NICU RESIDENT HANDBOOK

Contributors

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1. Orientation / Workflow

Things to review each day

- Progress or admission notes from previous day
- Note current weight and change from previous day in grams
- Note day of life. Day of birth is day 1, or 0-1. The first number is the number of weeks and second number is number of days. Ex. A baby that is 3-2 is 3 weeks and 2 days old.
- Assess vital signs: T, HR, RR, BP, O2 sat. Look at the trends.
- Record number of As/Bs. Note HR and saturations during event, duration of event, and whether stimulation was required and type.
- Note type of respiratory support and blood gases.
- Note any overnight interventions.
- If PO/Gavage feeding, note number of NG, PO and PO/NG feeds. Calculate the percentage taken by mouth of total enteral intake.
- Meds. Name, frequency and dose. If an antibiotic, know what day of antibiotic and expected duration of antibiotic.
- Labs. Morning results. Lab schedule. Follow up on culture and other pending labs.
- Xrays. Follow up on official reads. Always look at the xray yourself and have your own read.

Calculations

Examining your babies

- Remove all jewelry
- Begin each day with a “3 minute” hand to elbow wash.
- Talk with the nurses as time allows before examining the patient. Ask for an update on overnight events and how the infant is doing. The nurses can be a wealth of knowledge.

Presentations

Go down in the order of your rounding sheet

Ex. **This is baby Smith, 29 weeker, now 5-4, she is 1800, up 20 grams from yesterday. Vital signs were stable and physical exam she had a 2/6 systolic murmur. She took in 155 ml/kg/day for 120 kcal/kg/day, all NG. 6 voids and 3 stools. She is taking EBM/DHM 24 kcal/oz at 150 ml/kg/day. No emesis. Labs today: BMP was reassuring. H/H was 10/28. She had one A/B overnight that was 10 seconds with HR to 55 that self recovered. She is in room air. Plan for the day is to continue current feeds. Consult OT to start working on PO feeds.**
Write down daily plans and goals as the bottom of your rounding sheet and make a daily check list.

Keep up with health maintenance. Immunizations and when they are due.

Eye exams. Past results and when they are due again.
Cranial sector scans (CSS). Past results and when they are due again.
Preparing for discharge. Hearing screen, congenital heart disease screen.

**After rounds**
Orders ideally all in before noon conference. In NICU, co-residents can place orders for the team while one resident is presenting to increase efficiency of the team and implement the changes for the day sooner.
Prioritize. In level 2, milk orders are due by noon and TPN orders are due by 1400.
Consults need be done before noon! Be courteous to the consulting subspecialties.
Progress notes should be submitted prior to rounds. If the attending did not sign them during rounds you can finish/update the note.
Update your handoff sheet for the night team.
Update discharge summaries. In level 2, babies can get sick requiring overnight transfer to the NICU. No one likes starting a discharge summary from scratch when the baby is actively crashing. Poor form.

**Deliveries**
The intern with the baby pager and 2nd year attend all deliveries that Peds are called to, that includes all c-sections, premature vaginal deliveries, and term vaginal deliveries with complications (fetal anomalies, meconium, maternal chioriamnionitis, non-reassuring fetal heart tones).
In general, the intern or resident runs the resuscitation and assigns the APGARs.
In the micropremies (<28 wga), the attending will run the resuscitation.
In the OR, you must wear Sentara scrubs, cap and mask. No other jackets.
APGARs

Apgar Scoring System

<table>
<thead>
<tr>
<th>Indicator</th>
<th>0 Points</th>
<th>1 Point</th>
<th>2 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity (muscle tone)</td>
<td>Absent</td>
<td>Flexed arms and legs</td>
<td>Active</td>
</tr>
<tr>
<td>Pulse</td>
<td>Absent</td>
<td>Below 100 bpm</td>
<td>Over 100 bpm</td>
</tr>
<tr>
<td>Grimace (reflex irritability)</td>
<td>Floppy</td>
<td>Minimal response to stimulation</td>
<td>Prompt response to stimulation</td>
</tr>
<tr>
<td>Appearance (skin color)</td>
<td>Blue; pale</td>
<td>Pink body, Blue extremities</td>
<td>Pink</td>
</tr>
<tr>
<td>Respiration</td>
<td>Absent</td>
<td>Slow and irregular</td>
<td>Vigorous cry</td>
</tr>
</tbody>
</table>

Delivery sheet/H&P

Male/female born on date @ time to a maternal age yo G total gestations including current P full term delivery – preterm delivery – abortions – living children. Mode of delivery. If induced or c-section indicate reason. Note if forceps or vaccum used. Prenatal care. Maternal blood type. Serologies: rubella, hep B, HIV, gonorrhea, chlamydia. GBS status. If IDM, note class of DM. Complications of pregnancy. ROM (artificial or spontaneous) at __ hours prior to delivery (clear, meconium, bloody) fluid. Note any maternal fevers or other signs of infection. Antibiotics given (type and # hours prior to delivery). Any NRFHTs, narcotics given systemically, or general anesthesia. Note any resuscitative measures after delivery. PPV/Intubation. Maximum FiO2 and PIP. Time of intubation, size of tube, tube placement.

Criteria for admission to well-baby nursery

>35 wga
> 2 kg

Criteria for admission to level 2 nursery

≥28 wga
> 800 grams

NICU admissions

< 28 wga
< 800 grams
Cardiac conditions requiring prostaglandins and cardiac team
Neurologic conditions requiring neurosurgical intervention (myelomeningocele)
Surgical conditions requiring Peds Surgery (ex. Omphalocele, gastrochisis)

Admissions tasks to complete
Admission orders
Procedures, line placement etc.
History and physical note
Delivery sheet if at Sentara
Ad hoc (hand off sheet)
Packet for rounding

Transfers
Transfer to NICU: discuss with attending. Write discharge summary. Print out 2 copies of discharge summary. One to give to resident or NP in NICU while giving sign out and one to give to accepting NICU attending physician.
Transfer to level 2 from NICU: similar to transfer to NICU.
Transfer from well baby to level 2: discuss with attending. Patient needs new H&P for level 2 that includes reason for transfer. “Transfer patient” order. Update orders in EPIC to reflect level of care.
Include in discharge summaries when transferring, what labs are pending at the time of discharge and if any follow up labs or imaging need to be completed. If continuing medications, include the last time the medication was given.
2. Cardiovascular

Blood Pressure
Estimation of MAP’s for neonates: MAP’s ~ gestational age
Shock: Basic etiologies
  - Hypovolemic (placental hemorrhage, twin-twin transfusion, ICH, pulmonary hemorrhage)
  - Distributive (paralytics, shunting, sepsis, drugs)
  - Cardiogenic (intrapartum asphyxia, infection, electrolyte abnormalities)
  - Obstructive (outflow obstruction, congenital anomalies, aortic stenosis)

Resuscitation for low BPs
Verify it’s an accurate BP. If an arterial line is in place, does it correlate with the cuff or not? Is it the appropriate size BP cuff? Consider arterial line for better BP monitoring.

ABCs
  - 10 ml/kg Normal Saline Bolus
  - DOPAMINE 2-20 mcg/kg/minute
  - EPINEPHRINE 0.1-1 mcg/kg/minute *
  - In general cardiac medications are infused “per minute”

Steroids (stress dose)
For pressor resistant hypotension or adrenal insufficiency/crisis:
  - Hydrocortisone 1mg/kg IV/PO q8hrs. Max dose: 1.5mg/kg every 6 hours.
Per endocrinology: 50-100mg/m²/day divided q6hrs

Fetal Circulation
Normal physiologic events at birth: Large negative intrathoracic pressures -> cry.
Umbilical cord clamping -> rise in SBP and massive stimulation of sympathetic nervous system.
Pulmonary vascular resistance decreases, followed by a gradual transition (over minutes to
Incidence
6-13 per 1000 live birth
Most common defects are VSDs and secundum ASDs. Tetrology of Fallot is the most common cyanotic CHD.

**When to suspect cardiac conditions in neonate**

**Prenatal History**
- Low SpO2 that is unchanged with increased respiratory support, +/- tachypnea, +/- murmur, >5% difference in pre/post ductal saturations
- CXR with unusual cardiac silhouette
- Well baby becomes cyanotic or in distress at several days of age when ductus arteriosus is closing

**IDM**
- Other congenital anomalies

**Murmurs**
- Innocent murmurs
- Still’s murmur: when the ventricle contracts, forcing blood into the aorta. Systolic ejection soft or vibratory murmur. Grade 1-2/6. Normal S1, S2. No extra sounds. Best heard at left lower sternal border. Best heard with bell of the stethoscope.
- Ductus arteriosus: the blood vessel closes soon after birth. The murmur normally disappears after the first day.

**Murmur location**

![Cardiac Cycle: Mechanisms of Heart Sounds and Murmurs](image)

**Ductal Dependent Congenital Cardiac Defects -> initiate prostaglandin E1**
- Single ventricle (hypoplastic right/left heart)
Transposition of the Great Arteries
Severe Coarctation/Interruption of the aorta
Pulmonary/Aorta stenosis/atresia
Total anomalous pulmonary venous return

**Prostaglandin Administration (PGE1)**
Dose: 0.01-0.1 mcg/kg/minute. Use the lowest rate to maintain adequate oxygenation.

Indication: any clinical condition in which blood flow must be maintained through the ductus arteriosus to sustain either pulmonary or systemic circulation until corrective or palliative surgery can be performed.

Mechanism of action: vasodilation of all vascular smooth muscle including the ductus arteriosus

Adverse effects: APNEA is experienced in about 10-12%. Most often in neonates < 2 kg at birth and usually appears in the first hour of drug infusion. May cause gastric outlet obstruction and reversible cortical proliferation of the long bones after prolonged treatment. Hypotension, cutaneous vasodilation, bradycardia, inhibits platelet aggregation, hypoventilation, seizure-like activity, jitteriness, temperature elevation, hypokalemia, hypoglycemia.

**Cyanotic Heart Lesions (5 Ts)**
- Truncus Arteriosus
- Transposition of the great vessels
- Tricuspid Atresia
- Tetralogy of Fallot
- Total Anomalous pulmonary venous return

**Timing of Presentation**

<table>
<thead>
<tr>
<th>AGE</th>
<th>ECG</th>
<th>X-RAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-first week of life</td>
<td>RVH</td>
<td>PBF (inc)</td>
</tr>
<tr>
<td>First week of life</td>
<td>RVH</td>
<td>PBF (inc)</td>
</tr>
<tr>
<td>1-4 weeks of life</td>
<td>LVH</td>
<td>PBF (dec)</td>
</tr>
<tr>
<td>1-12 weeks of life</td>
<td>RVH</td>
<td>PBF (dec)</td>
</tr>
<tr>
<td>Anytime in infancy</td>
<td>BVH</td>
<td>PBF (inc)</td>
</tr>
</tbody>
</table>

**Key:** RVH = right ventricular hypertrophy. PBF = pulmonary blood flow. inc = increased. LVH = left ventricular hypertrophy. dec = decreased. BVH = biventricular hypertrophy.


*Infant of a diabetic mother (IDM)*
25-75% of IDMs, although most without signs of disease, develop hypertrophic cardiomyopathy and septal hypertrophy.

Congenital malformations occur more frequently in IDMs than the general population, cardiac defects included (TGA, VSD, ASD).

**Congenital anomalies associated with heart defects (*not all infants with these syndromes have heart defects*)**

- Trisomy 21: AV canal, VSD
- Trisomies 13, 15, 18: VSD, PDA
- XO (Turner syndrome): Coarctation of aorta, aortic stenosis
- Fanconi syndrome: PDA, VSD
- Thrombocytopenia-absent radius syndrome: ASD, TOF
- Noonan syndrome: pulmonary stenosis
- DiGeorge Syndrome (chromosome 22 deletion): TOF, aortic arch anomalies
- Smith-Lemli-Opitz syndrome: VSD, PDA
- De Lange syndrome: TOF, VSD
- Williams syndrome: Supravalvular aortic stenosis, peripheral pulmonary artery stenosis
- Asymmetric crying facies: variable
Work up
EKG  ECHO  CXR  Pre- & Post-ductal sats  ABG
4 extremity BPs (difference > 10mmHg SBP suspicious for coarctation of the aorta)

Hyperoxia challenge: Measure arterial oxygen on room air.
Normal PaO2 in term 80-95 mmHg, preterm (30-36 wga) 60-80 mmHg, and preterm (<30wga) 45-60 mmHg. Then place infant on 100% oxygen for 10-20 minutes. Then remeasure arterial oxygen. Normal infant PaO2 > 300 mmHg. A value of >150 mmHg does not always rule out cyanotic heart disease. Cardiac disease will have PaO2 <50-70 mmHg. In cyanotic heart disease the PaO2 will not increase significantly.

Echocardiogram How To
Page Cardiology PA or NP…or On Call Cardiologist
Things to Know/Have available
Reason for echocardiogram/concerns
Most recent fetal echocardiogram from either OB or CHKD Cardiologist
Vital signs, blood gas, physical exam
Have the patient’s chart open when calling (if possible)

Order while at Sentara
Nursing Communication
Type In:
“Please obtain 4 point blood pressures and fax blood pressures, height, weight and facesheet to CHKD Cardiology”
Testing: Echocardiogram
Indication: “Concern for coarctation, VSD, PDA, etc.”

Order while in NICU
Echocardiogram. Know height and weight of baby. Notify PA or cardiologist prior to placing order if it’s the first echo.

Patent Ductus Arteriosus
Ductus arteriosus connects main pulmonary trunk with descending aorta (5-10mm distal to origin of left subclavian artery)
Functional closure in 50% of full term infants by 24 hours of life, 90% by 48 hours and in all by 96 hours after birth
Factors associated with ↑ incidence of PDA: prematurity, RDS and surfactant treatment, fluid administration in first few days of life, asphyxia, congenital syndromes, high altitude, congenital heart disease
Factors associated with ↓ incidence of PDA: antenatal steroid administration, IUGR, PROM
Incidence in preterm infants. ≈45% infants < 1750 g and ≈80% infants < 1000g
Presentation: systolic or continuous murmur, widened pulse pressure, worsening respiratory status, hypotension, hyperactive precordium
Management:
If not hemodynamically significant, often times just observation.
Fluid restriction, typically to 120 ml/kg/day
Course of Tylenol IV or PO is trialed at times for possible closure of PDA
15mg/kg/dose IV/PO every 6 hours x 3-7 days. 2 courses = 7 days
Indomethacin
Side effects include transient decrease in GFR and urine output, association with spontaneous intestinal perforation, impaired platelet function
Contraindications include: Cr > 1.7 mg/dl, frank renal or GI bleeding or generalized coagulopathy, NEC, sepsis

<table>
<thead>
<tr>
<th>Indomethacin (Indocin®) IV only</th>
<th>PDA Closure Dose (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at 1st dose</td>
<td>1st</td>
</tr>
<tr>
<td>&lt; 48 hours</td>
<td>0.2</td>
</tr>
<tr>
<td>2 to 7 days</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt; 7 days</td>
<td>0.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load: 10 mg/kg/dose IV x 1 dose then 5 mg/kg/dose IV every 24hrs x 2 doses starting 24 hrs after load</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV doses x 3 = 1 course, maximum 2 courses</td>
</tr>
</tbody>
</table>

Last consideration is surgical ligation

**Cardiac Arrhythmias**

Normal heart rates in newborns
Heart rate can decrease to 70-90 beats/min during sleep, particularly in a healthy term baby. Can also increase to 170-190 beats/min with crying.

**Tachycardia:** HR > 2 standard deviations above the mean for age.
Benign causes: post-delivery, heat or cold stress, painful stimuli, medications
Pathologic causes:
Common: fever, shock, hypoxia, anemia, sepsis, PDA, CHF
Uncommon: hyperthyroidism, metabolic disorders, cardiac arrhythmias and hyperammonemia

**Bradycardia:** HR > 2 standard deviations below the mean for age.
Transient bradycardia is fairly common in newborns
Benign: defecation, vomiting, micturition, gavage feedings, suctioning, medications
Pathologic causes:
Common: hypoxia, apnea, convulsions, airway obstruction, air leak, CHF, intracranial bleeding, severe acidosis and severe hypothermia
Uncommon: hyperkalemia, cardiac arrhythmias, pulmonary hemorrhage, diaphragmatic hernia, hypothyroidism, hydrocephalus

Benign arrhythmias
Any transient episode < 15 seconds of sinus bradycardia or tachycardia
Premature atrial beats (PACs) can occur in the newborn and are usually benign. They tend to decrease in number or go away entirely in the first month of life.
Premature ventricular beats (PVCs) are fairly frequent in the newborn. QRS is wide and the T wave is discordant with the sinus T wave. Obtain EKG. Do not treat unless symptomatic. Tend to decrease in number or go away in the first few months of life.

