis
  - Acute inflammation of CNS
  - Decreased incidence following use of "Hib" vaccine
  - Can be caused by various bacterial agents
    - *Haemophilus influenzae (HIB)*
    - *Strep pneumoniae (pneumococcal)*
    - *Neisseria meningitidis (meningococcal)*...more common in teens and young adults. Invades fast and very quickly turns to sepsis that causes a wide-spread DIC. Any child presenting with neuro symptoms, meningeal irritation symptoms, flu-like symptoms and petechial rash (does not blanch)...this is an EMERGENCY!
- Transmission of Bacterial Meningitis
  - Droplet infection from nasopharyngeal secretions
  - Appears as extension of other bacterial infection through vascular dissemination
  - Organisms then spread through CSF
- S&S of Bacterial Meningitis
  - Brudzki's bend neck, they pull up knee.
  - Kernig's you raise up leg and it hurts b/c this stretches the meninges.
  - Altered LOC
- Diagnostics for Bacterial Meningitis
  - LP is definitive diagnostic test

- Trying to differentiate if bacterial or viral
- DO NOT DO LP if signs of increased ICP!
- Management of Bacterial Meningitis
  - Manage ABC: airway support
  - Manage ICP: Fluid restrict 2/3 of maintenance
  - Direct treatment: Antibiotic therapy of bacterial; if viral then supportive care unless they suspect herpes...in that case they may give Acyclovir.
  - Prevent complications:
    - Cerebral Edema: Treat with corticosteroids
    - Subdural Effusions (pus coming out into subdural space...will block CSF flow and can lead to hydrocephalus): Close neuro monitoring
    - SIADH: Monitor fluids, serum Na and urine sp. grav.
  - Infection Control: Isolation precautions until on abx for 24 hours.
    - Treatment of known contacts (everyone in the household gets tx as well)
  - Supportive treatment: Comfort measures
  - Long-term issues: Hearing tests (hearing loss d/t cranial nerve damage), hydrocephalus d/t occlusion of the tract.

TYPES OF MENINGITIS	Viral	Bacterial
Symptoms	Fever, HA, stiff neck, sensitivity to light, ALOC	High fever, severe HA, stiff neck, sensitivity to light, ALOC, N/V, rash, sore throat
Labs	CSF: normal glucose, mild increase in WBC, mild increase in protein	CSF: low glucose, high WBC, high protein
Effects	Self-limiting	Hearing loss, Developmental Delays, SIADH, DIC, SDE (subdural empyema?)
Treatment	Symptomatic	IV Abx Symptomatic

### Working with the child with cerebral palsy

NEED TO KNOW quick overview:

- Know what it is...not all children with CP have cognitive defects.
- Most common cause in kids is hypoxic events
- Know this is a problem with the motor centers of the body...can be too rigid or too flaccid, or mixed (more common). Hypertonic is more common than the others (spastic muscles). The spasticity is one of the biggest problems!
- Nursing priorities
  - Assist physical mobility
  - Medications to treat spasticity
    - benzos (Valium)...you give someone Valium and it decreases spasms and respiratory....also going through life sedated (not good).
    - Dantolene (CCB) decreases muscle contraction but has a systemic effect.
    - Baclofen decreases motor nerve conduction...so it decreases spasticity...in order to give a high enough oral dose to work, you'd get tremendous side effects. One of the things that came out of that is a baclofen pump...yay! Much lower doses and great impact on spasticity. The pump can be refilled and reset externally...but it's an ICU procedure when you first put one in.

## **Cerebral Palsy (CP)**

- Definition: Nonprogressive motor and posture dysfunction 2/2 anoxic damage in motor centers of the brain
- Occurs in 2/1000 births
- Associated conditions vary:
  - Visual defects
  - Hearing, speech, language delay
  - Seizures
  - Cognitive
- Causes of Cerebral Palsy
  - Prematurity
  - Perinatal Asphyxia
  - Infection
  - Intrauterine Ischemia
  - Congenital Brain Anomalies
  - Metabolic Disorders
- Types of Cerebral Palsy
  - Spastic
  - Dyskinetic (Athetoid)
  - Ataxic
  - Mixed
- Nursing priorities in CP
  - Impaired physical mobility
    - Therapy; assistive devices; ongoing support
    - Medications to treat spasticity (discussed above)
    - Surgical intervention
  - Sensory/Perceptual Alteration
    - Assessment and adaptive devices
  - Altered Nutrition
    - Assessment and support
    - Aspiration precautions
  - Family process/growth/development
- Baclofen Pump
  - Intrathecal admin
  - Decrease spasticity
  - Dose adjusted in office
- Pediatric Neurological Disorders Summary Statements
  - Assessment requires comparison with EXPECTED
  - Care of child with neurological impairment:
    - Provide for supply of oxygen & glucose to brain
    - Prevent complications
    - Promote realization of potential