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Lab Values and Vital Signs in the Neonatal Intensive Care Unit

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Learner Outcomes

As a result of this course, participants will be able to:

- Identify normal and abnormal values for neonatal vital signs
- Identify normal and abnormal values for neonatal laboratory measurements
- Select an appropriate therapeutic plan of action based on neonatal vital signs and laboratory measurements

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Vital signs

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Vital signs

- Classic 5
  - Temperature, heart rate, respiratory rate, blood pressure, oxygen saturation
- What else?
  - Pain
  - Other important items that are worth documenting: respiratory effort, capillary refill time.
- Preterm babies may have marked variations in normal vital signs – immature heart/lungs and immature thermoregulation

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CONTINUED

Temperature

- 97.7°F – 99.5°F (36.5°C-37.5°C) usually considered normal range.
- Axillary!
  - Skin probes unreliable
  - Rectal temps should not be used (perforation risk)
- Goal is thermal neutral environment, heat loss preventive measures as appropriate.
- Typical is cold stress due to decreased fat tissue, large surface-volume ratio, inability to produce heat by shivering, and not enough fat

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CONTINUED

Hypothermia

- Preterm babies have an inherent risk of hypothermia. Increased risk if **sepsis** or other complications such as asphyxia.
- Signs/symptoms: tachypnea/apnea, bradycardia, acrocyanosis, increased oxygen requirements, lethargy or irritability, seizures, hypoglycemia (needs to be monitored!), feeding intolerance.
- Prevent!
- Treat! Rewarm slowly – too quick can cause hypotension and apnea.

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A note about sepsis

- Very rare for infants to present with fever unless immediately after delivery by mother with fever.
- Much more common for infant to be hypothermic
  - Non-specific marker of sepsis, along with lethargy, poor feeding, anuria, and other signs/symptoms specific to the cause.
  - Most preterm infants will show apnea, bradycardia and cyanosis.
- "Subtle changes in respiratory status of newborns, temperature instability and feeding problems can be the first signs of a life-threatening infection" (Simonsen, 2014)

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Preventing hypothermia

- All surfaces should be prewarmed
- VLBW infants need to be in warm humidified environment
- Use caps, blankets
- May need to use barrier film to prevent evaporative heat loss (skin precautions – film must wear off itself, never remove film!)
- NOTE: there may be cases in which controlled hypothermia is desirable – protocols for neonatal encephalopathy

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Considering temperature in daily care

- Always take temperature prior to therapy
  - Adjust environment if necessary (eg radiant warmer if low, unbundle if high)
- Provide care using isolette portholes.
  - Porthole covers are an infection risk, so not used anymore
  - But should use the boost curtain to prevent heat loss through portholes
- Protocol for weaning from isolette varies
  - SMH: At 1500 g and 34 weeks, transfer to air temp and begin weaning to open crib

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Hyperthermia

- Etiology:
  - Environmental
  - Dehydration
  - Sepsis
  - Maternal hyperthermia
- Signs:
  - Tachycardia, arrhythmia
  - Hypotension
  - Worsening respiratory distress
  - Flushed skin, sweating (older infants)
  - Weak cry
  - Decreased tone

What to do?

Treat the cause.

Cool slowly if environmental

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Heart rate

- Usually 120-160 beats per minute
  - Range may be broader, varies with behavioral state
- For a truly accurate pulse, read with preemie stethoscope and count rate for full minute. Murmurs are common, but should not be ignored.
- Bradycardia: <80 bpm
  - Apnea, cerebral defects, vagal response, congenital heart block, stress
- Tachycardia: >160 bpm, sustained
  - Respiratory distress, anemia, congestive heart failure, hyperthermia, shock, supraventricular tachycardia

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Respiratory rate

- 35-60 breaths per minute
- >60 breaths/minute = tachypnea
- TTN: transient tachypnea of the newborn
  - Mild, self-limiting (~3 days)
  - May be due to slow absorption of fluid from lungs
  - More common in term babies
- Consider the overall picture:
  - Respiratory effort
  - Retractions, nasal flaring, grunting

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- Apnea of prematurity
  - Pause in breathing > 15-20 seconds, or accompanied by drop in oxygen saturation (≤80% for at least 4 seconds) and bradycardia
  - Babies on "A & B watch"
- Apnea management: Quickest thing that can be done: provide tactile stimulation, change position to prone
- Obviously needs to be investigated, and potential causes need to be addressed. May need caffeine citrate, or respiratory support initiation or modification