Ventricular tachycardia
Ventricular premature beats at a rate of 120-200 beats/minute, widened QRS complex
Treatment is electrical cardioversion

Supraventricular Tachycardia
Suspicous if HR >220 persistently. Ventricular rate of 180-300 beats/minute. No change in HR with activity or crying.
Examine Patient
Place EKG leads on the patient and obtain EKG.
Treatment:
Don’t panic
Call Attending!
Vagal maneuvers may be attempted, such as place bag of ice/water on forehead/eyes (don’t obstruct nares!)
Adenosine: 0.1 mg/kg IV RAPID. Max first dose = 6mg. May double dose up to 12mg/dose and repeat in 1-2 minutes. ***Contraindicated in heart failure patients or heart block. Infuse through the most central IV line available site and immediately flush IV with saline to ensure dose enters circulation. Half-life is < 10 seconds
Consult Cardiology
If the patient is hemodynamically unstable, electrical cardioversion is indicated.

Resources:
Images from Mayo Foundation.
App for Congenital Heart Disease is Heartpedia. Download for more learning.
3. Respiratory

**Physical Exam**
- Increased Work of Breathing- tachypnea, retractions, nasal flaring, head bobbing, grunting
- Aeration/Lung Sounds
- Respiratory Rate
- SpO2 and FiO2

**Blood Gas**
- Order of Accuracy: Arterial Blood Gas > Capillary Blood Gas > Venous Blood Gas
  - Almost always get capillary gas unless UAL is in place.
  - Unless blood gas is arterial the PO2 is inaccurate and rarely clinically useful.
  - If capillary gas is very abnormal (particularly in well-appearing patient), can obtain arterial gas to confirm.

**Evaluation of a blood gas**

<table>
<thead>
<tr>
<th>NORMAL ABG</th>
<th>TERM - 30 WEEKS</th>
<th>&lt; 30 WEEKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.30-7.40</td>
<td>7.25-7.35</td>
</tr>
<tr>
<td>PaCO2</td>
<td>35-45</td>
<td>45-55</td>
</tr>
<tr>
<td>PaO2</td>
<td>80-95</td>
<td>60-95</td>
</tr>
<tr>
<td>BE</td>
<td>+/- 5</td>
<td>+/- 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ABG</th>
<th>Normal</th>
<th>Concerned</th>
<th>Worried</th>
<th>OH MY GOD!</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.25-7.45</td>
<td>7.20-7.25</td>
<td>7.15-7.20</td>
<td>&lt;7.15</td>
</tr>
<tr>
<td>pCO2</td>
<td>35-45</td>
<td>45-55</td>
<td>55-65</td>
<td>&gt;65</td>
</tr>
<tr>
<td>pO2</td>
<td>50-70</td>
<td>45-55</td>
<td>40-50</td>
<td>&lt;40</td>
</tr>
<tr>
<td>Base Deficit</td>
<td>&gt;-5</td>
<td>-5 to -10</td>
<td>-8 to -12</td>
<td>&gt;-13</td>
</tr>
<tr>
<td>SpO2</td>
<td>85-94%</td>
<td>80-85%</td>
<td>75-80%</td>
<td>&lt;70%</td>
</tr>
</tbody>
</table>

**Rule of thumb:**
- If pH > 7.2 = Likely OK
- CO2 in 30s = wean, 40s = wean, 50s = stay, 60s = talk to senior

**Chest X-ray**
- Always obtain Portable Chest X-ray-STAT
- All X-rays will be obtained AP (vs PA) due to patient positioning.
Specific Chest X-ray Findings:
- **RDS-Surfactant Deficiency:** reticulogranular pattern to lung fields (“ground glass”) with air bronchograms
- **TTN:** hyperaeration with symmetric perihilar and interstitial streaky infiltrates (“fluid in fissure”)
- **Pneumothorax:** radiolucent zone of air displacing lung away from lateral chest wall
- **Meconium Aspiration Syndrome:** hyperinflation of the lung fields with flattened diaphragms, bilateral patchy course infiltrates

**TYPES OF RESPIRATORY SUPPORT**

**High Flow Nasal Cannula**
- Provides some distending pressure, similar to “PEEP”
- Maximum Settings (in ELBW): 4 LPM
- In larger infants, flow can be increased higher (2L/kg/minute).
  - Ex. 3kg baby, could use HFNC 6Lpm
- Minimum Settings: 1 LPM
- Settings to order: Flow

**NIPPV (Nasal Intermittent Positive Pressure Ventilation)**
- Provides both a distending pressure (PEEP) and breaths to the infant (PIP)
- Rate intended to ~50% of infant’s respiratory rate
- Maximum settings: Rate 40, PIP 26, PEEP 7.
- Minimum settings: Rate 30, PIP 16, PEEP 5
- Settings to order: Rate, PIP, PEEP, I:Time always 0.5 seconds
- **NIPPV/RAM Cannula: HOW TO START**
  - Rate: <1000 grams – 40, >1000 grams – 30
  - Set Rate should support 50% of the total RR
  - PIP: 18 or 2 above previous intubated setting
  - Reassess (MAX 26 cm H20)
  - PEEP: 5-6 (MAX 7 cm H20)
- **NIPPV/RAM Cannula: WEANING:**
  - PIP is FIRST – by 2 to 16 cm H2O
  - Rate (once PIP is 16 cm H2O)
    - <1000 grams – 40 to 30
    - >1000 grams – 30 is the min
  - Wean PEEP by 1 to 5 or 6
  - Once stable on Rate 30, PIP 16, PEEP 5 for 4 hours transition to HFNC at 4-6 L/min

**Conventional Ventilation**
- Definitions
- Rate: breaths per minute
PIP: peak inspiratory pressure
PEEP: positive end-expiratory pressure
Pressure support: pressure above the PEEP during spontaneous breaths (infant initiated when in SIMV). Infant takes a breath and the ventilator adds pressure to that breath to make it easier for the patient to achieve a good tidal volume.
TV: tidal volume
FiO2: fraction of inspired oxygen
I time: length of time in inspiration
Flow: air flow L/minute

Principles
Oxygenation: pO2 is largely determined by MAP & FiO2
Ventilation: determined by minute ventilation (rate x tidal volume)
Rate controls the number of breaths a minute the ventilator will supply at your given TV or (less frequently) PIP
PIP is the total inspiratory pressure the infant will receive at a predetermined rate. At CHKD, PIP is the peak pressure. At SNGH, the PC (pressure control) setting is added to the PEEP to get the PIP the lungs will receive (aka what you will read on rounds).
Volume Guarantee: A set volume is given for each breath (normal is 5-6 mL/kg), machine will give the volume until the pressure exceeds a set alarm threshold.
Maximum settings: Rate 40, Volume 6 mL/kg, PEEP 6 in ELBW infants. At times older infants may require higher settings than these due to their lung compliance and increased dead space over time.
Minimum settings: Rate 20, Volume 4.5 mL/kg, PEEP 5
Settings to order: Rate, Volume (mL/kg), PEEP, Pressure Support (if in SIMV), I:Time
Always pay attention and report on rounds the pressure required by the infant to maintain your set volume for the ventilator. The saying goes: when in volume, pay attention to the pressure. When in pressure, pay attention to the volume. To prevent volutrauma and lung injury.
Other types of ventilator settings:
Assist Control: A set volume is delivered for each breath the patient takes that triggers the machine, with a backup rate in place (e.g. 20 bpm) if patient became apneic.
Set up/Weaning (Dr. Siegfried’s Guide to Respiratory Support): Volume Guarantee: HOW TO START
Set Rate: 25 – 40

<table>
<thead>
<tr>
<th>WEIGHT</th>
<th>VT (mL/kg)</th>
<th>I-TIME</th>
<th>PEEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.0 kg</td>
<td>4.5-6</td>
<td>0.25-0.35</td>
<td>5-6</td>
</tr>
<tr>
<td>1.0-1.5 kg</td>
<td>4.5-6</td>
<td>0.3-0.4</td>
<td>5-6</td>
</tr>
<tr>
<td>&gt;1.5 kg</td>
<td>5-6</td>
<td>0.3-0.4</td>
<td>5-6</td>
</tr>
</tbody>
</table>

Low PIP: in patients with PIP < 10 cmH20 with: increased WOB, increased O2 requirements, and increased RR and PaCO2
Increase V̇T 0.5-1 mL/kg for Wt <1.0 kg
Increase V̇T 1-2 mL/kg for Wt >1.0 kg
High PIP: Underinflation or Opacification
Increase T₁ and/or Increase PEEP
Can also be caused by large leak
Volume guarantee: WEANING: Wean Rate, Monitor PIP, remember appropriate TV is physiologic, no need to wean TV
If O2<30, PIP <18, PEEP <6: ? Extubate

High frequency jet ventilation (HFJV)
Principles
Exhalation during HFJV is a result of passive lung recoil Used in combination with conventional mechanical ventilation to provide optimal oxygenation. The conventional ventilator provides PEEP and, if needed, “sign breaths”
Tidal volumes are small and are equal or slightly greater than physiologic dead space
Indications for high frequency jet ventilation
persistent/recurrent pneumothoaces or broncho-pleural fistula
pulmonary interstitial emphysema
hypoplastic lungs
need for PIP > 25 or tidal volume > 7ml/kg in ELBW, PIP > 30 for 1000-2000 g infants, PIP > 35 for > 2000 g infants
PPHN unresponsive to conventional ventilation
Risks of jet ventilation
increased risk of severe IVH or PVL in some but not all RCT
increased risk of severe hypocapnea (PCO2 < 30, which may be the reason for increased risk of IVH/PVL)

Initial settings
Rate: ELBW infant - 420 bpm, term or late-preterm - 360 bpm
PEEP range 6-12, usually started 6-8 unless MAP is already high with larger baby
PIP often 2-3 higher than conventional PIP
Need to obtain CXR and blood gas no greater than 1 hour after starting on the jet
Sigh breaths (to treat lobar atelectasis)
Usually, no sigh breaths when starting jet ventilation
if develops lobar atelectasis then start sign breaths 2-4/minute
Sigh PIP should be about 75% of Jet PIP, but no higher than 25 for ELBW

Hypoxia
First increase inspired oxygen
if oxygen already at 100%, increase PEEP by 1-2, goal 9-10 rib inflation
only wean PEEP when directed by attending and when FiO2 < 60%

Hypercapnea
permissive hypercapnea is ok, PCO2 50s and 60s ok if pH > 7.20
increase PIP by 2 unless PIP is already high, then only by 1

Hypocapnia
Avoid PCO2 in 30s, wean PIP by 2
Aggressively wean PIP by at least 2 if PCO2 < 30, after telling attending STAT and get follow up blood gas within 30 minutes
**Wall O2**

100 % oxygen from wall without humidifier at flows of 1L or less (typically ½, ¼, or 1/8 Lpm)

Usually a late intervention used in infants with bronchopulmonary dysplasia who fail a wean to room air

**Surfactant**

Given to premature infant with respiratory distress or an infant requiring high FiO2

Initial dose is 2.5 mL/kg of Curosuf

Second dose is 1.25 mL/kg, if needed

Order “Poractant alfa” known as Curosurf

Benefits: leads to rapid improvement in oxygenation and decrease in the degree of ventilator support required, decrease in the signs of RDS

Possible side effect: pulmonary hemorrhage
Nitric Oxide
Increases intracellular cGMP, which relaxes the vascular smooth muscle -> pulmonary vasodilation.
Settings: 1-20 ppm (typically start at 20ppm)
Side effects: risk of methemoglobinemia due to iNO toxicity (important to obtain one metHb level after starting nitric oxide as per protocol). Rebound hypoxemia when iNO discontinued abruptly.
Approach to wean: Discuss with attending. Once FiO2 has been weaned appropriately as per attending, often can wean from 20 ppm to 5 ppm. When weaning off from 5 ppm, typically wean 1 ppm every 6-12 hours. Only stop iNO if tolerating 1ppm and if FiO2 requirement <50%.

Differential Diagnosis to consider in infant with respiratory distress
- Transient Tachypnea of the Newborn
- Respiratory Distress Syndrome
- Meconium Aspiration Syndrome
- Pneumothorax
- Paralyzed Diaphragm/Eventration
- Congenital Diaphragmatic Hernia
- Neonatal Pneumonia (rare)

Apnea of prematurity
Apnea = absence of breathing > 20 seconds or a shorter pause (> 10 seconds) associated with oxygen desaturation or bradycardia (<100 beats/minute)
Incidence of apnea of prematurity is inversely correlated with gestational age and birthweight
Try to distinguish the type of apnea (central vs obstructive vs mixed)
“As and Bs” are common in premature infants (about 70% experience apnea before 34 weeks gestation). Apnea in a term infant is never physiologic; it requires a full workup to determine the cause.
Apnea of prematurity is a diagnosis of exclusion; therefore, it is important to diagnose and treat any secondary cause.

Significant events:
- Any apnea (monitor alarms if > 20 sec)
- Bradycardia with desaturation requiring stimulation
- Bradycardia with/without desaturation > 20 sec

Non-significant events:
- Feeding related events (unless requiring vigorous intervention)
Ascribing the event to “reflux” is not a valid construct. Multiple studies have shown no correlation with events (other than “choking on feeds”) with reflux.

Document the date and time of the event and describe the event in detail HR, O2 sat, presence of apnea or not, length of event, state of the infant (sleeping, feeding), and what interventions were done if any.

ALTE watches
- If ≥32 weeks, 5 24-hour periods of observation
- If <32 weeks, 7 24-hour periods of observation
- In more mature patients that have a dusky, apnea, bradycardic event occurring soon after delivery, can have 3 day observation period
- After caffeine is discontinued, the ALTE watch can start.
  - The date and time the first scheduled caffeine dose is NOT given is when the “watch” starts
  - For any baby who has “completed” an ALTE watch but remains in the hospital, if infant has a significant ALTE, an observation period (determined by the original gestational age at birth) needs to be restarted and completed

Management
- If less than 32 wga, will start caffeine after delivery with loading dose and daily maintenance dose
- Initial caffeine loading dose = 40 mg/kg IV or PO
- Initial caffeine 8mg/kg/dose daily
  - If remains symptomatic while on caffeine, can weight adjust caffeine or check caffeine level.
  
  **Calculation for target caffeine bolus dosing**
  - Desired target level – current caffeine level = number A
  - Take number A and multiply by 2 and then by current weight = bolus dose in mg
  - Ex. Baby weighs 1480 g and current level is 21.5 mcg/ml. 30 -21.5 = 8.5 -> 8.5 x 2 x 1.48 = 25 mg is the bolus dose

  **Calculation for increase in maintenance dose**
  - Desired target level divided by current caffeine level = number B
  - Take number B and multiply by current daily dose
  - Ex. Baby is on current daily dose of 8.5 mg and the level is 21.5. Desired target level is 30. 30/21.5 = 1.39 -> 1.39 x 8.5mg = 11.8 mg daily new dose for caffeine (can round up to 12mg)
Prevention of bronchopulmonary dysplasia (chronic lung disease)

All infants < 28 weeks gestational age
Dosing: hydrocortisone 0.5mg/kg Q12hrs for 7 days then hydrocortisone 0.5mg/kg Q24hrs for 3 days

Monitor for adrenal insufficiency
If necessary to increase dose due to adrenal insufficiency, then wean as tolerated when clinically stable, per weaning algorithm above

RESPIRATORY RESOURCES
Initial fluids should NOT contain sodium. An infant’s low serum sodium is an indication of increased free fluid intake and elevated sodium indicates excess water loss.

Definitions:
- Low birth weight (LBW) – BW <2,500 grams
- Very low birth weight (VLBW) – BW <1,500 grams
- Extremely low birth weight (ELBW) – BW <1,000 grams

For term and LBW infants
Initial fluids should be D10W, typically started at 80 mL/kg/day. Change to D10L after first BMP or by 24 hours of life, if BMP is reassuring.

D10L = D10 + 1/4NS + 5 mEq KCl per 250 mL of fluid

For VLBW and ELBW infants
Initial fluids should be D10PNC (parenteral nutrition cocktail) at 80 mL/kg/day (do not exceed this rate as this will give too much calcium per day). Also, typically not used for more than 24 hours.
If more fluid is needed and haven’t started TPN, can y in D10W to make up the difference

Components of D10PNC (per 100 mL of fluid)
- D10W which provides glucose at a Glucose Infusion Rate (GIR) of 5.5
- Trophamine (without Cysteine) – 3.8% amino acids
  Early AA administration helps replenish protein that ELBW infants lose after birth
  Early AA also helps promote insulin secretion, decreases hyperglycemia and hyperkalemia in ELBW
- Calcium gluconate – 3.8 mEq. For adequate bone development
- Heparin – 0.5 units/mL per protocol

D10PNC is typically changed to TPN on day two of life in VLBW and ELBW infants once it is available.