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Blood pressure

- BP cuff should be in upper arm or thigh (cuff <2/3 limb length)
- SMH guidelines
  - <1000 g, mean arterial pressure 22-42 mm Hg
  - >1000 g, mean arterial pressure 41-66 mm Hg
- Low mean arterial pressure may indicate PDA or another heart disorder
- Assess peripheral perfusion and capillary refill time (should be <2-3 seconds)

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Oxygen saturation

- Typically measured by pulse oximetry
  - Displayed value is ratio of hemoglobin to deoxyhemoglobin
- Relies on accurate perfusion and placement of the probes
- 90-92% is desirable for most infants
- Brief changes may be due to handling
- Adapt treatment to patient response

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The preterm baby: reading their signals

- Not ready to interact (stress)
  - Color change
  - Altered respiratory rate or pattern
  - Altered heart rate
  - Extension or limpness
  - Gaping mouth
  - Hiccuping, yawning
  - Gaze aversion, squirming
  - Frantic activity, motoric disorganization
  - Hyperalertness

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- Ready to interact (stable)
  - Normal color
  - Regular respiratory/heart rate
  - Flexed or tucked position
  - Hand to mouth or face
  - Grasping/clasping
  - Alert gaze, focusing
  - Relaxed tone and posture

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Therapy implications

- Early loss of protective boundaries of womb and immature nervous system may cause exaggerated physiological and behavioral response to sensory stimuli and handling.
- Promote a developmentally appropriate environment, proper positioning
- Monitor response to therapy, and modify as necessary
  - Oxygen saturation
  - Color
  - Respiratory rate
  - Heart rate
  - Behavioral signs

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Pain

- Should be assessed and documented with vital signs
- Use standardized tools – reliable and valid
  - Choose appropriate tools based on gestational age, medical status, nature of pain. Eg: NPASS, CRIES, NIPS, PIPP, etc.
- Assess multiple dimensions of pain (behavioral/ physiological)
- Reevaluate after interventions as appropriate
- Long term effects: impaired immune function, increased morbidity/mortality, metabolic dysfunction

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Pain in the preterm infant

- Pain pathways active at 20-24 weeks GA
- Pain modulatory tracts not active until 36-40 wks GA
- RESULT: more sensitivity to pain than older or term infants
- Infants can feel and remember pain

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CONTINUED

Indicators of pain

- Physiologic
  - Tachycardia, increased respiratory rate/effort
  - Decreased oxygenation, bradycardia, decreased respiratory rate or apnea
  - Color changes: cyanosis, pallor, duskiness, mottling
  - Increased sweating
  - Vomiting
  - Failure to thrive

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CONTINUED

Indicators of pain

- Behavioral:
  - States: fluctuations in state, hyperalertness, difficult to console
  - Decreased self-regulation
  - Motor behavior: arching, hyperextension, flailing extremities, or the opposite – decreased activity
  - Vocalizations: high-pitched cry, intense cry
  - Facial expressions: frowning/brow bulge, gaze aversion, “tune out”, “square mouth”, eye squeeze
  - Feeding and sleep difficulties

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CONTINUED

Alleviating pain

- Nonpharmacological
  - Reducing stimulation (light, noise, handling)
  - Swaddling, containment, facilitated tucking
  - Breast milk or sucrose solution
  - Sucking
  - Soft rocking
  - Kangaroo care
  - Soft voice/soft music
- Pharmacological
  - Acetaminophen, fentanyl, morphine, topical anesthetics.

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CONTINUED

Laboratory testing and values

2/22/2019

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CONTINUED

Lab testing in the NICU

- Typically performed daily
- Assists with diagnosis, monitoring, and follow-up
- Can be used to screen and prevent problems
- Helps determine prognosis
- May be used in counseling (e.g. genetic testing)
- Evaluate one-time events, such as a medication error

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CONTINUED

Collection of lab samples

- Capillary blood sampling
- Venipuncture or arterial puncture
- Point-of-care testing
- Lumbar puncture
- Urine samples
- Thoracentesis
- Peritoneal tap

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CONTINUED

Capillary blood sampling

- Most common way to obtain small blood samples
- Mixture of capillary, arterial, venous blood and tissue fluid
- Heel sticks
- Why don't we use "finger sticks"?
- Heel sticks not used if edema, injury/bruising to feet, infections, or other anomalies of the feet
- No "milking"!

Verklan, 2015

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CONTINUED

Venipuncture

- Cochrane reviews – best choice for blood collection in term neonates
- Less painful than heel sticks if done skillfully
- But difficult in smaller infants, frequent venipuncture not usually feasible in preemies
- Can be obtained from a site (hand, arm, foot, leg, scalp) or from a catheter
  - PICC (peripherally inserted central catheter)
  - Umbilical vein catheter

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CONTINUED

Arterial puncture

- Arterial sample from radial, tibial, temporal arteries
- Brachial and femoral arteries not typically used in NICU
- Can also be obtained from a catheter
  - Percutaneous arterial line
  - Umbilical artery catheter

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CONTINUED

"Point-of-care testing"

- Capillary, arterial or venous samples for real time testing
- Examples: electrolytes, calcium, creatinine, hematocrit, hemoglobin, blood gases, glucose
- Small blood volumes

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CONTINUED

Lumbar puncture

- Removes cerebrospinal fluid from spinal canal
- Diagnosis of infection, hemorrhage, tumors, demyelinating diseases

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CONTINUED

Urine samples

- Chemical analysis, cultures, microscopic examination
- Collected via bag or catheter

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CONTINUED

Thoracentesis or peritoneal tap

- Thoracentesis: Remove abnormal fluid (effusion) from thorax using needle tap or chest tube
- Peritoneal tap: Remove abnormal fluid (ascites) from abdomen using needle tap
- Used to diagnose infection, obtain chemistry values (electrolytes, protein, glucose, triglycerides), hematology values (WBC)

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CONTINUED

Pain management during sample collection

- Heel stick:
  - Pain from stick and squeeze
  - Heel warming – evidence is mixed.
  - Evidence-based pain management: sucrose-dipped pacifier, swaddling, containment, facilitated tucking, breastfeeding, skin-to-skin with parent
  - Topical anesthetic not effective for heel sticks!

Anand 2001; Spence, 2010; Verklan, 2015

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CONTINUED

Pain management during sample collection

- Venipuncture
  - Evidence-based pain management: sucrose-dipped pacifier, swaddling, facilitated tucking
  - Topical anesthetic only if 37 weeks GA and above
- Lumbar puncture:
  - Extreme flexion could cause hypoxemia
  - Evidence-based pain management: sucrose-dipped pacifier
  - Topical anesthetic only if 37 weeks GA and above

Anand 2001; Spence, 2010; Verklan, 2015

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CONTINUED

Role of the neonatal therapist

- May be asked to assist with non-pharmacological pain management
- Should be aware of sampling sites during handling
  - Pain
  - Skin disruption
  - Risk of infection

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Common lab values of interest

- Chemistry analysis
- Hematologic tests
- Microbiology tests
- Urinalysis and fecal analysis
- Others
  - Microscopy
  - Transfusion/blood bank tests
  - Immunoassays
  - Cytogenetic tests
  - Immunology tests

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CONTINUED

Chemistry analysis (serum)

- Chemicals
  - Sodium, potassium, calcium, magnesium, phosphorus, total proteins, albumin, hormones, vitamins
- Metabolites
  - Bilirubin, ammonia, blood urea nitrogen (BUN), creatinine, uric acid
- Biomarkers of cell damage or abnormalities
  - Alkaline phosphatase, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and creatinine kinase
- Drugs, toxic substances
  - Antibiotics, caffeine, phenobarbital, drugs of abuse

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CONTINUED

Hematologic tests

- Related to blood cells or plasma
- Examples: Hematocrit (Hct), Hemoglobin (Hgb), red blood cell count, white blood cell count (WBC), WBC differential count, platelet count, plasma proteins, coagulation factors, immunoglobulins.
- A complete blood count (CBC) with RBC, WBC, platelet count, Htc, Hgb

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CONTINUED

Microbiology, urinalysis

- Microbiology: to detect infectious agent. Example: cultures, bacterial stains
- Urinalysis: renal function, fluid balance, proteinuria, glycosuria, other substances in urine, infections

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CONTINUED

Most relevant NICU tests

- Fluids/nutrition/electrolytes: sodium, potassium, calcium, magnesium, phosphorus, glucose, albumin
- Respiratory: blood gas, pH, PaO2, PaCO2, bicarbonate
- Cardiac: isoenzymes
- Gastrointestinal: alkaline phosphatase, triglycerides, AST and ALT (liver enzymes aspartate aminotransferase and alanine aminotransferase) , bilirubin

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CONTINUED

- Renal: BUN, creatinine, urine sodium, urine potassium, urine osmolality
- Endocrine: TSH level, GH level, metabolic screening tests
- Neurologic: phenobarbital level
- Hematologic: CBC (includes RBC, WBC, platelet count, Htc, Hgb), may be done with differential

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Reference range

- Establishes a range of values "within normal limits" by setting thresholds or boundaries
- Specific to patient attributes, for example age or gender, or setting
- Range can vary between labs
- Usually in the EMR, values outside established range for your setting are flagged.