Heparin requirements for fluids
- UAL/UVL – 0.5 units/mL
- PICC or CVL – 1 unit/mL
- PIV – no heparin needed
<table>
<thead>
<tr>
<th></th>
<th>Initial dose</th>
<th>Advancing</th>
<th>Goals</th>
<th>Taper goals with increasing enteral feeding volumes below</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preterm</td>
<td>Term</td>
<td>Both</td>
<td>Preterm</td>
</tr>
<tr>
<td>Gest. Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipids</td>
<td>1-2</td>
<td>1-2</td>
<td>0.5-1</td>
<td>3</td>
</tr>
<tr>
<td>Amino acids</td>
<td>3.5-4.0</td>
<td>2-3</td>
<td>0-0.5</td>
<td>3.5-4.0</td>
</tr>
<tr>
<td>Dextrose (GIR)</td>
<td>5-6</td>
<td>7-9</td>
<td>1-2</td>
<td>10-13</td>
</tr>
<tr>
<td></td>
<td>(if &lt;1000g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(if &gt;1000g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total kcal/kg/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Decrease GIR by 1-2 per every 20 mL/kg/day increase in feeds
**Micronutrients – typical requirements**

<table>
<thead>
<tr>
<th></th>
<th>Preterm (0-5 DOL)</th>
<th>Preterm (stable/growing)</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mEq/kg/day)</td>
<td>0</td>
<td>1-5</td>
<td>2-4</td>
</tr>
<tr>
<td>Potassium (mEq/kg/day)</td>
<td>0-2</td>
<td>2-3</td>
<td>2-3</td>
</tr>
<tr>
<td>Magnesium (mEq/kg/day)</td>
<td>0-0.3</td>
<td>0.3-0.5</td>
<td>0.3-0.6</td>
</tr>
<tr>
<td>Calcium (mEq/kg/day)</td>
<td>2-3</td>
<td>3-4</td>
<td>2-3</td>
</tr>
<tr>
<td>Phosphorus (mmol/kg/day)</td>
<td>0.5-1.5</td>
<td>1.5-2.0</td>
<td>1-1.5</td>
</tr>
<tr>
<td>Chloride: Acetate Ratio</td>
<td>Usually 100% Acetate</td>
<td>If more acidotic – add Acetate</td>
<td>If more alkalotic – add Chloride</td>
</tr>
</tbody>
</table>

**Helpful tips:**
- If <1,000 grams AND <5 days old – withhold Cysteine from TPN
- D12.5 is the highest concentration of dextrose that can be given via a PIV
- Will likely need more potassium added to TPN with the use of diuretics
- Mg may need to be left out of initial TPN if mom received Mg during labor
- Lab schedule – typically will obtain daily BMPs and qM/Th TPN panels while on TPN

**Enteral feeding recommendations**
- Initiation of enteral nutrition should be considered within the first 1-3 days of life
- Should be bolus feeds (typically q3h) unless there is intolerance of bolus feeds or if bolus feeding is contraindicated
- Initial feeds, ideally breastmilk. If no breast milk available, then donor milk if baby qualifies. Otherwise formula.
- If < 34 wga OR < 2000 grams, use Enfamil Premature
- If ≥ 34 wga AND 1800-2200g, use transitional formula
- Enfacare 22 kcal/oz for initial feeds
- Once feeds reach 80 mL/kg/day of enteral nutrition, fortify feeds
- Fortify initially with Prolacta 26 kcal/oz for all infants < 1.25 kg and < 34 wga
- Prolacta can be fortified to 26, 28, and 30 kcal/oz
Prolacta cream also available to fortify further up to 32 or 34 kcal/oz
Fortify with Similac HMF < 34 wga OR >1.25 kg AND <1.8kg
This fortification is typically done in two steps over two days
– initial fortification to 22 kcal/oz and then 24 kcal/oz
Fortify with Enfacare if 34-36 wga or 1800-2500 grams

For Term infants
Will often start with PO ad lib feeds (unless on respiratory support or otherwise ill)
Can start with EBM, Enfamil Infant, or Donor Human Milk

For Preterm infants (and <1.25 kg)
Typically start with EBM, DHM, or EPF (using formula is always a last resort option)
Initiate with trophic feeds and continue with this for minimum of three days
Decrease TPN proportionally with increasing volumes of enteral feeds

Typically consider PO trials (either breastfeeding or bottle) at 34 wga with OT

**Feeding schedule** (may need to decrease goal volume if significant cardiac or respiratory disease)

<table>
<thead>
<tr>
<th>Birth Weight (g)</th>
<th>Initiation Rate</th>
<th>Advancement Schedule</th>
<th>How to Advance</th>
<th>Goal Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤750</td>
<td>10-20 ml/kg/day</td>
<td>See feeding guidelines for infants ≤ 1250 gm BW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>751-1250</td>
<td>10-20 ml/kg/day</td>
<td>See feeding guidelines for infants ≤ 1250 gm BW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1251-1500</td>
<td>20 ml/kg/day</td>
<td>If tolerated, may advance after 24-48 hours</td>
<td>20 ml/kg/day</td>
<td>140-160 ml/kg/day</td>
</tr>
<tr>
<td>1501-2000</td>
<td>20 ml/kg/day</td>
<td>If tolerated, may advance after 24-48 hours</td>
<td>25-40 ml/kg/day</td>
<td>140-160 ml/kg/day</td>
</tr>
<tr>
<td>2001-2500</td>
<td>25-30 ml/kg/day</td>
<td>Daily</td>
<td>25-40 ml/kg/day</td>
<td>140-160 ml/kg/day</td>
</tr>
<tr>
<td>&gt;2500 (stable)</td>
<td>50 ml/kg/day OR ad lib with minimum</td>
<td>Daily</td>
<td>25-40 ml/kg/day</td>
<td>140-160 ml/kg/day</td>
</tr>
</tbody>
</table>
### Weight gain goals
Minimum 15-20 g/kg/day (if current weight < 2000g)
Minimum 25-35 g/day (if current weight ≥2000g)
Greater gains are needed for catch up growth, discuss with nutritionist

### When to add vitamins
Once infant tolerates goal volume feeds

<table>
<thead>
<tr>
<th>If receiving:</th>
<th>Baby D drops</th>
<th>Poly-vi-sol w/ Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfortified EBM/DHM, Prolacta, or Similac HMF</td>
<td>Preterm: &lt;0.75 kg 400 units daily</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Preterm: &gt;0.75 kg-2.5 kg 400 units daily</td>
<td>0.5 mL daily</td>
</tr>
<tr>
<td></td>
<td>Preterm: &gt;2.5 kg 400 units daily</td>
<td>0.5 mL BID</td>
</tr>
<tr>
<td></td>
<td>All Term Infants (&gt;37 wga) 400 units daily</td>
<td>--</td>
</tr>
<tr>
<td>Enfamil HMF:</td>
<td>Hematocrit &gt;30 400 units daily</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Hematocrit &lt;30 and &lt;2.5 kg 400 units daily</td>
<td>0.5 mL daily</td>
</tr>
</tbody>
</table>

### Timing of transition off Prolacta
Clinical decision between Neonatologist and Dietician

<table>
<thead>
<tr>
<th>PMA of 33 weeks &amp; ≤1.8 kg</th>
<th>Continue to use EBM/DHM</th>
<th>Wean over 4 days to Enfamil HMF as fortifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMA of 34 weeks &amp; &gt; 1.8 kg</td>
<td>Discontinue DHM</td>
<td>Change to EPF</td>
</tr>
<tr>
<td>PMA of 34 weeks &amp; &gt; 1.8 kg</td>
<td>Continue EHM</td>
<td>Wean over 4 days to Enfamil HMF</td>
</tr>
</tbody>
</table>
For Q3 hour feeds

<table>
<thead>
<tr>
<th>LAST DAY OF 100% HUMAN MILK DIET</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
<th>Prolect+ HP/MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSITION DAY 1 CMB &amp; Prolect+ H’MF</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
<td>Prolect+ HP/MF</td>
<td>Prolect+ HP/MF</td>
<td>Prolect+ HP/MF</td>
<td>Prolect+ HP/MF</td>
<td>Prolect+ HP/MF</td>
<td>Prolect+ HP/MF</td>
</tr>
<tr>
<td>TRANSITION DAY 2 CMB &amp; Prolect+ H’MF</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
</tr>
<tr>
<td>TRANSITION DAY 3 CMB &amp; Prolect+ H’MF</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>Prolect+ HP/MF</td>
</tr>
<tr>
<td>TRANSITION DAY 4 CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
<td>CMB</td>
</tr>
</tbody>
</table>

**Transitioning off Prolacta for Continuous Feeds:**

Transitioning off EHM/DHMF & Prolacta to EHM/ DHMF & traditional (bovine) HMF or formula is done at 33-34 weeks with an MD order: It is at least a 4-day process, increasing the frequency of traditional (bovine) HMF or formula feeds in a 4-hr feeding cycle, while simultaneously decreasing Prolacta HMF feeds.

<table>
<thead>
<tr>
<th>Feeding sequence of Q4H continuous feeding cycles over 6 in 24hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000- 2400</td>
</tr>
<tr>
<td>Transition Day 1</td>
</tr>
<tr>
<td>Transition Day 2</td>
</tr>
<tr>
<td>Transition Day 3</td>
</tr>
<tr>
<td>Transition Day 4</td>
</tr>
</tbody>
</table>

**Basic calculations**

**Total fluids**

Calculated in mL/kg/day (24 hour day). This includes all mIVF, feeds, continuous IV medications, and flushes. Always know the breakdown of IV vs enteral fluid intake for reporting on rounds and in documentation.
Example: Total fluids are 140 mL/kg/day, 80 mL/kg of DHM and 60 mL/kg of TPN

Enteral feeds
PO intake is measured in mL/kg/day
Take total amount of enteral intake and divide by weight (in kg)
Example: 1.4 kg baby took in a total of 161 mL in a 24 hour period
= 161 mL/1.4 kg
= 115 mL/kg/day

Urine Output (UOP)
Calculated in mL/kg/hr (if baby is <24 hours old or there is not 24 hours of data, only divide by the number of hours of data that you do have).
Example: 1.2 kg baby admitted 8 hours ago has had 20 mL of UOP total since admission…
= 20 mL/1.2 kg/8 hours
= 2.1 mL/kg/hr
If the same 1.2 kg baby has been in NICU for 24 hours and had 20 mL of UOP…
= 20 mL/1.2 kg/24 hr
= 0.7 mL/kg/hr

Glucose Infusion Rate (GIR)
Calculated at mg of Dextrose/kg/min
GIR = [%Dextrose x rate] / [weight x 6]
Rate is mL/hr of IV fluids or TPN
Weight is in kg
Example: 1.35 kg baby on D12.5 at 130 mL/kg/day
= [12.5 x 7.3] / [1.35 kg x 6]
= 11.3 mg/kg/min
Cornell University has a handy GIR calculator online

Calorie calculations
Dextrose containing fluids
Divide the volume of each fluid by the patient’s weight – mL/kg
Multiply by the % dextrose (not the percentage – e.g., for D5 you multiply by 5)
Multiply by 0.034
Simple method for D10: multiply the cc/kg/d x 0.34 gives you the kcal/kg/d.

Enteral feeds
Divide the total volume of enteral intake by the patient’s weight in kg to get mL/kg/d
Multiply by the caloric density of the formula (usually 20, 22, 24, 27, or 30 Kcal/oz)
Divide by 30mL/oz
Shortcuts - 20Kcal/oz = 0.67Kcal/mL; 22Kcal/oz = 0.73Kcal/mL; 24Kcal/oz = 0.8Kcal/mL; 27Kcal/oz = 0.9Kcal/mL

TPN – remember to include volume from both bags of TPN administered in a 24-hour period
   For **Dextrose** containing component:
   \[(\text{mL/kg/day}) \times \% \text{ dextrose} \times 0.034\]
   This is done exactly like other dextrose containing fluid calculations

   For **Lipids**:
   \[(\text{mL/kg/day}) \times 2\]

   For **Amino Acids**:
   \[(\text{grams/kg/day}) \times 4\]

   **All of these TPN calculations yield kcal/kg/day**

**Hyperglycemia**

May be secondary to high glucose intake. Very common in ELBW, associated with increased mortality. GIR >10-12 can lead to hyperglycemia

**Causes**

   Factitious: Blood drawn from IV line containing glucose
   Transient: Low birth weight, Age <72h, Excessive glucose administration (hyperosmolar formula, high glucose infusion rate GIR)
   Common cause: Sepsis - especially fungal infections, Stress response (catecholamine response), Hypoxia, Steroid use, Ionotrope use
   Idiopathic: diagnosis of exclusion

**Evaluation:** rule out false high glucose using bedside glucose; labs to consider - CBC, cultures – to evaluate for sepsis, BMP - hyperglycemia may cause osmotic diuresis, leading to electrolyte loss and dehydration, Serum insulin, C-peptide, ketones, Genetic testing

With patients with hyperglycemia:
   Recheck glucose level
   Know the GIR that is being administered
   Feeding enterally decreases risk of hyperglycemia by promoting pancreatic function and the secretion of insulin
Treat the underlying cause (ie, sepsis, respiratory distress, medications), +/- decrease GIR being administered
Can start insulin if two glucoses 300+
  Start continuous insulin drip (range 0.01 to 0.2u/kg/hr). Start at 0.02 u/kg/hr. Titrate up or down by 0.01-0.02 u/kg/hr. In general, if glucose drops to less than 150, suspend the insulin drip.
Monitor glucose and potassium levels closely
Wean insulin for every glucose <200

**Hypoglycemia**
If the sample is from a BMP, send an istat blood glucose to confirm as BMP glucose can be artificially low due to time between collecting the lab and the lab being run.
No absolute definition for low blood glucose
AAP recommends aggressive screening and treatment in late preterm, SGA, LGA infants

**Causes**
- Factitious
  Can be falsely low in BMP/lab sample - confirm with bedside glucose meters
  High hematocrit can cause false low glucose
  Umbilical artery catheter near pancreas
- Transient: Maternal drug therapy, Insufficient calorie/glucose intake, Polycythemia, HIE/Asphyxia, Perinatal Stress, RDS, Infection/Sepsis/Shock, Hypothermia
- Persistent: Congenital Hyperinsulinism (most common cause), Isolated GH Deficiency, Isolated ACTH Deficiency, Adrenal Insufficiency, Congenital Hypothyroidism, Inborn Error of Metabolism, Galactosemia, Glycogen Storage Disorder, FA Oxidation Defect (MCAD, LCHAD), AA Metabolism Disorder (MSUD, Tyrosinemia), Organic Aciduria (MMA, PPA), Glucose Transporter Deficiency - "neurohypoglycemia"
  Syndrome: Beckwith-Weidemann
  Idiopathic - diagnosis of exclusion

**Evaluation**
Symptoms include: Irritability, Tremors, Jitteriness, Floppiness, Apnea, Cyanosis, Poor feeding, Exaggerated Moro, Eye Rolling, Seizures, Weak/High-Pitched Cry
Rule out false low glucose using bedside glucose Labs to consider: Insulin level, Serum ketones (β-OH butyrate), FFA - can indicate excessive insulin, Urine ketones, reducing substances, C-Peptide levels, IGF, GH, Cortisol, ACTH, Thyroid studies, Ammonia, Lactate, Plasma acylcarnitine, Serum amino acids, urine organic acids US/Echo Genetic testing

Treatment
With low glucose, feed infant enterally and recheck in 30-60min
Will need intervention if:
  Symptomatic with glucose <40
  Symptomatic with initial glucose <25 and/or follow-up glucose <40 in hours 0-4 of life
  Asymptomatic with glucose <35 and/or follow-up glucose <45 in hours 4-24 of life

Transient
  Oral dextrose gel
  IV glucose (2cc/kg D10 bolus), followed by continuous infusion (80cc/kg/day for GIR of 5.5) - highest dextrose concentration through PIV is D12.5. If there is continued hypoglycemia, can increase GIR incrementally by one

Persistent
  Corticosteroids
  Diazoxide - 10 mg/kg/day divided q8h PO, trial for five days (will need echocardiogram to monitor for pulmonary hypertension)
  Consider: GH, Glucagon

For weaning GIR, fluids can typically be decreased by a GIR of one for every two glucoses >60
Hyponatremia

With increased extracellular water:
- From increased fluid administration, increased third spacing of fluids (sepsis, shock, increase capillary leak)
- May be secondary to SIADH after CNS injury or IVH
- Treat with free water restriction
- If level is <120 mEq/L and symptomatic, can consider treatment with 3% saline boluses

With decreased extracellular water:
- From excess diuretic use, vomiting, diarrhea
- Treat with replacing sodium and water while preventing further loss of sodium

Hyponatremia

Symptomatic and <40 mg/dL \(\rightarrow\) IV glucose

**ASYMPTOMATIC**

<table>
<thead>
<tr>
<th>Birth to 4 hours of age</th>
<th>4–24 hours of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>INITIAL FEED WITHIN 1 hour</td>
<td></td>
</tr>
<tr>
<td>Screen glucose 30 minutes after 1st feed</td>
<td></td>
</tr>
<tr>
<td>Continue feeds every 2–3 hours</td>
<td></td>
</tr>
<tr>
<td>Screen glucose prior to each feed</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial screen &lt;25 mg/dL</th>
<th>Screen &lt;35 mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed and check in 1 hour</td>
<td>Feed and check in 1 hour</td>
</tr>
</tbody>
</table>

- **<25 mg/dL**
  - IV glucose*
- **25–40 mg/dL**
  - Refeed/IV glucose* as needed
- **<35 mg/dL**
  - IV glucose*
- **35–45 mg/dL**
  - Refeed/IV glucose* as needed

**Target glucose screen >45 mg/dL prior to routine feeds**

*Glucose dose – 200 mg/kg (dextrose 10% at 2 mL/kg) and/or IV infusion at 5–9 mg/kg per min (80–100 mL/kg per day). Achieve plasma glucose level of 40–50 mg/dL.