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Fluid and electrolyte balance

- Fluids: a tricky balance
  - Too little: dehydration
  - Too much: intravascular overload
  - Not always a matter of too little or too much
    - Septic shock: low intravascular volume combined with tissue edema
  - Changes can be acute or gradual
- Monitoring fluids is crucial in NICU

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CONTINUED

Assessment of fluid balance

- Body weight changes (not specific)
- Urine volume
  - At least 0.5 mL/kg/hr
  - Keep that diaper, and careful with evaporation
- Specific gravity of urine
  - Normal is 1.002 to 1.012
  - Measures osmolality of urine (100-300 mOsm/L)

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CONTINUED

- Physical and hemodynamic assessment
  - Skin turgor, edema, fontanelles, eyes
  - Blood pressure, capillary refill, temperature, acid-base balance
- Lab eval: serum sodium, osmolality, BUN, creatinine, Htc.

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CONTINUED

Typical observations in infant with fluid depletion

- Possible weight loss
- Low urine output, high specific gravity
- Dry skin, poor turgor
- Tachycardia, peripheral vasoconstriction (pale, cool, mottled skin, prolonged capillary refill)
- BUN and creatinine may be elevated
- Blood gas values may show metabolic acidosis
- Sodium may be elevated, but not necessarily

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CONTINUED

Typical observations in infant with fluid excess

- Weight gain
- Possible decrease in urine output
- Edema
- Low serum osmolality (<280 mOsm/L), normal urine osmolality.
  - Exception: dysfunction of antidiuretic hormone, will have low urine output with high specific gravity and high sodium; and serum with low osmolality and low sodium)

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CONTINUED

Therapy considerations

- Babies with fluid disorders may not be sufficiently stable for additional handling, always check with nurse and adjust plan of care accordingly.
- Preterm babies have high evaporation of water through immature skin
- Factors that can increase water loss include activity, phototherapy, tachypnea, high ambient temperature, radiant warmers, low humidity, convection.
- Keeping a baby clothed or with blankets will reduce water loss

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CONTINUED

Therapy considerations

- Edema predisposes the skin to injury.
- Frequent and appropriate repositioning is important in infants with edema.
- Provide proper positioning support, and a gel or fluid mattress.
- Edema that is of lymphatic etiology may be addressed with manual lymph drainage if appropriate for age and status

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Electrolytes: sodium

- Range 135-145 mEq/L
- Sodium is a crucial electrolyte
  - Water balance and acid base balance
  - Osmotic equilibrium
  - Electrochemical gradients across membranes (sodium-potassium pump, neuromuscular impulses)
  - Growth of new tissue
- Sodium imbalances
  - Hyponatremia
  - Hypernatremia
  - <120 or >155 mEq/ L can be life-threatening

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Hyponatremia

- Excess body water or sodium depletion
- Prematurity predisposes infants to sodium loss
- Other causes: renal losses, medications, excessive water intake, inadequate sodium intake, vomiting, diarrhea, etc.
- Usually asymptomatic, but if acute or dropping to very low levels can cause symptoms
- Therapy implications: infant may show irritability, apnea, seizures, failure to thrive. Chronic hyponatremia can impair skeletal growth

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CONTINUED

Hypernatremia

- Typically due to deficit in body water
- Causes: insufficient fluid intake, high sodium intake (infusions, medications), diabetes insipidus, water loss (evaporation).
- May show signs of dehydration.
- Therapy implications:
  - Prevent water loss.
  - Infant may show high-pitched cry, lethargy, irritability, apnea, seizures.
  - Acute increases in plasma osmolality can contribute to IVH. Careful with sudden positional changes during handling - may affect cerebral hemodynamics.