Symptoms of hypoglycemia include: irritability, tremors, jitteriness, exaggerated Moro reflex, high-pitched cry, seizures, lethargy, floppiness, cyanosis, apnea, poor feeding.

Hypernatremia

Defined as >150 mEq/L

- If decreased extracellular water – can be caused by increased free water loss or increased insensible water loss
- If increased extracellular water – can be caused by increased NS administration or sodium bicarb administration

Ensure that total fluids are at goal

Treat by replacing free water
Must not correct too quickly as this can lead to seizures
Goal to decrease sodium level by 0.5 mEq/L/kg/h or less; target correction time 24-48 hours

**Hyperkalemia**
If sample is hemolyzed, obtain a repeat level to confirm if potassium > 6.5 mEq/L, preferably free flowing venous sample
Defined as level >5.5 mEq/L, can by symptomatic at levels >6
Concern is primarily cardiac conduction
If level is true, remove potassium from IV fluids
Observe telemetry/consider obtaining an EKG to evaluate for peaked T waves
Consider calcium gluconate 60-100 mg/kg slow IV push
For preterm infants, can use insulin and glucose in combination to lower serum potassium level by shifting extracellular potassium into the cell. There is a powerplan in Powerchart for a single bag with the glucose/insulin infusion for hyperkalemia.
Can consider diuretic like furosemide 1mg/kg in patients with good renal function. Those with poor renal function may require higher doses. Can improve urinary potassium excretion.

**Hypocalcemia**
If serum calcium is low, repeat lab and obtain an ionized calcium level for confirmation. Check albumin, as low albumin can make calcium falsely low.
Typically defined as serum calcium <6.3 mg/dL
Causes
- Early-Onset Hypocalcemia (first week of life): IUGR, IDM, Preterm infant, Perinatal stress - asphyxia, acidosis, Poor PO intake, Hypomagnesemia, Congenital syndromes: DiGeorge/Velocardiofacial Syndrome
- Late-Onset Hypocalcemia (after first week of life): Hyperphosphatemia, Vitamin D Deficiency, Diuretic therapy, Blood/exchange transfusion
Evaluation - can present with: Apnea, stridor, Irritability, jitteriness, tremors, seizures, Hyperreflexia, clonus, tetany, Arrhythmia (prolonged QT), Feeding intolerance, Skeletal fractures
Treat if symptomatic. Can give IV calcium gluconate via PIV, IV 10% calcium gluconate 100-200 mg/kg, over 15-20 min. Risk of extravasation through PIV causing subcutaneous
calcium deposition leading to limited joint movement and nephrocalcinosis

**Hypercalcemia**

Defined as ionized calcium >1.35 mmol/L  
Discontinue extraneous calcium intake  
Increase phosphorus in TPN  
Causes: Neonatal Hyperparathyroidism, Familial Hypocalciuria, Hypophosphatemia, Hypothyroid/Hyperthyroid, SQ Fat Necrosis, Hypothermia, Renal Tubular Acidosis, ECMO  
Evaluation - can present with: Lethargy, hypotonia, Feeding intolerance, constipation, failure to thrive, Bradycardia (short QT)  
Treatment  
- Asymptomatic: consider bisphosphonates, glucocorticoids  
- Symptomatic: discontinue parenteral calcium intake, increase calcium excretion using furosemide  
- Refractory: consider parathyroidectomy

**Hypophosphatemia:** Hypercalcemia, Renal Tubular Acidosis  
**Hyperphosphatemia:** Perinatal stress – asphyxia, Transient Hyperphosphatemia of Infancy  
**Hypomagnesemia:** IUGR, IDM, Preterm infant, Poor magnesium intake, Hypocalcemia, Hypoparathyroid, Renal wasting - Gitelman syndrome, Nephrocalcinosis, Diuretic therapy, Citrated blood exchange transfusions  
**Hypermagnesemia:** Increased maternal levels (magnesium sulfate for pre-eclampsia, neonatal neuroprotection), Excess magnesium intake (TPN)
5. GI

Necrotizing enterocolitis

**Epidemiology**: timing of onset inversely related to gestational age (i.e. occurs closer to one month in premature infants and closer to one week in term infants). This may be related to earlier enteral feeding in term infants higher risk in extremely low BW (<1000g) and very low BW (<1500g) infants other risk factors: hypothermia, congenital heart disease, sepsis

**Symptoms**

GI symptoms: abdominal distension, bloody BMs, increased residuals or emesis

Systemic symptoms: hemodynamic instability (hypotension, temperature instability, bradycardia), lethargy, increased A/Bs, poor glucose control

Physical exam findings: abdominal distension, firmness, or tenderness

- Red flags
  - palpable mass, indicating fixed bowel loops and edema
  - abdominal wall erythema or crepitus
  - discolored scrotum in males

**Diagnosis**

what to do if you're concerned? Assess the patient! Consider holding feed(s).

Labs: CBC, CRP, blood cultures, lactate, blood gas

- Labs findings: thrombocytopenia, hyponatremia, metabolic acidosis (lactic acidosis), neutropenia, leukocytosis

blood cultures only positive in 1/4 of infants

2-view AXR (AP and left lateral decubitus)

gas-filled bowel loops may be present but this is non-specific pneumatosis intestinalis: gas in the intestinal wall. Intestinal bacteria ferment carbs and produce hydrogen gas.
Portal venous gas pneumoperitoneum, present in up to 1/3 of infants. Indicates perforation -> contact attending then Pediatric Surgery STAT.

If in Level 2, this warrants urgent transfer to NICU.

Staging

<table>
<thead>
<tr>
<th>STAGE</th>
<th>CLASSIFICATION</th>
<th>SYSTEMIC SIGNS</th>
<th>ABDOMINAL SIGNS</th>
<th>RADIOGRAPHIC SIGNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>Suspected</td>
<td>Perinatal stress, temperature instability, apnea, bradycardia, lethargy</td>
<td>Gastric retention, abdominal distention, emesis, heme-positive stools</td>
<td>Normal or intestinal dilation, mild ileus</td>
</tr>
<tr>
<td>Ib</td>
<td>Suspected</td>
<td>As above</td>
<td>Grossly bloody stools</td>
<td>As above</td>
</tr>
<tr>
<td>Iia</td>
<td>Definite, mildly ill</td>
<td>As above</td>
<td>As above, with absent bowel sounds, with or without abdominal tenderness</td>
<td>Intestinal dilation, ileus, pneumatosis intestinal</td>
</tr>
<tr>
<td>IIb</td>
<td>Definite, moderately ill</td>
<td>As above, with mild metabolic acidosis and thrombocytopenia</td>
<td>As above, with no bowel sounds, tenderness, with or without abdominal cellulitis or right lower-quadrant mass</td>
<td>As above, with ascites</td>
</tr>
<tr>
<td>IIIa</td>
<td>Advanced, severely ill, intact bowel</td>
<td>As above, with hypotension, bradycardia, severe apnea, metabolic acidosis, respiratory acidosis, disseminated intravascular coagulopathy, and neutropenia</td>
<td>As above, with peritonitis, marked tenderness, and abdominal distention</td>
<td>As above</td>
</tr>
<tr>
<td>IIIb</td>
<td>Advanced, severely ill, perforated bowel</td>
<td>As above</td>
<td>As above</td>
<td>As above, with pneumoperitoneum</td>
</tr>
</tbody>
</table>

**Management:** Confirm feeds are being held and place a gastric decompression tube
Start or increase IV fluids and consider starting TPN
IV antibiotics: ampicillin, gentamicin/amikacin, oxacillin. Due to
gentamicin resistance at CHKD, may use amikacin at NICU
instead of gentamicin.
  depending on the infant's history, symptoms, and diagnostic
  findings, may consider 48-hour rule out vs. 5 vs.7-14 days of
  abx
serial abdominal x-rays
blood products if anemic, thrombocytopenic, or coagulopathic
pressors for blood pressure support
respiratory support: abdominal distension may limit pulmonary
reserve
up to 50% of infants may require surgical intervention
ex-lap with resection of necrotic bowel vs. peritoneal drain
  placement at the bedside (often done in infants < 1500g)

Outcomes
Mortality: Surgically treated patients have mortality rate of about
35% compared to 20% in those medically managed. In those
medically managed, survival correlates with prematurity and
weight.
Post-op complications
  Short-term: wound infection, breakdown, or dehiscence,compartent syndrome
  Long-term: intestinal stricture, short-gut syndrome,
    neurodevelopmental concerns

Bilious Emesis
Intestinal atresia
Duodenal: failure of recanalization of this bowel segment during
development. associated with polyhydramnios, Down
syndrome, congenital heart
disease. more common in males.
presents with bilious emesis a
few hours after birth, no
distention
  AXR: “double bubble”

  Management: gastric
decompression tube, surgery
in 24-48 hours
Jejunoileal: mesenteric vascular
accident during fetal life
Presents with bilious emesis, abdominal distension within 24 hours
AXR: air-fluid levels proximal to the lesion or triple bubble
Management: gastric decompression tube, surgery in 12-24 hours

**Midgut malrotation/volvulus**
Incomplete bowel rotation during the 1st trimester, causing the midgut to twist around the superior mesenteric vessels. Leads to obstruction and potential infarction
Typically presents with volvulus within the first week of life
Infants may become critically ill with hemodynamic instability, metabolic acidosis, bowel necrosis and perforation
Diagnosis with ultrasound or upper GI study
Management: surgery to release fibrous tissue (Ladd’s band) between retroperitoneum and duodenum

**Meconium ileus**: retention of thick meconium in the bowels, leading to obstruction
Associated with cystic fibrosis
Up to half of infants have associated volvulus, jejunoileal atresia, bowel perforation and/or meconium peritonitis
Presents with abdominal distension, bilious emesis, palpable bowel loops
May expel mucous plugs with rectal exam
AXR: distended bowel loops with thickened bowel wall
“ground glass” sign: meconium mixed with swallowed air
Management: Gastrograffin enema if stable or surgery
GI RESOURCES
Necrotizing Enterocolitis
https://clinicalgate.com/necrotizing-enterocolitis/

Images obtained from Radiopaedia, which is a great resource for learning how to read images.

Bilious Emesis
HEMATOLOGY RESOURCES
Unconjugated Hyperbilirubinemia (Pages 400-409, 672-685)

<table>
<thead>
<tr>
<th>CAUSES</th>
<th>Non-Physiologic Hyperbilirubinemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiologic Hyperbilirubinemia</td>
<td>• Breast-Feeding Jaundice (early onset)</td>
</tr>
<tr>
<td>• Peaks day of life 3-5</td>
<td>• Breast Milk Jaundice (late onset)</td>
</tr>
<tr>
<td>• Prematurity (more severe, lasts longer)</td>
<td>• Hemolytic Disease of Newborn</td>
</tr>
<tr>
<td>• Bruising (increased bilirubin load from RBC breakdown)</td>
<td>• ABO Incompatibility</td>
</tr>
<tr>
<td>• Breast-Feeding (decreased hepatic excretion, increased enterohepatic circulation)</td>
<td>• C, D (Rh), E</td>
</tr>
<tr>
<td>• Severe weight loss/dehydration</td>
<td>• Infection (jaundice as only sign of sepsis)</td>
</tr>
<tr>
<td>• Labor induction with oxytocin</td>
<td>• Cephalohematoma/Subdural Hematoma</td>
</tr>
</tbody>
</table>

Exclusions
• Jaundice in first 24h
• Rising rate 0.2+mg/dL/h or 5+mg/dL/day
• If TcB 10+, 75%ile on Bhutani nomogram, or within 3 mg/dL of phototherapy light level, check T/D bilirubin

Evaluation
If maternal blood type O positive or Rh negative, check Blood Type and DAT status
Transcutaneous Bilirubin while in Newborn nursery
If SGA or late preterm (35-36.6 wga), check TcB at 24hrs and 72 hrs or day of discharge
All the other babies, check TcB at 36hrs
If TcB 10+, 75%ile on Bhutani nomogram, or within 3 mg/dL of phototherapy light level, check T/D bilirubin
Total + Direct Bilirubin while in NICU/Special Care Nursery
Initial at 24hrs, if DAT-positive, check at 12hrs and q12h afterwards
Physical exam:
5+: Face
10+: Upper Chest
12+: Abdomen
15+: Palms & Soles
However, studies have shown that even the most astute pediatrician is not good at determining bilirubin level by physical exam.

Subtle abnormal neurologic signs can indicate early bilirubin encephalopathy. Consider CBC with differential, reticulocyte count. Consider albumin (<3 is a risk factor) - assess fraction of unbound bilirubin in circulation. Consider further testing as indicated.

**Treatment**

Determining light level for initiating phototherapy or exchange transfusion

35+ weeks - by AAP Bhutani nomogram

(BiliTool: [https://biltool.org/](https://biltool.org/))

- Use total bilirubin. Do not subtract direct reacting or conjugated bilirubin.
- Risk factors = isoimmune hemolytic disease, GSPD deficiency, asphyxia, significant lethargy, temperature instability, sepsis, acidosis, or albumin < 3.0g/dL (if measured)
- For well infants 35-37 6/7 wk can adjust TSB levels for intervention around the medium risk line. It is an option to intervene at lower TSB levels for infants closer to 35 wks and at higher TSB levels for those closer to 37 6/7 wk.
- It is an option to provide conventional phototherapy in hospital or at home at TSB levels 2-3 mg/dL (35-50mmol/L) below those shown but home phototherapy should not be used in any infant with risk factors.
Exchange transfusion levels for 35+ weeks

Determining light level for initiating phototherapy or exchange transfusion for pre-term infants

- If <35 weeks and less than 48 hours old, use birthweight or gestational age
- If <35 weeks AND > 48 hours hold, use Stanford Premie BiliRecs: https://pbr.stanfordchildrens.org/
- If the infant was born before 35 wga but is now corrected 35cga, still cannot technically use the BiliTool graph. The maximum level on Premie BiliRecs is 13.9 w/o risk factors and the bottom curve on BiliTool is 15, so would use light level 14-15 as a guideline for those babies. If they have neurotoxicity risk factors, would use the maximum premie bili rec for with risk factors which is 11.9

<table>
<thead>
<tr>
<th>Birth Weight</th>
<th>PTX: LL DOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-750g</td>
<td>5</td>
</tr>
<tr>
<td>751-1000g</td>
<td>5</td>
</tr>
<tr>
<td>1001-1500g</td>
<td>6-8</td>
</tr>
<tr>
<td>1501-2000g</td>
<td>8-9</td>
</tr>
</tbody>
</table>
**Table 100-1. SUGGESTED PHOTOTHERAPY AND EXCHANGE TRANSFUSION CONSENSUS RECOMMENDATIONS IN PRETERM INFANTS <35 WEEKS' GESTATIONAL AGE**

<table>
<thead>
<tr>
<th>Gestational Age* (wk)</th>
<th>Begin Phototherapy (total serum bilirubin mg/dL)</th>
<th>Exchange Transfusion (total serum bilirubin mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;26</td>
<td>Optional: start right after birth</td>
<td>N/A</td>
</tr>
<tr>
<td>&lt;28 0/7</td>
<td>5–6</td>
<td>11–14</td>
</tr>
<tr>
<td>28 0/7–29 6/7</td>
<td>6–8</td>
<td>12–14</td>
</tr>
<tr>
<td>30 0/7–31 6/7</td>
<td>8–10</td>
<td>13–16</td>
</tr>
<tr>
<td>32 0/7–33 6/7</td>
<td>10–12</td>
<td>15–18</td>
</tr>
<tr>
<td>34 0/7–34 6/7</td>
<td>12–14</td>
<td>17–19</td>
</tr>
</tbody>
</table>


Phototherapy - photoisomerization to an excretable form.

Blue high-intensity LEDs
- Risks: retinal degeneration - need eye protection.
- bronze-baby syndrome (photodestruction of copper porphyrins)
- Contraindication to phototherapy -- congenital erythropoietic porphyria

IVIG
- Can be used if bilirubin rising despite phototherapy or in the setting of immune (ABO or Rh) incompatibility in efforts to avoid exchange transfusion. Blocks Fc receptors, competes with sensitized neonatal RBCs and prevents further hemolysis

Exchange Transfusion - double volume exchange with whole blood (replaces 85% of circulating RBCs)
- Total bilirubin can be decreased by 50% of pre-exchange level
- Chronic bilirubin encephalopathy (Kernicterus) – Tetrad: choreoathetoid CP, high-frequency sensorineural hearing loss, vertical gaze palsy, dental enamel hypoplasia

**Conjugated Hyperbilirubinemia** (Pages 392-400)
- Direct bilirubin is 20% of total bilirubin OR direct bilirubin 1.0 or higher if total bilirubin is < 5 mg/dl
- Always pathologic!
Biochemical marker of cholestasis, sign of hepatobiliary dysfunction

**Anemia (Pages 557-564)**

**Causes**

Hemorrhagic Anemia (loss of RBCs) - pallor without cyanosis or jaundice, vascular instability
- Placental insufficiency. Umbilical cord anomalies.
- Fetomaternal hemorrhage.
- Subgaleal/Subaponeurotic hemorrhage > Cephalohematoma > Caput succedaneum.
- Intracranial hemorrhage. Pulmonary hemorrhage.
- Visceral parenchymal hemorrhage (liver, spleen, kidneys, adrenal glands)

Hemolytic Anemia (destruction of RBCs) - pallor with early jaundice

Hypoplastic (underproduction of RBCs)

Physiologic Anemia of Infancy: decreases by 3-4 weeks, nadir at 8-12 weeks – Term (Hg 11); Preterm (7-9)

**Evaluation**

<table>
<thead>
<tr>
<th></th>
<th>Hct</th>
<th>Hgb</th>
</tr>
</thead>
<tbody>
<tr>
<td>37-40 weeks</td>
<td>50-55</td>
<td>16.5 - 18</td>
</tr>
<tr>
<td>32-34 weeks</td>
<td>45</td>
<td>14.5</td>
</tr>
<tr>
<td>26-30 weeks</td>
<td>40</td>
<td>13.5</td>
</tr>
</tbody>
</table>

**RBC Indices**
- Microcytic (fetomaternal, TTTS, thalassemia)
- Normocytic (acute hemorrhage, systemic disease, hypoplastic anemia, intrinsic RBC defect)

**Blood Smear:** Spherocytes, Elliptocytes, Schistocytes, Pyknocytes
Blood Type, DAT
Other: RBC Enzyme Study (intrinsic RBC defect), Bone
Marrow aspiration (concern for hypoplastic or aplastic
anemia), TORCH infection serologies, Kleihauer-Betke test
(fetomaternal hemorrhage), Abdominal US, Head US (occult
hemorrhage)

Treatment
Ongoing deficit replacement to maintain effective oxygen-
carrying capacity
Emergent Transfusion at Birth: use type O, Rh-negative, not
cross-matched packed RBCs
Neonatal routine pRBC transfusion: Irradiated, CMV-
immune, leukocyte-depleted, 10-15 cc/kg, transfuse over 4
hours
NPO for 12 hours following completion of transfusion, then
resume half-volume feeds for 2 feeds then full feeds
Goal Hematocrit in neonatal period: 30+: ELBW on high-
frequency jet ventilation. 35+: Neonate requiring pressors for
hypotension. 40+: Neonate with congenital heart disease or
PPHN
Nutritional replacement (iron, folate, vitamin E)

Polycythemia (Pages 484-488, 826-830)
Hematocrit > 65% OR hemoglobin > 22 g/dl
About half of infants with polycythemia are symptomatic from
hyperviscosity: Tissue hypoxia, Microthrombi, Metabolic
acidosis, Hypoglycemia

Causes
Maternal/Placental: IUGR, smoking: fetal hypoxia →
increased erythropoietin production, Placental insufficiency,
Precipitous delivery: intrapartum asphyxia → enhances net
umbilical flow towards infant, Delayed cord clamping, Twin
Twin Transfusion Syndrome (TTTS) → Twin Anemia-
Polycythemia Sequence (TAPS), Post-dates
Neonatal: Infant of Diabetic Mother IDM: increased oxygen
consumption, Beckwith-Weidemann (secondary
hyperinsulinsim), Thyrotoxicosis, CAH

Evaluation
Hemoglobin & Hematocrit
Physical Exam - non-specific clinical signs from
hyperviscosity

Treatment
Asymptomatic → expectant observation
Symptomatic → consider Partial Exchange Transfusion PET (exchange normal saline for blood). Desired Hct should be 50-55%. Volume to be exchanged in a term infant is almost always in the range of 40-60 ml/kg. If calculated volume is outside this range, re-check the calculations.

\[
\text{Volume (ml)} = \frac{\text{Initial Hct} - \text{Desired Hct} \times \text{Weight (kg)}}{\text{Initial Hct}} \times 90 \text{ ml/kg}
\]

**Thrombocytopenia** (Pages 902-907)

Most common hematologic abnormality
- Mild: 100-149 (K)
- Moderate: 50-99 (K)
- Severe: <50 (K)

**Causes**
- Maternal: Chronic Intrauterine Hypoxia (most common), Preeclampsia/HELLP, TORCH infection, Medications, Auto-Immune: ITP, lupus, medication-induced
- Placental: Placental Abruption
- Neonatal: Decreased Platelet Production: TORCH – Rubella, Congenital Leukemia, Trisomy 21, 18, 13, Turner Syndrome, Fanconi Anemia, TAR Syndrome
- Neonatal: Increased Platelet Destruction: Birth Asphyxia, Pathological State: RDS, PPHN, Sepsis, NEC; Thrombosis, DIC, Kasabach-Merritt Syndrome, Allo-Immune: most common cause of severe thrombocytopenia <72h of age
- Neonatal: Platelet Dysfunction: Glanzmann Disease, Metabolic Syndrome, Medication-Induced

**Evaluation**
- CBC/Platelet Count
  - Fetal: Most commonly due to neonatal alloimmune thrombocytopenia
  - Early-Onset Neonatal - nadir at day 4-5, return to normal by day 7-10
  - Most commonly due to placental insufficiency or fetal hypoxia. Can be associated with transient neutropenia and polycythemia. Clinically unstable infants and/or preterm infants have higher risk of bleeding
  - Late-Onset Neonatal
    - Presumed sepsis or NEC until proven otherwise
    - At significant risk of hemorrhage
Treatment
Platelet transfusion - 10cc/kg should raise platelet count by ~50 (K). Transfuse if actively bleeding.
Goal platelet count in neonatal period:
  30+: all neonates
  50+: clinically unstable, concurrent coagulopathy
  >75-100: IVH protocol, ELBW on high-frequency jet ventilation, post-operative period

Coagulation Disorders (Pages 584-590)
Neonatal platelets are hyporeactive, but balanced by increased vWF activity
Factor V, Factor VIII, Fibrinogen at normal levels
Vitamin-K Dependent (Factor II, VII, IX, X) 50% of normal adult values

Causes
Congenital: Hemophilia A (Factor VIII) - severe factor VIII deficiency (activity <1%) most common congenital coagulation disorder, often presents with bleeding manifestations during first month of life, Hemophilia B (Factor IX), von Willebrand Disease, Isolated Factor Deficiencies

Acquired

Hemorrhagic Disease of Newborn (vitamin K deficiency bleeding in newborn)
- Early: first 24h, maternal medications, presents with early severe bleeding
- Classic: day 1-7, tends to occur in infants who did not receive vitamin K or receiving inadequate overall milk intake
- Late: between 2 and 12 weeks, exclusively breast-fed, usually present with ICH

Consumptive Coagulopathy - DIC (sepsis, NEC, severe RDS, asphyxia), Liver disease, Multiple organ dysfunction

Evaluation
- Coagulation studies: platelets >100, fibrinogen >100, PT <45sec, PTT <sec, Factor levels, D-dimer (concern for DIC), Rule out underlying hepatic condition (e.g. capillary hemangioma)

Treatment
- Treat underlying cause for consumptive coagulopathy
- Active Bleeding and/or Fibrinogen <100
  - FFP (start 10cc/kg) - coagulation factors. Increase PT/PTT
  - Cryoprecipitate (start 10cc/kg) - concentrated Factor VIII and fibrinogen
  - Vitamin K

Thromboembolic Disorders (Pages 590-598)
- Inherited blood coagulation disorders that predispose to thrombosis

Causes
- Thrombophilic State: Factor V Leiden, Prothrombin mutation, Antithrombin deficiency, Protein C, S deficiency, MHTR (hyperhomocysteinemia), Maternal lupus/antiphospholipid antibodies
- Arterial: Spontaneous Arterial Thrombosis, Arterial Ischemic Stroke: second most common etiology of neonatal seizures, Purpura Fulminans
Venous: Cerebral Sinovenous Thrombosis, Deep Vein Thrombosis: indwelling catheters increase risk, Right Atrial Thrombosis: echocardiography, Renal Vein Thrombosis: most common non-catheter associated thrombosis (Palpable abdominal mass, hematuria, thrombocytopenia), Portal Vein Thrombosis: associated with umbilical vein catheterization

Evaluation: Coagulation studies (PT, PTT), Anti-Xa levels, Imaging as needed

Treatment

Anticoagulation: Indicated with evidence of thrombus propagation, multiple emboli, severe pro-thrombotic state, Contraindicated with intracerebral hemorrhage
Primary treatment = LMWH (Lovenox)
Infants < 2 months: Initial dose
   Prophylaxis: 0.75 mg/kg q12hrs
   Treatment: 1.5 mg/kg q12 hrs
Infants > 2 months and children ≤ 18 years
   Prophylaxis: 0.5 mg/kg q12hrs
   Treatment: 1 mg/kg q12hrs
Less risk of bleeding; SQ administration
Monitor anti-Xa levels (goal 0.5 to 1.0) - check level 4hr after dose until therapeutic, then weekly (see table below)

Unfractionated Heparin
   Lower efficacy in neonates due to physiologic low antithrombin levels
   Complications: bleeding, accidental overdose (heparin-induced thrombocytopenia rare)
   Short half-life
   1mg protamine neutralizes 100u heparin
Thrombolytic Therapy (tPA) - degrade fibrin to dissolve clot
Surgical Thrombectomy - rarely needed
Hematology consult
<table>
<thead>
<tr>
<th>Anti-Xa factor level</th>
<th>Hold next dose?</th>
<th>Dose change</th>
<th>Repeat Anti-Xa</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.35</td>
<td>No</td>
<td>Increase by 25%</td>
<td>4h after next morning dose</td>
</tr>
<tr>
<td>0.35-0.49</td>
<td>No</td>
<td>Increase by 10%</td>
<td>4h after next morning dose</td>
</tr>
<tr>
<td>0.5-1.0</td>
<td>No</td>
<td>No</td>
<td>Next day, then once a week 4h after morning dose</td>
</tr>
<tr>
<td>1.01-1.5</td>
<td>No</td>
<td>Decrease by 20%</td>
<td>Before next morning dose; administer decreased dose if level &lt;0.5 units/mL and recheck 4 hours post administration</td>
</tr>
<tr>
<td>1.51-2.0</td>
<td>3h</td>
<td>Decrease by 30%</td>
<td>Before next morning dose and recheck 4 hours post administration</td>
</tr>
<tr>
<td>&gt;2.0</td>
<td>Until anti-Xa factor &lt;0.5 units/mL</td>
<td>Decrease by 40%</td>
<td>q12h until &lt;0.5 units/mL Then administer decreased dose and recheck 4 hours post administration</td>
</tr>
</tbody>
</table>
7. ID

HSV 1 and 2 (The Red Book 2018 off aap.org)

Clinical Manifestations: disseminated HSV in the liver and lungs, localized CNS disease, or localized to the skin/eyes/mouth as vesicles

Risk of transmission from a primary genital HSV infection near delivery is 25-60%

Diagnostics:
- Mucus membranes, nasopharynx, conjunctivae and anus swabs for HSV culture or PCR assay
- Skin vesicles HSV culture or PCR assay if present.
- CSF HSV PCR
- Blood HSV PCR
- CBC and CMP (can have neutropenia from acyclovir, baseline labs)
- Ophthalmologic exam
- MRI head to establish a baseline

For infants born to infants born to Mothers with HSV with NO active lesions at the time of delivery, close observation is required. There is a low threshold for obtaining diagnostic tests if infant has respiratory distress, signs of sepsis or vesicular lesions on exam.

Treatment:
- Acyclovir 60mg/kg/day divided in 3 doses
- 14 days in SEM disease
- 21 days in CNS disease or disseminated disease or until CSF PCR is negative
Signs & Symptoms: IUGR, microcephaly, periventricular calcifications, thrombocytopenia, sensorineural hearing loss, retinitis

0.5-1% of newborns are infected in utero and excrete CMV at birth

Primary infection in early pregnancy is associated with severe sequelae

Treatment for symptomatic congenital CMV in neonates: valganciclovir 16 mg/kg/dose BID for 6 months

Need to monitor CBC and CMP

Needs serial hearing tests

Diagnosed by urine CMV early antigen and culture

Make sure to obtain head US and eye exam
Treatment for preterm infants with symptomatic CMV infection should be treated with Ganciclovir for 2 weeks. Re-evaluate after 2 weeks to determine if needs longer treatment (up to 6 weeks if retinitis present). Should monitor for neutropenia.

**HIV (from Aidsinfo.com Management of Infants Born to Women with HIV Infection)**

When to Treat:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Risk</td>
<td>Mother received ART during pregnancy &amp; Viral Load &lt;1000</td>
<td>4 Weeks of AZT (Zidovudine) if &lt;20 viral load and 6 weeks if 20-1000 viral load</td>
</tr>
<tr>
<td>Moderate Risk</td>
<td>Viral load between 1000-10,000 OR</td>
<td>6 weeks of AZT &amp; 3 dose of Nevirapine prophylaxis (Given on Day 1, day 3, and day 7 of life)</td>
</tr>
<tr>
<td>Higher Risk</td>
<td>Primary HIV during pregnancy -OR Viral Load &gt;10,000 OR Mom not on medication OR unknown adherence CALL ID IF HIGH RISK</td>
<td>2/4/6 Treatment · 2mg/kg/dose q12h of Lamivudine · 4 mg/kg/dose q12h of Zidovudine · 6mg/kg/dose q12h of Nevirapine</td>
</tr>
</tbody>
</table>
### Antiretroviral:

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zidovudine</strong></td>
<td><strong>&gt;35 WGA</strong>&lt;br&gt;Birth to 4/6 weeks: 4mg/kg/dose orally q12h **&lt;br&gt;**30-35 WGA&lt;br&gt;Birth to 2 weeks: 2mg/kg/dose orally q12h 2 weeks to 4/6 weeks: 3mg/kg/dose orally q12h <strong>&lt;br&gt;</strong>&lt;30 WGA&lt;br&gt;Birth to 4 weeks: 2mg/kg/dose orally q12h 4-6 weeks old: 3mg/kg/dose orally q12h</td>
</tr>
<tr>
<td><strong>Lamivudine</strong></td>
<td><strong>&gt;32 WGA</strong>&lt;br&gt;Birth to 4 weeks: 2 mg/kg/dose orally q12h 4-6 weeks: 4mg/kg/dose orally q12h</td>
</tr>
<tr>
<td><strong>Nevirapine</strong></td>
<td><strong>Prophylaxis</strong>&lt;br&gt;Birth weight 1.5-2kg 8mg PO daily **&lt;br&gt;**Birth Weight &gt;2kg 12mg PO Daily</td>
</tr>
<tr>
<td><strong>Nevirapine</strong></td>
<td><strong>Treatment</strong>&lt;br&gt;<strong>&gt;37 WGA</strong>&lt;br&gt;Birth to 6 weeks: 6mg/kg/dose orally q12h **&lt;br&gt;**34-37 WGA&lt;br&gt;Birth to 1 week: 4mg/kg/dose orally q12h Age 1-6 weeks: 6mg/kg/dose orally q12h</td>
</tr>
</tbody>
</table>

Labs to be drawn: HIV DNA PCR before discharge  
When to call Infectious Disease - Will need ID follow up!  
   Mother with undetectable HIV viral load call during daylight hours (after 8:00 AM)  
   Mother with detectable HIV viral load and any questions on appropriate treatment call anytime  
Antiretrovirals should be initiated as close to birth as possible, preferably within 6-12 hours of delivery
**Syphilis**

Clinical manifestations: stillbirth, hydrops fetalis, hepatosplenomegaly, copious nasal secretions, pneumonia, osteochondritis, periostitis, pseudoparalysis, edema, maculopapular rash on palms and soles, thrombocytopenia

Diagnosis: the test performed on the infant should be the same as the mom’s test

Treatment: Penicillin G is the preferred drug

Follow the algorithm on UpToDate and The Red Book for specific evaluation and treatment guidelines

**Hepatitis B** *(From CDC MMWR 011218)*

Birth dose (monovalent HepB vaccine only)

**Mother is HBsAg-negative:**
1 dose within 24 hours of birth for all medically stable infants ≥ 2,000 grams. Infants < 2,000 grams: administer 1 dose at chronological age 1 month or hospital discharge.