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CONTINUED

Electrolytes: potassium

- Range 3.5 – 5.5 mEq/L
- Potassium is a crucial electrolyte
  - Intracellular fluid volume homeostasis
  - Electrochemical gradients across membranes (sodium-potassium pump, cardiac and skeletal muscle contraction)
- Potassium imbalances
  - Hypokalemia
  - Hyperkalemia

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Hypokalemia

- Excessive loss (in urine, or trough NG tube) or insufficient intake of potassium
- Medications: insulin, bicarbonate, diuretics
- Metabolic alkalosis (high serum pH)
- Therapy implications: infant may show cardiac anomalies on EKG, abdominal distention, hypotonia

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Hyperkalemia

- "Milking" during heel stick can falsely elevate potassium reading.
- Extreme prematurity predisposes infants to hyperkalemia
- Can also be due to metabolic acidosis (low serum pH), renal failure, hemorrhage, injury to tissues
- Life threatening – potential cardiac arrest
- Therapy implications: Infant may show arrhythmias, therapy may need to be placed on hold during temporary measures to decrease potassium (dialysis, exchange transfusions, etc)

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CONTINUED

Electrolytes: calcium

- Range 8.5-10.2 mg/dL (ionized calcium: 4.4-5.3 mg/dL)
- Calcium is a crucial electrolyte
  - Membrane permeability
  - Muscle contraction, nerve transmission
  - Enzyme activation
  - Blood clotting
  - Bone mineralization
- Calcium imbalances
  - Hypocalcemia
  - Hypercalcemia

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CONTINUED

Hypocalcemia

- Extreme prematurity predisposes infant to issues with calcium balance – placenta plays major role in calcium homeostasis
- Other causes: infant of diabetic mother, perinatal asphyxia and stress, low intake, maternal anticonvulsants, malabsorption, etc
- May not need treatment (Greer, 2016)
- Therapy implications: infant may show increased neuromuscular excitability (twitching), in severe cases seizures, high-pitched cry, laryngospasm. Monitor calcium infusion sites for tissue necrosis or calcifications.

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Hypercalcemia

- Potentially lethal
- Therapy implications
  - Hypotonia
  - Weakness
  - Irritability
  - Poor feeding
  - Bradycardia
  - Dehydration.

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Metabolic bone disease

- Increased risk in premature babies. Also due to non-supplemented breast milk or formula, medications (glucocorticosteroids, caffeine citrate)
- Decreased bone strength. Demineralization diagnosed by x-ray, labs (calcium may be low or normal, but have low phosphorus <4 mg/dL and high alkaline phosphatase > 500 mg/dL)
- Therapy implications:
  - Increased risk of fracture – gentle handling
    - No chest PT (percussion, etc)
  - May demonstrate pain with handling
  - Respiratory distress from rib dysfunction

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CONTINUED

Electrolytes: magnesium

- Range 1.5-2.5 mg/dL
- Magnesium is a crucial electrolyte
  - Enzyme reactions
  - Bone homeostasis
  - Carbohydrate metabolism
- Magnesium imbalances
  - Hypomagnesemia
  - Hypermagnesemia

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CONTINUED

Hypomagnesemia

- Extreme prematurity and intrauterine growth restriction predispose infant to issues with magnesium balance
- Other causes: renal and GI disorders, low intake, etc
- Therapy implications: infant may show hyperreflexia, tremors, irritability, potentially seizures. Overtreatment can cause hypotonia and respiratory depression.

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CONTINUED

Hypermagnesemia

- Mothers treated with magnesium sulfate (self-limiting), infant renal failure
- Therapy implications
  - Hypotonia
  - Decreased reflexes
  - Poor suck
  - Lethargy
  - Respiratory depression, apnea
  - Abdominal distention
  - Watch out for cardiac arrest, respiratory failure

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Glucose

- Primary energy source for brain. Immediately after birth, lactate metabolism until glucose intake stabilizes.
- Infants need more glucose than adults (brain-to-body size ratio)
- Preterm infants need 8 mg/kg/min of glucose
- Optimal range for plasma glucose 70-100 mg/dL
- But desirable values depend on age, general health status and symptoms
- A broader range may be 40-160 mg/dL.

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- Hypoglycemia: plasma level < 40 mg/dL (some say 50)
  - Insufficient glucose supply, decreased stores, increased use (stress), endocrine disorders
  - Can also occur in infants of diabetic mothers
  - Therapy implications: may present with tremors, exacerbated Moro reflex, irritability, respiratory distress, apnea, hypotonia, lethargy, temperature instability, poor feeding, seizure.
  - Careful – many times together with hypothermia
  - Follow-up testing every 30 minutes may be needed when bolus administered to resolve hypoglycemia. This may affect scheduling.