**Mother is HBsAg-positive:**
Administer **HepB vaccine** and **hepatitis B immune globulin (HBIG)** (in separate limbs) within 12 hours of birth, regardless of birth weight. For infants < 2,000 grams, administer 3 additional doses of vaccine (total of 4 doses) beginning at age 1 month.

Test for HBsAg and anti-HBs at age 9 – 12 months. If HepB series is delayed, test 1 – 2 months after final dose.

**Mother’s HBsAg status is unknown:**
Administer **HepB vaccine** within 12 hours of birth, regardless of birth weight.

For infants < 2,000 grams, administer **HBIG** in addition to HepB vaccine (in separate limbs within 12 hours of birth. Administer 3 additional doses of vaccine (total of 4 doses) beginning at age 1 month.

Determine mother’s HBsAg status as soon as possible. If mother is HBsAg-positive, administer **HBIG** to infants ≥ 2,000 grams as soon as possible, but no later than 7 days of age.

**Parvovirus** *(From The Red Book 2018)*

Clinical Manifestations: hydrops, IUGR, pleural effusion, pericardial effusion, death

Risk of fetal death is 2-6%, greatest risk is in the 1<sup>st</sup> trimester
Treatment: may receive intrauterine blood transfusion but otherwise supportive

Rubella (From The Reb Book 2018)
Clinical Manifestations: cataracts, microphthalmus, PDA, peripheral pulmonary artery stenosis, microcephaly, sensorineural hearing loss, IUGR, radiolucent bone disease, thrombocytopenia, blueberry muffin rash, autism Occurs in 85% if infection in the first 12 weeks of pregnancy
Diagnosis: detection of rubella IgM antibody in the first 6 month or stable/increasing rubella IgG antibody over first 7-11 months.
Treatment: Supportive

Group B Strep
Indications for intrapartum GBS prophylaxis: Previous infant with GBS sepsis, GBS bacteremia during pregnancy, positive vaginal-rectal GBS screening, unknown GBS status and any of the following: <37 WGA, ROM >18h, temperature >38.0, intrapartum NAAT positive for GBS
Appropriate treatment for GBS: Penicillin, Ampicillin or Cefazolin >4 hours prior to delivery
When to do a CBC and Blood Culture
Late preterm (< 37WGA)
  GBS negative mother but ROM ≥18 hours
  GBS positive/unknown with adequate treatment but ROM ≥18 hours
  Always if GBS positive without adequate treatment
Term (≥37 WGA)
  GBS positive/unknown without adequate treatment and ROM ≥18 hours
  If GBS positive/unknown without adequate treatment but ROM < 18 hours then get a CBC at 12 hours
Consider antibiotics at birth when: Preterm without adequate treatment of GBS, PPROM, Chorioamnionitis

Bacterial sepsis and meningitis
Signs & Symptoms: decreased activity, increasing events, increased oxygen requirement, Fever > 38.0 or Hypothermia < 35.5, change in emesis or stool, feeding intolerance, metabolic acidosis
Work Up:
  NPO and IVF
CBC and CRP (I:T ratio is the ratio of immature neutrophils to total neutrophils, concerning if >0.2)
Blood cultures (including any lines in place if able)
Consider CXR or KUB
Consider LP if meningitis suspected
Urinalysis and urine culture
Antibiotics: Ampicillin, Amikacin or Gentamicin
+/- Oxacillin (covers S. aureus )
+/- Vancomycin if MRSA positive

Length of Treatment:
48 hours: negative workup and improving clinically
5-7 days: negative cultures, other labs or clinical condition suspicious
10-14 days: proven bacteremia (depends on organism being treated)
21 days: proven meningitis

Candida Infection (The Red Book 2018 from AAP)

Thrush
Diagnosis clinically
Treated with oral nystatin until thrush resolved

Dermatitis
Diagnosed clinically
Treat with nystatin cream until resolved

Invasive
Disseminated candida has a preference for ELBW infants likely due to many line exposures and skin breakdown
Can be rapidly fatal

Diagnostic
Blood culture should be done and repeated until negative for 48 hours
Make sure to do peripheral and any line cultures
Ophthalmologic examination to look for retinal lesions
Ultrasound of abdomen to look for kidney, liver, or spleen involvement
Cranial US to look for brain involvement
Echo to look for heart involvement

Treatment
Amphotericin B is preferred only if a line is in place
Fluconazole treatment dosing
Consider starting prophylactic dosing if infant has skin breakdown
Follow blood culture susceptibilities
Durations of Treatment
2 weeks without other organ involvement
3 weeks if organ involvement including eyes
8. Neurology

Intraventricular hemorrhage
Pathophysiology: Germinal matrix: area of new brain cell production that requires rich blood supply in the fetal brain. Risk of bleeding from the subependymal germinal matrix. The ependymal lining may rupture, and blood may move into the ventricles.
Risk factors: prematurity, males, respiratory distress syndrome, BW < 1500g. Risk highest in the first 3 days following birth.
Clinical signs: Altered consciousness, impaired visual tracking, roving eye movements, hypotonia, reduced spontaneous movements, or abnormal movements/seizure activity, respiratory distress, hemodynamic instability, apnea/bradycardia.
Grading
- Grade I: subependymal hemorrhage confined to the germinal matrix
- Grade II: blood in the lateral ventricle
- Grade III: blood in lateral ventricle causing distension (hemorrhage > 50% of ventricular area)
- Grade IV: blood from ventricle spilling into periventricular tissue
Prognosis: increased risk of cerebral palsy and neurodevelopmental impairment even with grade I and II.
Screening with head ultrasound:
Obtain if < 32 weeks OR < 1500 grams
Intervals: 1 week, 1 month, term AGA (37 weeks corrected), 3-6 months and PRN.
If IVH is detected on initial US, follow weekly.
Prevention: Administration of prenatal glucocorticoids reduces risk of IVH. Partially due to prevention of RDS, in addition to presumed neuroprotective benefits

CHKD PIVH Prevention Bundle – DRAFT 10/10/18

Continual education and awareness is the most significant intervention

Neonatology-MFM

1. Encourage 2 doses of betamethasone for infants ≥ 22 weeks gestation
2. Encourage delayed cord clamping
3. IVH bundle for infants ≤ 28 weeks gestation or ≤ 1250 grams

Delivery Room

1. Heat wrap for ELBW infant
2. Gentle ventilation, consider noninvasive ventilation with CPAP, NIPPV
3. If required, gentle intubation with emphasis on minimal head extension, and minimal pressure on cranium, keep head in midline position
4. Avoidance of high tidal volumes, keep VT ≤ 6 ml/kg
5. Avoid over-ventilation, use lower IMV (20-30)
6. Place infant in “Transportle” in transport incubator

NICU

1. “Golden Hour” – lines in place, fluids started, radiographs done, glucose and blood gases done and top down on incubator
2. Weigh on admission and at 96 hours, first bath ≥ 96 hours
3. Avoid routine suctioning, if stomach decompression needed-use OGT
4. Strict thermal regulation and humidity
5. Cluster routine care times
6. Decrease ambient noise
7. Maintain head in midline, supine and elevated to 30 degrees for the first 96 hours of life
8. Protect eyes from bright or direct light
9. Avoid rapid infusions and blood draws, not to exceed 1 ml/minute
10. Avoid sudden increases in thoracic or abdominal pressures, no leg lifting above hips
11. If HFV not needed, use low volume-targeted ventilation
12. Keep platelets >75,000, for 96 hours
13. Prophylactic hydrocortisone (BPD protocol)
14. Report MABP < GA to physician
15. NR brain oxygenation measurement × 24 hours
16. US on admission, repeat US at 72 hours
17. Obtain CSS on day of admission and again on day of life 7

Seizures

Dominant etiology in the newborn period = cerebral hypoxia-ischemia

Other causes include electrolyte abnormalities (i.e. hyponatremia, hypoglycemia, hypocalcemia, hypomagnesemia, IVH, CNS infections, cortical malformations, genetic conditions, drug withdrawal, or infantile seizure syndrome
Neonates more susceptible to seizures due to predominance of excitatory neurotransmitters and immature inhibitory systems. Seizures commonly present as orobuccal movements (i.e. sucking, smacking, chewing), oculomotor movements (i.e. eye deviation or jerking, sustained eye opening with fixed gaze), or apnea. Generalized tonic-clonic seizures do not typically occur as neonates have incomplete myelination.

Classification

- Subtle: more common in premies and present with orobuccal or oculomotor movements or bicycling of lower extremities, not consistently associated with EEG changes.
- Clonic: focal, slow jerking of an extremity, may be suggestive of underlying structural lesion (i.e. stroke, cortical malformation).
- Tonic: focal sustained extension or flexion of an extremity.
- Myoclonic: single or multiple non-rhythmic jerks of an extremity.

Have a low threshold to obtain an EEG, as many seizures are subclinical.

Clinical diagnosis (differentiate from jitteriness or tremors)

- Neonatal seizures are not generally stimulus sensitive.
- Usually associated with autonomic changes.
- Usually associated with eye deviation, abnormal gaze.
- The predominate movement clonic/tonic movement.
- Movements continue despite passive flexion of extremity.

Treatment

- Address any electrolyte abnormalities.
- Benzodiazepines, such as lorazepam (Ativan), often used for initial seizure control.
- Loading dose

![Diagram of seizure resolution and continued seizures](image)

Prognosis: increased risk for cerebral palsy, abnormal cognitive outcome, epilepsy.

**Neonatal encephalopathy – Hypoxic Ischemic Encephalopathy (HIE)**

Brain injury caused by inadequate oxygen delivery and cerebral blood flow.
Majority of cases are related to intrapartum events

Diagnostic criteria
- Metabolic acidosis with pH < 7.0 (from umbilical cord gas or on ABG within 1 hour of birth)
- Base deficit ≥ 12mEq/L
- APGAR ≤ 5 at 10 minutes with continued need for resuscitation
- Multi-organ dysfunction
- Clinical evidence of encephalopathy (hypotonia, abnormal oculomotor or pupillary movements, weak or absent suck, apnea, hyperpnea, or clinical seizures)

Pathophysiology
1. Immediate primary neuronal injury
   - Initial lack of oxygen and glucose to the brain → decreased ATP → cerebral swelling, depolarization, and cell death
2. Variable latent period: lasts ~6 hours
   - Following reperfusion, some cells may partially recover but die several hours later
3. Late secondary neuronal injury: lasts ~24-48 hours
   - Further damage following reperfusion, including cell swelling and death, accumulation of ROS

Treatment
- Hypothermia protocol for infants > 35 wga
  - Cooling to a core body temperature between 33°C for 72 hours, then rewarm
  - Attempt to minimize secondary neuronal injury by decreasing metabolic demands
  - Risks: thrombocytopenia, hypoglycemia, hypotension, bradycardia
  - MRI once infant has been rewarmed to evaluate for axonal injury
  - These infants need close monitoring of neurological status

Sedation
- Each patient will be evaluated individually and management decided as a team.
- Extubated: Fentanyl 0.5mcg/kg/dose IV q4hrs PRN.
  - *Administer only if Pain Score ≥4 or ≥2 if on phenobarbital
- Intubated (determined by number of IV access/lines)
  - 1 line: Fentanyl drip 0.5 mcg/kg/hr, titrate to 1mcg/kg/hr if needed. *If already on phenobarbital, titrate drip if Pain Score ≥2. Can
add lorazepam 0.05mg/kg/dose IV q6hrs PRN only if needed for more sedation
2 lines: Fentanyl drip 0.5mcg/kg/hr, titrate to 1mcg/kg/hr if needed. *If already on phenobarbital, titrate drip if Pain Score ≥2. Can add Midazolam 0.05mg/kg/dose IV q4hrs PRN only if needed for more sedation.

**Neonatal abstinence syndrome**
Result of abrupt discontinuation from substances that infant had chronic exposure to via maternal use during pregnancy
Opiates have a low molecular weight, so they transfer across the placental barrier and blood-brain barrier early
Incidence is increasing, particularly due to increased use of opioid pain relievers
Many pregnant women now using methadone or buprenorphine (Subutex) as treatment for opioid dependency
Been shown to improve prenatal care and neonatal outcomes, but infants may still develop NAS
NAS also associated with psychotrophic medications (i.e. SSRIs, SNRIs, TCAs, benzodiazepines)
Transmission increases with increased gestational age
Premature infants have decreased incidence due to various factors
  - Decreased placental transmission
  - Decreased cumulative exposure
  - Decreased morphine clearance/decreased excretion due to immaturity of the kidneys and liver
  - Decreased fatty tissue (where methadone accumulates)
  - Decreased receptor development and sensitivity

**Mechanism**
Sudden lack of opioids leads to increased activity at opioid receptors
Increased adenyl cyclase sends off a cascade of enzymatic activity
Neonatal abstinence syndrome (cont’d.)

Clinical presentation
CNS signs: irritability, jitteriness, tremors, high-pitched/excessive crying, hypertonia. Infants may also present with seizures.
Autonomic signs: hypertension, tachycardia, tachypnea, hyperthermia, sweating, sneezing, mottled skin
GI signs: poor feeding, regurgitation, vomiting, diarrhea (leading to significant diaper dermatitis), and hyperphagia
Onset of symptoms depends on time of last dose, duration of exposure, and which substances were used
Initial phase of symptoms typically lasts 1-2 weeks, but infants may have long-term effects for weeks to months

Diagnosis
UDS on mom (at OB discretion) and UDS or meconium screen on baby (preferably within 12 hours of delivery)
Meconium testing is more sensitive and has a longer window of detection, but we rarely order this (it takes a long time to result)
Need to obtain assent (verbal agreement) and document in chart
SW consult for any positive infant UDS result
This is a clinical diagnosis. Any infants with known drug exposure or symptoms suspicious for NAS are assessed using the Finnegan scores
NAS screening: modified Finnegan score starting 4 hrs after birth
At risk infant: no prenatal care, maternal UDS positive for current visit or during this pregnancy, mom enrolled in treatment program, h/o drug abuse and/or history of infant with NAS, infants with signs/symptoms of withdrawal (exclude nicotine, SSRI or bupropion exposure as cause of symptoms)
Well baby nursery
72 hr minimum known methadone or suboxone exposure during pregnancy
48hr minimum known heroin, oxycodone, other short acting opioids
72 hr minimum for unknown type of exposure but UDS with opioid positive
48hr for suspected NAS without confirmed exposure

Treatment
Non-pharmacological: minimize stimulation, feeding on demand with high-calorie formula, swaddling, kangaroo care, low noise music therapy, manual rocking, breastfeeding
Threshold for treatment: “24 rule”
2 consecutive scores $\geq 12$, or average of 2 consecutive scores $\geq 12$ (sum $\geq 24$)
3 consecutive scores $\geq 8$, or average of 3 consecutive scores $\geq 8$ (sum $\geq 24$)
Pharmacological
Morphine: decreased incidence of seizures, improves feeding, diarrhea, and agitation
Prolongs hospitalization
Half-life only 3-4 hours
Can increase dose relatively quickly, but must wean slowly. Start at 0.05mg/kg PO q3hrs. May be increased by 0.05mg/kg every 12 hrs PRN if 3 prior scores add up to $\geq 24$. Maximum dose 0.1mg/kg PO q3hrs.
Add clonidine if maximum dose reached. Start at 0.5 mcg/kg/dose every 6 hours. Can increase
every 12 hours by 0.5mcg/kg/dose to a maximum of 1.5mcg/kg/dose every 6 hours
Methadone: longer half-life (~12 hours), so more difficult to titrate up
Naloxone contraindicated due to risk of seizures in neonates
In non-opiate NAS, may use phenobarbital, lorazepam, clonidine

Weaning of therapy
Should not undergo weaning until scores stable < 8 for a 48 hr period
Weaning should occur every 24 hours at 10% of maximum dose
Morphine is discontinued once dose is 0.02mg/kg
If on morphine and clonidine
  Wean morphine 10% every 24 hrs until minimum dose of 0.02mg/kg morphine
Prognosis: must evaluate these infants for neurodevelopmental deficits, behavioral problems, ophthalmologic issues (nystagmus, strabismus, visual deficits), and growth problems

Morphine Treatment Protocol

At Risk Infants: NAS score q4hrs
  Short acting opioid: Observe for min of 48hrs
  Long acting opioid: Observe for min of 72hrs

2-3 consecutive scores adding up to 24

Transfer to Level 2 Nursery:
  Start morphine 0.05mg/kg PO q3hrs
  IV:PO dosing is 1:3

After 12hrs at initial dose, sum of last 3 scores < 24?

Yes
  Proceed to weaning algorithm

No
  Multiple scores >12: refer to rescue dosing

Increase morphine dose by 0.05mg/kg/dose q12hrs PRN
Max Morphine dose 0.2mg/kg/dose (1.6mg/kg/day)

After 12hrs at current dose, Sum of last 3 scores < 24?

Yes
  Proceed to weaning algorithm

No
  Add Clonidine 0.5mcg/kg q6hrs

Increase Clonidine dose in
0.5mcg/kg every 12 hours as needed
(Max 1.5mcg/kg/dose)
**Neuro Resources**

**IVH: Core Concepts: Intraventricular Hemorrhage.** Andrew Whitelaw - Neoreviews - 2011

**Seizures:**
- Neonatal Seizures, D. Olson - Neoreviews – 2012
- Seizures in the Preterm Neonate, Lekha Rao-Charles Marcuccilli - Neoreviews – 2017

**NAS:**
- Neonatal Abstinence Syndrome, P. Kocherlakota - Pediatrics - 2014
9. RENAL

**Insensible Losses**
Daily insensible loss (mainly skin and lungs) in newborns increases with decreasing birth weight (BW) as follows

- >2000g : ~20 ml/kg/day
- 1501-2000 g : 20-30 ml/kg/day
- 1251-1500g : 30-40 ml/kg/day
- 1001-1250g : 50-60 ml/kg/day
- 750-1000g : 60-70 ml/kg/day
- <750g : 100-200 ml/kg/day

Radiant warmers increase losses compared to incubators. The increased daily fluid increment for infants receiving phototherapy is ~20ml/kg/day


**Hydronephrosis**
Definition: dilation of the renal pelvis
General Information:
Common finding on prenatal U/S, may be transient benign condition, or can represent problem with urine drainage (i.e., obstruction) or reflux
Society for Fetal Urology (SFU) grading system for hydronephrosis

Grade I – dilation of the renal pelvis (“pelviectasis”)
Grade II – dilation of the renal pelvis and major calyces (“pelvicaliectasis”)
Grade III – dilation of pelvis, major, and minor calyces
Grade IV – dilation of pelvis, major/minor calyces, and thinning of renal parenchyma
Evaluation:

Ultrasound kidneys and bladder if prenatal renal pelvic diameter \( \geq 10\text{mm} \)

If unilateral, ultrasound 2 or more days after birth to prevent underestimated hydronephrosis. Ideally after infant returns to birth weight/within first 2 weeks of life. Relative oliguria in the first 24-48 hours after birth may cause underdistension of the pelvis and lead you to underestimate the true degree of dilation

If bilateral, ultrasound within 48 hours

VCUG if postnatal renal pelvic diameter \( \geq 10\text{mm} \) (moderate to severe hydronephrosis)

Diuretic renography – infants with persistent grade 3 or 4 hydronephrosis with normal VCUG

Magnetic resonance urography (MRU) – infants with complex congenital uropathy

Antibiotic Prophylaxis:

May be used to reduce risk of UTI in high-risk patients, such as those with high grade hydronephrosis or RPD (renal pelvic diameter) > 10mm until VUR or obstruction is ruled out

Amoxicillin 12-25 mg/kg/day; need to be cautious regarding increased risk for yeast/fungus, especially in VLBW/ELBW neonates

Bactrim (1-2 mg/kg/day of trimethoprim component) is preferred in older infants (>2 months) – urinary concentration of antibiotics leads to less problems with antimicrobial resistance. However, this medication should be avoided in young infants due to concerns that it may displace albumin-bound bilirubin and precipitate kernicterus


**Acute Kidney Injury**

Definition: Acute decrease in GFR, rise in serum creatinine from baseline

General Information:

- Newborn Cr reflects mother’s Cr and decreases as infant ages
- Preterm infant Cr nadir at roughly 1-2 months of life

Pre-renal – reduced renal perfusion

Most common form
Hypovolemia, impaired cardiac output, sepsis, third spacing

Intrinsic – renal pathology
- ATN from ischemia
- Exposure to nephrotoxic medications
- Vascular thrombosis – arterial (from UAC) or venous, renal vein thrombosis
- Glomerular disease (rare)
- Infections (CMV, syphilis, toxoplasmosis, candidiasis, pyelonephritis)
- Congenital renal anomalies (decreased renal reserve makes AKI more likely)

Post-renal – obstruction. For a patient with two kidneys, requires a single bladder-level obstruction (most commonly posterior urethral valves in boys) or bilateral upper tract obstructions (UPJ or uretero-vesical (UVJ) most commonly)

Signs/Symptoms: Increasing Cr, edema, oliguria, anuria, HTN, hyponatremia, hyperkalemia, hyperphosphatemia, hypocalcemia, metabolic acidosis

Diagnosis: Increase of Cr 0.2 – 0.3 mg/dL per day or ≥50 % from previous lowest value or UOP <1ml/kg/hr on days of life 2-7.

Treatment:

Identify underlying cause and treat it

- Prerenal: for patients with true volume depletion, 10-20 ml/kg isotonic saline fluid challenge will restore UOP and decrease serum creatinine (avoid fluid challenge in the setting of hypertension or signs of volume overload – heart failure, edema, respiratory distress); some immature neonates also have pre-renal type AKI caused by systemic blood pressures inadequate to maintain renal autoregulation (vasomotor nephropathy), and benefit from vasopressors or high-dose hydrocortisone

- Intrinsic: Stop nephrotoxic medications if possible. Limit fluid administration to insensible water loss plus urine output.

- Postrenal: Relieve obstruction. Consult pediatric urology.

Carefully adjust electrolytes in parenteral nutrition to optimize electrolytes (typically, potassium and phosphorus should be restricted and bicarbonate should be increased).
For neonates and infants feeding enterally, a low solute, low potassium/phosphorus formula like Similac PM 60/40 is usually ideal.

Avoid nephrotoxic medications to the extent care allows (especially aminoglycoside antibiotics, vancomycin, NSAIDs, and amphotericin B).

Weight every 12 hours

Reasons to consider Renal Replacement Therapy: refractory fluid overload or electrolyte abnormalities (especially hyperkalemia or metabolic acidosis) nonresponsive to medical management

For most neonates and infants, the preferred dialysis modality is peritoneal dialysis. Vascular access for hemodialysis or continuous renal replacement therapy (CRRT) can be challenging. Provision of CRRT at CHKD requires transfer to the PICU.


Renal Tubular Acidosis
Definition: Defect that affects kidney’s ability to absorb bicarb

General Info:
- Normal anion gap metabolic acidosis
- Retained hydrogen, or lost bicarb
- Most common in pediatrics is Type 1 and Type 2
- Many premature neonates will have a transient-RTA like phenotype that resolves with improving tubular maturity

Type 1 = Distal
- Poor distal acid secretion
- Etiology: genetic, amphotericin B, obstructive uropathy
- Urine pH > 5.5, K ≤ 3.0mEq/L, hyperchloremic metabolic acidosis (bicarb < 10 mEq/L)
- Tx – 2-4 mEq/kg/day of bicarbonate or citrate, administered as salts with sodium or potassium, divided into 3-4 doses

Type 2 = Proximal
- Poor proximal bicarb reabsorption
- Etiology: Fanconi syndrome (especially due to cystinosis), cisplatin, valproic acid, deferasirox, heavy metals
Growth failure, tachypnea, recurrent vomiting, feeding difficulties
Bicarb (12-20 mEq/L), urine pH variable, hypokalemia
Tx – 10-20 mEq/kg/day of bicarbonate or equivalent, given as sodium or potassium salts
Type 3 = Mixed. Autosomal recessive disorder, rare carbonic anhydrase 2 deficiency
Type 4 = Aldosterone deficiency/resistance
Uncommon in children
Congenital adrenal insufficiency, aldosterone synthase deficiency, pseudohypoaldosteronism


**Other Syndromes with Renal Involvement:**
Renal-coloboma syndrome -- renal hypoplasia, VUR, colobomas
Turner syndrome -- 45,XO karyotype; broad chest, webbed neck, streak ovaries; may be associated with, renal agenesis, horseshoe kidney
VATER/VACTERL -- Vertebral anomalies, anorectal malformations, CV anomalies, trachea-esophageal fistula, esophageal atresia, renal anomalies, limb defects
Potter Syndrome -- oligohydramnios, bilateral renal agenesis, pulmonary hypoplasia, limb/facial anomalies
Trisomy 18 -- dysplastic kidneys, horseshoe kidney, abnormal facies, overlapping digits
Trisomy 13 -- dysplastic kidneys, horseshoe kidney, abnormal facies, cleft lip, heart anomalies
10. ENDOCRINOLOGY


Infant of a Diabetic Mother (IDM) (Pages 709-714)
Maternal hyperglycemia leads to fetal hyperinsulinemia and hypoglycemia in the newborn period
Complications: Macrosomia → C/S, Birth Trauma (shoulder dystocia, brachial plexus injury, cephalohematoma), Perinatal Asphyxia, RDS/TTN - fetal hyperinsulinism delays surfactant production, Hypertrophic cardiomyopathy, septal hypertrophy, Polycythemia, Hyperbilirubinemia, Renal venous thrombosis, Congenital anomalies: caudal regression, cardiac defects (situs inversus), spina bifida
Can present with lethargy, jitteriness, poor feeding, apnea in first 6-12h after birth
Monitor glucose levels closely

Hypopituitarism
Can present as isolated or multiple hormone deficiencies
Secondary to genetic or anatomic abnormalities
Associated with midline defects: Agenesis of corpus callosum, Septo-optic dysplasia, optic nerve hypoplasia, Holoprosencephaly, Hypoglycemia, Hypothermia. Micropenis
Anterior Pituitary – replacement by levothyroxine, growth hormone, cortisol, testosterone and estrogen when age appropriate
Posterior Pituitary - Vasopressin
Central Diabetes Insipidus (defect in vasopressin release leading to inappropriate water loss and dilute urine) → managed by desmopressin (vasopressin analog)
Contrast with Nephrogenic DI (kidney resistant to actions of vasopressin)
Non-specific signs can make diagnosis difficult
Diagnosed by individual hormone testing and MRI of pituitary and hypothalamus
**Neonatal Hypothyroidism** (Pages 908-911)

All infants experience a TSH surge at birth. Congenital hypothyroidism leads to profound developmental delay if unrecognized and untreated within first two weeks of life. → early detection through newborn screening and initiation of therapy mitigates adverse effects on growth, intelligence, quality of life.

Early presentation (0-2 weeks): LGA, large fontanelle, umbilical hernia, RDS, hypotonia, lethargy, hypothermia, Constipation, feeding difficulty, prolonged jaundice.

Late presentation (6 weeks): Puffy eyelids, coarse hair, hoarse cry, myxedema, macroglossia, Risk for high-output cardiac failure.

**Causes**

- **Transient Hypothyroidism**: initially ↓ free T4 with ↑ TSH but <40 mU/L then recheck shows normal T4 and TSH.
  - Causes: Exposure to maternal antithyroid drugs or placental transfer of thyrotropin receptor antibody (TRAb).
- **Transient Hypothyroxinemia of Prematurity**: ↓ thyroid hormone level with normal TSH due to immature HPA axis - common in ELBW.
- **Euthyroid Sick Syndrome**: ↓ thyroid hormone level with normal or low TSH due to transient alteration in thyroid function, more frequent in preterm infants and neonatal stress.
- **Congenital Hypothyroidism**: ↓ thyroid hormone level with ↑ TSH.
  - Primary - most common. Developmental (ectopic thyroid, thyroid hypoplasia, thyroid agenesis), Inborn Errors of Metabolism (iodide organification defects), Iodine Deficiency.
  - Secondary: TSH Deficiency, Hypopituitarism.
  - Tertiary: TRH Deficiency.
  - X linked thyroid binding globulin deficiency (males).
  - Normal free T4 and TSH.
  - Low total T4 and TBG level.

**Evaluation**

- **Newborn Screen**: Per AAP: collect within 48hrs for term delivery, within seven days of birth for preterm delivery/extended NICU stay.
  - At Sentara, collected after 24 hours of age in newborn nursery and after 48 hours of age in the special care nursery (or prior to a blood transfusion).
  - In the NICU, collected 48-60 hours of age.
Thyroid function tests (TSH, free T4)  
Can consider ultrasound

Treatment  
Transient - no treatment necessary  
Persistent - Synthroid 10-15mcg/kg/day oral starting dose  
Goal is to maintain T4 in upper normal range (10-15mcg/dL), TSH in lower normal range (0.5-2 mU/L)  
Follow thyroid function tests: Two and four weeks after initiating therapy then every 1-2 months for first six months of life

Diagnostic algorithm for congenital hypothyroidism. Note that each screening program sets its own T4 and TSH cutoffs. The results for serum TSH, free T4, T4, and T3 resin uptake are typical for neonates around 2 wk of age. It is important for clinicians to compare serum results to age-normal reference ranges for their specific laboratory.

Full article link (algorithm)

**Neonatal Hyperthyroidism/Thyrotoxicosis** (Pages 912-913)  
**Causes**  
Transient: Placental transfer of TSH receptor-stimulating antibodies (h/o maternal graves)  
Persistent: Congenital non-autoimmune hyperthyroidism (TSH-R mutation, McCune Albright syndrome)  
Presentation
Fetal tachycardia in third trimester
Early presentation: Tachycardia, hypertension, flushing, tremor, poor weight gain, hepatomegaly, poor feeding, irritability
Late presentation: Goiter, can cause tracheal compression, Lid retraction, exophthalmos, Craniosynostosis, Arrhythmia, cardiac failure
Labs: ↑T4, FT4, and T3. ↓TSH.
Treatment: often self-limited, disappears spontaneously within two to four months
  Mild: close observation
  Moderate: PTU or methimazole
  Severe: prednisone, propranolol
  Refractory: IVIG, consider thyroid gland ablation or thyroidectomy

Evaluation and management of infants at risk for Neonatal Grave’s disease – SEE LINK1 and LINK2

Adrenal Insufficiency
Causes
  Primary Adrenal Insufficiency
    Transient adrenal insufficiency in premature infants
    Impaired steroidogenesis: Congenital Adrenal Hyperplasia
    Adrenal dysgenesis: Congenital Adrenal Hypoplasia
    Adrenal destruction: Severe infection, Hemorrhage - can have palpable adrenal masses, associated with anemia and thrombocytopenia, Waterhouse-Frederickson syndrome - typically caused by meningococcemia, associated with purpuric rash and DIC, Adrenoleukodystrophy
  Secondary Adrenal insufficiency: ACTH Deficiency, Hypopituitarism, ACTH Suppression - long-term steroid use (iatrogenic)
    Pseudohypoaldosteronism - failure to respond to aldosterone
  Adrenal Crisis (acute adrenal insufficiency)
    Associated with hypotension, hyponatremia, hyperkalemia, hypoglycemia, hypothyroid
    Medical emergency and potentially life-threatening

Evaluation: CBC/Culture, BMP, Blood glucose, ACTH (cosyntropin) stimulation test, Cortisol level
Treatment
  Stress-Dose Steroids 50-100 mg/m²/day divided q6hrs
Treat underlying cause - fluid and blood volume resuscitation as needed
Slow steroid wean as tolerated when stable. Maintenance hydrocortisone 10-15 mg/m²/day divided TID

**Congenital Adrenal Hyperplasia (Pages 619-626)**
Enzyme deficiency in cortisol pathway leads to excessive adrenal androgens and testosterone

**21-Hydroxylase Deficiency** - most common
- Hypoaldosteronism leads to hyponatremia/hypochloremia, hyperkalemia
- Hypocortisolism leads to hypoglycemia, hypotension
- Hyperandrogenism is the most common cause of ambiguous genitalia in 46XX female infants
- Elevated metabolite 17-hydroxyprogesterone 17-OHP (200+)
- Can be associated with severe salt-wasting leading to adrenal crisis

**11-Hydroxylase Deficiency**
- Metabolite 11-Deoxycorticosterone has weak mineralocorticoid activity, retaining sodium at expense of potassium
- Rarely associated with salt-wasting - instead will have water retention, hypertension, hypernatremia, hypokalemia

Newborn screening - has high false positive rate. Immunoassays are still in use and remain a source of false-positive results. Specificity may be improved with organic extractions to remove cross-reacting substances. 170HP levels are normally high at birth and decrease rapidly in the first few days post-natally. Diagnostic accuracy is poor in the first 2 days. Premature, sick or stressed infants have higher levels of 17OHP than do term infants, generating many false positives.