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- Hyperglycemia: plasma level > 160 mg/dL
  - ELBW infants more susceptible to hyperglycemia
  - Other causes: stress response, excessive supply, corticosteroid therapy.
  - Treatment usually if >200 mg/dL
  - Therapy implications: baby may show signs of dehydration, increased temperature, failure to thrive, increased risk of IVH due to increased osmolality.
  - Possible relationship with severe retinopathy of prematurity

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CONTINUED

Disorders of acid-base balance

- Normal blood pH is 7.35-7.45
  - Buffers (bicarbonate, plasma proteins, hemoglobin)
    - Normal bicarbonate (HCO3-) is 22-26 mEq/L
  - Lungs remove CO2
  - Kidney reabsorbs buffers, excretes acids.
- Deviations from normal
  - Acidosis (pH <7.35)
  - Alkalosis (pH >7.45)

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CONTINUED

Oxygenation and acid-base homeostasis

- pH, PaO_2, $PaCO_2$, bicarbonate
- Normal arterial blood gas values: $PaCO_2$ 35-45 mm Hg, PaO_2 45-65 mm Hg (preterm), bicarbonate 22-26 mEq/L
- High PaO_2 associated with retinopathy of prematurity
- Respiratory acidosis: $PaCO_2$ increases when lungs not effective at removing CO_2
  - A nonpulmonary cause can be low muscle tone due to genetic syndromes, medication side effects
  - Therapy implications: look for altered respiratory rate, grunting, nasal flaring, chest wall retractions. May need ventilatory support

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- Respiratory alkalosis: PCO_2 below normal due to excessive clearance
  - Hyperventilation, excessive ventilator support, or response to hypoxemia
  - Therapy implications: there may be abnormal neurological signs or increased CNS excitability. Baby may be stressed and tachypneic.
- Untreated or unrecognized acid-base or oxygenation disturbances can have devastating consequences. The whole team should be vigilant.
- Treatment may involve changes in respiratory support which may affect therapy scheduling or therapeutic procedures.

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Metabolic acidosis

- Low pH, low bicarbonate, normal PCO_2
- Due to loss of bicarbonate or excess acids (can be differentiated with "anion gap")
  - Prematurity increases risk of bicarbonate loss, as does severe diarrhea
  - Excess acid could result from hypoxia, respiratory distress, congenital heart disease, sepsis, poor nutrition
  - If cells don't get enough oxygen, lactate may be high
- Therapy implications: consider possible underlying disease, may show respiratory compensations (tachypnea), low blood pressure, hypothermia, seizures.

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CONTINUED

Metabolic alkalosis

- High pH, high bicarbonate, normal PCO_2
- Due to excess bicarbonate or acid deficit (vomiting, suction, diuretics)
- Prematurity increases risk of bicarbonate loss, as does severe diarrhea
  - Excess acid could result from hypoxia, respiratory distress, congenital heart disease, sepsis, poor nutrition
- Therapy implications: may cause hypercalcemia, hypokalemia

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Compensations

- Infants with chronic disorders may have compensated acid-base imbalances and actually reach normal pH range
- For example, normal pH with high PCO_2, high bicarbonate in a child with chronic lung disease (respiratory acidosis is compensated by metabolic alkalosis)

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CONTINUED

Cardiac biomarkers

- Cut-off values depend on gestational age and other factors, no single accepted threshold. Normal elevation in the days following birth
- Persistent postnatal elevation in natriuretic peptides and troponins is a red flag
- Natriuretic peptide levels are elevated during atrial strain (atrial natriuretic peptide (ANP)) or ventricular strain (brain natriuretic peptide (BNP).
  - These markers correspond well with cardiac function and can be used to identify cardiac disease.

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CONTINUED

- Cardiac troponins are used to assess cardiomyocyte compromise.
  - Affected cardiomyocytes release troponin into bloodstream, resulting in elevated levels of troponin.
- Therapy implications:
  - Elevated cardiac biomarkers indicate underlying cardiac issues
    - Example: BNP elevated in PDA
  - Observe precautions and restrictions for underlying disorder.

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Liver function

- Albumin
  - Decreased levels in hepatic cell injury
  - Reference values established for term: 2.8-4.4 g/dL
- Alkaline phosphatase
  - Elevated in hepatitis, obstructions
- Aspartate aminotransferase (AST) and alanine aminotransferase (ALT)
  - Elevated in hepatocyte necrosis, liver injury
  - Ratio of ALT-AST can help differential diagnosis
- Acute liver disease would be reason for therapeutic hold.

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Bilirubin

- Byproduct of RBC breakdown, excreted in bile
- Unconjugated form must be conjugated for excretion
- Elevated when liver function is impaired, excretion is reduced (cholestasis, other blockages), or in hemolysis (causes excess unconjugated bilirubin) or infections.
- Other important labs to give supplemental information to bilirubin: mother and infant blood types, Rh, complete blood count including hematocrit, platelets, WBC, WBC differential, red blood cell morphology.
- Jaundice: yellowish skin, sclera from bilirubin elevation

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- Therapy implications of hyperbilirubinemia: decreased level of arousal/activity may impact assessment of development and feeding
- Acute bilirubin encephalopathy: poor sucking and hypotonia, progressing to hypertonia, and finally apnea, seizures and potentially death
- Kernicterus: irreversible encephalopathy due to bilirubin toxicity
  - Early on presents as hypotonia, increased DTRs and persistent infant reflexes, developmental delay
  - Eventually choreoathetoid cerebral palsy, some intellectual deficits.

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Treatment of hyperbilirubinemia

- Depends on infant weight and health status. For instance, 5-7 mg/dL bilirubin in an infant that is <1000 g would be indication for phototherapy if child healthy. Value would be 4-6 mg/dL if infant is generally sick.
- Phototherapy makes bilirubin water soluble and helps with excretion
- Therapy implications during phototherapy: maintain large body surface area exposed to light, protect eyes (ok to remove shield only briefly for visual responsiveness assessment if appropriate), monitor temperature, follow distance recommendations, increased risk of dehydration

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Treatment of hyperbilirubinemia

- Exchange transfusion may be necessary if intensive phototherapy unsuccessful
- Therapy implications: after exchange transfusion, stay informed about potential imbalances in electrolytes, glucose, hematologic complications or increased risk of necrotizing enterocolitis

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Kidney function

- Serum creatinine is best indicator
  - In preterm infants, rises for 48 hours post birth, then falls to equilibrium (~ 0.4 mg/dL)
  - High levels indicate impaired renal function
- Blood urea nitrogen (BUN) is an indirect measure of kidney function
  - High BUN indicates renal dysfunction
  - >20 mg/dL or rises at rate of at least 5 mg/dL/day

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Kidney function

- Urine output (ideally 2 mL/kg/hr, no less than 0.5 mL/kg/hr)
- Urine appearance: should not be cloudy (infection), brown-greenish (bilirubin), brown (upper urinary tract bleeding)
- Proteinuria – excess protein in urine
  - Persistent proteinuria -risk of developing future chronic kidney disease and hypertension.
- Therapy implications: renal dysfunction can lead to fluid and electrolyte imbalances.

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Hematologic tests

- Complete blood count
  - Red blood cell (RBC) count
  - Hemoglobin (Hgb) and hematocrit (Hct) (percentage)
  - Mean corpuscular hemoglobin (MCH and MCHC)
  - Mean corpuscular volume (MCV)
  - WBC count (can be with differential)
  - Platelet (thrombocyte) count
  - Cell morphology

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- Hematocrit: proportion of blood volume that is RBCs (%)
  - Mean at 28 weeks is 45%
  - Mean at 34 weeks is 47%
- Hemoglobin: measured in g/DL
  - Mean at 28 weeks is 14.5 g/dL
  - Mean at 34 weeks is 15 g/dL
- The MCV measures the average size of circulating erythrocytes
  - Elevated in polycythemia or in anemia folate or vitamin B12 deficiency.

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- MCHC measures hemoglobin concentration in a given volume of red blood cells.
  - Mean at 28 weeks is 31%
  - Mean at 34 weeks is 32%
- MCH measures the average amount of hemoglobin per RBC in a sample of blood
  - Mean at 28 weeks is 40%
  - Mean at 34 weeks is 38%
  - Can be used to identify anemia due to an acute or chronic blood loss

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- Anemia: low concentration of erythrocytes and hemoglobin
  - Neonatal acute, chronic, or iatrogenic blood loss; decreased erythrocyte production; increased destruction of erythrocytes
  - May need transfusion
  - Therapy implications: decreased endurance, hypoxia, fatigue. May need to adjust duration and intensity
- Polycythemia: hematocrit >65%
  - Increased blood viscosity
  - Therapy implications: could have lethargy, irritability, poor suck, respiratory distress, and hypotonia. May be associated with hyperbilirubinemia

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- WBC count:
  - CBC measures number and types of circulating leukocytes. Differential count identifies the types of leukocytes according to their morphology and categorizes the types as % of the WBC count
- Normal level in preterm children: 5,000-14,000 cells/μL after 72 hrs post birth
- Leukocytosis: elevated WBC count; infections, leukemias, or leukemoid reactions.
- Leukopenia: decreased WBC count; viral or bacterial infections, infants born to women with pregnancy-induced hypertension
- Therapy implications: abnormalities in WBC count may indicate a contraindication to therapy

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- Platelets
  - ~ 290,000/mm3 in preterm babies, similar to adults
- Thrombocytopenia
  - Very common in sick neonates
  - Signs and syptoms: petechiae; gastrointestinal, cutaneous, and mucosal bleeding; hematuria; and central nervous system hemorrhage
  - Therapy implications: prone to bleeding, increased risk of IVH, may need to decrease activity, consult with neonatologist. May be a sign of infection
- Thrombocytosis
  - May be physiologic or associated with infection, inflammation, iron deficiency, medications neoplasms, Down syndrome, or congenital adrenal hyperplasia
  - Usually asymptomatic

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Case 1

- Infant born at 31 weeks, currently 2 weeks old. Findings: respiratory rate 68 breaths per minute, heart rate 180 beats per minute, temperature 36.9°C (98.4°F), nasal flaring, gaze aversion, frowning.
- What numeric values are off?
- What else seems to be present?
- What would you do next?

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Case 2

- Baby who was born at 27 weeks gestation and is now 30 weeks corrected. Capillary blood gas values are pH 7.29, PO_2 45 mm Hg, PCO_2 58 mm Hg, bicarbonate 25 mEq/L.
- Which values are off?
- Medically, what would need to be done?
- From a therapy perspective, what other things would you look for? What adaptations may need to be made to plan of care?

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Case 3

- Baby born at 35 weeks, infant of diabetic mother. Temperature is 97.5°F (36.4°C). Baby is in open crib, swaddled with one blanket.
- What is the first thing you would do?
- Would you proceed with therapy?
- What lab value would you want to look at on the chart? If that value was low, what may you observe if you are working with this child?

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CONTINUED

Case 4

- Baby born two weeks ago, currently 34 weeks old, weighs 1100 g, recently had intestinal surgery. He is on TPN/fluids and phototherapy for elevated bilirubin. He is voiding 0.5 mL/kg/hr. Urine specific gravity is 1.015. Heart rate is 170 bpm, respiratory rate 45 breaths per minute. Mean arterial blood pressure is 35 mm Hg. Sodium is within normal limits.
- What seems off?
- What else would you look for on physical exam and labs?
- What are some considerations for therapy?

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CONTINUED

Case 5

- 30-week gestational age baby on phototherapy. You are doing his initial assessment today.
- What are some guidelines you should follow regarding phototherapy?
- What do you need to consider in evaluating the results of your assessment?

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Case 6

- 32-week GA baby, 5 days old, due for initial therapy assessment today. Complete blood count indicates: platelets 150,000/mm3, WBC count 19,000 cells/μL, hematocrit 40%
- What precautions would there be in handling this baby?
- What else would you want to know?
- Would you go ahead with your initial exam?

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Case 7

- You are working with a 31-week CGA baby who is on TPN/fluids, in an isolette, and is demonstrating hypotonia and lethargy. You have worked with him for the last two days and this is unusual for him. The mother mentions in passing that some of his labs were “off” and that they are making some additional measurements later today.
- What would be some of the potential electrolyte imbalances this child could have? What other lab values may be abnormal in a child who is showing unusual hypotonia and lethargy?

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Case 8

- Baby is 30 weeks GA and is on caffeine citrate due to history of apnea. You notice on the chart that lab results from earlier today indicate low phosphorus and high alkaline phosphatase.
- What else will you look for in the chart?
- What are some precautions you would observe if the child has metabolic bone disease?
- What additional lab findings may make you postpone therapy?
- In a child that has an apneic episode, what are two immediate measures you can take?

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- Hope I have inspired you to dive deeper into the chart and not be scared of numbers…
- Every bit of information contributes to the big picture, so that you can make optimal decisions for the kids you treat.
- That's why we do what we do, right?

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