Diagnosed clinically, with lab findings and elevated 17-OHP; confirmed with genetic testing
Treated with replacement mineralocorticoid and glucocorticoid
Disorders of Sex Development/"Atypical Genitalia" (Pages 619-626)

Causes
- Female Virilization: Congenital Adrenal Hyperplasia is the most common cause
- Male Feminization/Inadequate Virilization
  - Decreased androgen production
  - Decreased response to androgen - partial or total 5α reductase deficiency
- Gonadal Dysgenesis: Streak gonad can carry risk for tumor potential in 46XY patients
- True Hermaphroditism

Evaluation: Physical examination (gonads, phallus length, presence of clitoromegaly, labioscrotal folds), Genetics (FISH, genome microarray), 17-OHP, T, DHT, BMP, Assessment of pituitary function, Ultrasound

Treatment: Activate team = Genetics, Urology and Endocrine ASAP, Gender-neutral terminology

Osteopenia of Prematurity (Pages 792-796)

Proper bone development requires adequate stores of calcium, phosphorus, and vitamin D. Preterm infants have not had time to develop those stores over 3rd trimester. Preterm infants are also born during a phase of rapid growth and mineral accretion and this accentuates their risk for poor bone health. Inadequate calcium intake to meet bone growth demands can progress to
pathologic fractures and osteomalacia or osteoporosis. Decreasing prevalence with improved prevention and treatment
Causes: Maternal vitamin D deficiency, Maternal smoking, IUGR (chronic placenta damage), Delayed enteral feeding, Prolonged human milk intake, Vitamin D deficiency (renal osteodystrophy, drugs - phenobarbital, phenytoin), Drugs (steroids, furosemide), Malabsorption (short gut syndrome, prolonged cholestasis), Lack of mechanical stimulation - especially with spina bifida and arthrogryposis
Evaluation
Clinical signs: Poor weight gain, Rickets (growth retardation, frontal bossing, craniotabes, rachitic rosary, epiphyseal widening), Fractures, Respiratory difficulties (poor chest wall compliance)
Labs: Calcium level - can initially be normal, then low, Phosphorus level – low, Vitamin D level, Alkaline Phosphatase ALP - up to five times normal adult levels → reflects both osteoblastic and osteoclastic activity, PTH, Serial radiographs
Treatment
Early enteral feeding using specialized preterm formula and human milk fortification
Adequate vitamin D intake/supplementation
Mechanical stimulation
Minimize steroid glucocorticoid usage

11. Health Maintenance

Discharge Criteria: Let discharge coordinators know 2 days in advance

- Around 2000 grams
- Around 35 WGA (if GA is unknown, use clinical picture to determine DC criteria)
- Temperature stable in open crib for 48 hours
- On home formula and gaining weight x1-2 days
- PO ad lib feeding
- Passed ALTE watch
- Passed discharge screening (cardiac, hearing, car seat)
- Pediatrician appointment in 24-48 hours. Please route the discharge summary to the pediatrician. Please give a call or message in EPIC/Powerchart for complicated patients, social situations, methadone weaning or any pertinent details that you feel need follow up or the pediatrician should be aware of.

Newborn screening:

At Sentara, collected after 24 hours of age in newborn nursery and after 48 hours of age in the special care nursery (or prior to a blood transfusion). In the NICU, collected 48-60 hours of age.
- If comes back abnormal, consider repeat screen and order labs as requested
- If on TPN, wait to repeat once off TPN for 2 weeks

Hearing screen: has 3 chances to pass prior to discharge
- If failed screen x3 will need urine (bag) for CMV early antigen to be collected
- If failed screen needs follow up with ENT in 1 month (to be made by pediatrician)
- If have hearing loss risk factor (family history of hearing loss), need to repeat in 3 months
- If in the hospital longer than 5 days will need repeat hearing screen at 6 months with ENT (to be made by pediatrician)

Head Ultrasound: IF < 32 WGA or < 1500 grams
- Obtain at 1 week, 1 month, at Term (37 wga), and at 3-6 months old
- If grade III/IV or hydrocephalus, discuss the need for weekly head ultrasounds

Retinopathy of Prematurity
- Eye Exams
Dr. Crouch comes on Mondays to do all exams that are due. He puts in orders for eye drops so DO NOT delete. Dr. Crouch’s office number: 965-7272

Dr. Crouch will make follow up schedule for when exams are due again

Zones:
Stages: determines severity
(From https://aapos.org/terms/conditions/94 )

Stage 1: line of demarcation
Stage 2: raised ridge of demarcation
Stage 3: extra-retinal vascular proliferation
Stage 4: partial retinal detachment
Stage 5: complete retinal detachment

Treatment: Laser photocoagulation, Bevacizumab

AAP Statement – Pediatrics: Screening Examination of Premature Infants for Retinopathy of Prematurity for more information.

NICU follow up: NICU office number 668-6410

BW < 1250g, Grade III/IV IVH, PVL, Teen Mom, Alcohol or drug use, Meningitis, Seizures, HIE, Severe IUGR <10%, Severe hypoglycemia, exchange transfusion, discharge with apnea monitor, CLD, PPHN, Congenital infections, Microcephaly, Severe chronic illness

Immunizations: Make sure to give the VIS to the parents before giving the vaccines (Pharmacists are a great resource)

Initial Hep B vaccine at birth if >2kg and medically stable. Infants < 2kg at 1 month or hospital discharge

2 Month: Polio, Hep B, Hib, PCV 13, DTaP
4 Month: Polio, Hib, PCV 13, DTaP
6 Month: Polio, Hep B, Hib, PCV 13, DTaP
12 Month: MMR, Varicella

CHKD Synagis Recommendations
NICU pharmacist will identify patients, encourage the 1st dose to be given 48-72 hours before discharge
Infectious Disease and Neonatology recommends all 5 doses be given if possible
Recommend beginning RSV prophylaxis November 1 and Ending March 31 (typically)
Summary of Guidelines for administration in the first year of life:

- Born before 29 WGA
- <32 WGA plus an oxygen requirement for 28 days after birth
- Cyanotic heart lesions
- Acyanotic heart disease who are receiving medications to control congestive heart failure and will require a surgical procedure
- Moderate to severe pulmonary hypertension
  Consider if pulmonary or neuromuscular abnormality that inhibit airway clearing
12. Procedures

Obtain parental consent unless the situation is life-threatening or emergent in nature. Discussions should include risks, benefits, and alternative procedures, when appropriate, using the facility’s consent forms. Have a nurse or physician witness, and an additional witness if consent is being obtained over the phone. For new NICU admissions, consider bundling blood, donor human milk, and PICC line consents.

Full sterile attire (hat, secure eyewear if necessary, mask, gown, and properly fitted gloves) is required for umbilical catheterization, chest tube placement, and lumbar puncture. Must do a time out before every procedure. Verify patient with arm band and that consent is signed. Perform with persons doing the procedure and nurses assisting with the procedure. Document the time of the “Time Out.”

UAC Placement*:
Indications: frequent or continuous measurements of arterial blood gases, continuous arterial BP monitoring, access for exchange transfusion, angiography, administration of emergency resuscitation medications and fluids (vein preferred), infusion of maintenance solutions, short term infusion/emergency infusion of volume expanders, parenteral nutrition and/or medications (controversial)
Complications: infection (septic emboli, cellulitis, omphalitis, sepsis), vascular accidents (vasospasm, thrombosis, embolism, infarction), arterial vasospasm (blanching and cyanosis or buttocks, legs, feet and toes) which is increased in low-lying catheters, loss of extremity is rare but can occur. If the leg blanches, warm the other leg (reflex vasodilatation), thrombosis, hemorrhage, vessel perforation, GI complications, hematuria, HTN 2/2 renal artery embolus
Catheter size: single lumen 3.5F if birth weight <1.5 kg
single lumen 5F if birth weight >1.5 kg
Goal Radiographic Depth: “high lying” UAC tip lies above the diaphragm at T6-T9
“low lying” UAC tip lies at L3-L5
CHKD does largely low-lying but confirm prior to placement
Confirm placement with stat A/P chest/abdomen x-ray
Insertion Length: “high lying” UAC length (cm) = (BW in kg x 3)+9
“low lying” UAC length (cm) = (BW in kg x 4) + 7
Dunn method measures length from top of shoulder to umbilicus and plots on nomogram. Both methods must account for length of stump.

*Refer to umbilical catheterization Job Instruction handbook for details.

*If an arterial line is needed and umbilicus cannot be used, a peripheral arterial line is always an option.

Removal: Notify the patient’s nurse and set up an optimal time to remove. Use suture removal scissors to carefully cut the suture anchoring the catheter to the stump but not the catheter itself. Pull the catheter up slowly at a rate of about 1 cm/min. Hold pressure with gauze to the stump for several minutes after catheter removal or until sure there is no active bleeding. The CDC recommends UACs remain for a maximum of 5 days, but this varies both in other sources and our practice here.

**UVC Placement**:
Indications: immediate postnatal access for IVF or medications, CVP monitoring, exchange or partial exchange transfusion, long-term central venous access, delivery of blood and blood products.
Complications: Infection, pericardial effusion, arrhythmias, cardiac tamponade, cardiac perforation, pneumopericardium, thrombotic endocarditis, thrombotic or embolic phenomenon, blood loss/hemorrhage, retroperitoneal fluid extravasation, NEC, fungal infections of right atrium, pulmonary edema, hemorrhage, infarction, hydrothorax, portal vein HTN, hepatic complications.
Catheter size: dual lumen 3.5F for preterm neonates, dual lumen 5F for late preterm, term, and/or birth weight > 3.5 kg.
Goal Radiographic Depth: UVC tip at T8-T10, or 0.5-1.0 cm above the right diaphragm at RA-IVC junction.
Lateral image needed to see exact UVC location in relation to the liver.
Insertion Length: UVC length (cm) = [(BW in kg x 3) + 9] / 2 + 1
Dunn method measures length from top of shoulder to umbilicus and plots on nomogram. Both methods must account for length of stump.
Removal: see UAC removal above.

*Refer to umbilical catheterization Job instruction handbook for details.
**Arterial Puncture:**
Indications: obtain arterial blood, obtain ammonia levels, lactate and pyruvate levels
Complications: bleeding, hematoma, vasospasm, thrombosis, embolism, infection, arteriovenous fistula, nerve damage, forearm compartment syndrome
Radial artery is most frequently used. The radial nerve does not lie close and low concern for nerve damage.
Check for collateral circulation and patency of the ulnar artery by means of the modified Allen’s test. Elevate the arm and occlude the radial and ulnar arteries at the wrist, rub the palm to cause blanching. Release pressure on the ulnar artery. If color returns in the palm in < 10 seconds, adequate collateral from the ulnar artery is present. If normal color does not return for > 15 seconds or at all the collateral circulation is poor.
Palpate the radial artery with index finger of your left hand. Clean the puncture site with povidone-iodine swab and then with an alcohol swab. Puncture the skin at about 30 degree angle. Advance the needle and penetrate the artery with the bevel up until blood appears in tubing. Collect blood. Withdraw the needle and apply firm pressure.

**PICC lines**
Indications: access for IVF or medications, long-term central venous access, delivery of blood and blood products
Complications: bleeding, arrhythmia, air embolism, catheter malposition, infection, thrombosis, catheter migration, catheter embolization, nerve injury

**Lumbar Puncture:**
Indications: obtain CSF for diagnosis of CNS disorders (meningitis/encephalitis), aid in the diagnosis of intracranial hemorrhage, diagnose an inborn error of metabolism, administration of intrathecal medications, monitoring efficacy of antibiotics used to treat CNS infection, diagnose CNS involvement with leukemia
Complications: contamination of CSF specimen with blood, infection, intraspinal epidermoid tumor, herniation of cerebral tissue through the foramen magnum, spinal cord and nerve damage, intramedullary hemorrhage resulting in paraplegia, bleeding/hematoma, cerebrospinal fluid leakage, apnea and bradycardia, hypoxia, cardiopulmonary arrest
AAP recommends applying *EMLA* (lidocaine/prilocaine mix) to procedure area 30 minutes beforehand.
Equipment: LP kit, tray, sterile water, betadine, 1-2 extra 22G 1.5” spinal needle with stylet, sterile gloves and PPE

Position: Have assistant situate infant in either lateral decubitus position or sitting with straight legs. The spine is flexed in the sacral region and is as parallel to the bed as able. A critically ill infant that is intubated must be treated in the lateral decubitus position. Make sure the neck is not flexed as this increases the risk of airway compromise. If right handed, use the right lateral decub position. If left handed, use the left lateral decub position. So that not dominate hand can grasp the iliac crest with index finger and palpate spinous process with thumb.

Landmarks: Prior to becoming sterile, palpate the iliac crest and slide your finger down to the L4 vertebral body.

Prep: Open all packaging and fluids into the kit and its wells. Once sterile, prepare the area with betadine widening in a circle up to and above the iliac crest. Place one drape beneath the patient and one covering the rest of the back. Re-orient.

Procedure: Use non-dominate hand to identify iliac crest then L5, palpate spinous process with thumb and insert needle midline at L4-L5 with bevel facing up if in lateral decubitus position and facing to the side if in sitting position just above your thumb and aim toward the umbilicus. Advance the needle slowly but steadily, removing the stylet to check for the appearance of fluid. Earlier stylet removal is associated with increased success. Characteristic “pop!” of entering the dural space is rare in this population.

Specimen: Collect 0.5-1 mL of CSF fluid in each of the sterile tubes from kit, with additional aliquot in tube 4 for further testing such as PCRs. If bloody specimen in tube 1, observe for clearing in tubes 2-3. If fewer RBCs in subsequent tubes, it was likely traumatic. Clot expression represents probable vessel injury and repeat LP is needed. If blood is not clearing or clotting, intracranial bleeding is probable.

Labs: In general, tube 1 = culture with gram stain, tube 2 = glucose, protein, tube 3 = cell count/diff, tube 4 = MEP-PCR, HSV and/or VDRL

Endotracheal Intubation:
Indications: provide mechanical respiratory support, obtain aspirates for culture, alleviate upper airway obstruction, management of congenital diaphragmatic hernia (to avoid bowel distention), administer medications, management of apnea
Complications: hypoxia, apnea, hypoventilation, bradycardia, hypopharyngeal or tracheal perforation/rupture, trauma,
esophageal perforation, laryngeal edema, improper tube positioning, tube obstruction or kinking, infection, palatal/alveolar grooves, subglottic stenosis, aspiration, atelectasis, pneumothorax, increased ICP, HTN

Whether in the OR or at the bedside, make sure you are comfortable with the height and position of the infant and that your supporting staff (attending, RN, RT) is prepared.

Equipment: Correctly sized endotracheal tube (ETT), suction apparatus, laryngoscope (‘00’ for extremely preterm, ‘01’ for preterm, and ‘1’ blade for full term with straight Miller blade preferred), end tidal CO2 colorimeter, tape, scissors, stethoscope, and bag/mask with pressure manometer

**ETT Guidelines**

<table>
<thead>
<tr>
<th>Weight (g)</th>
<th>Gestation (wks)</th>
<th>ETT diameter (mm)</th>
<th>Depth of insertion (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;500</td>
<td>&lt;24</td>
<td>2.0</td>
<td>5-6</td>
</tr>
<tr>
<td>&lt;1000</td>
<td>24-28</td>
<td>2.5</td>
<td>6 (if &lt;750 g)-7</td>
</tr>
<tr>
<td>1000-2000</td>
<td>28-34</td>
<td>3.0</td>
<td>7-8</td>
</tr>
<tr>
<td>2000-3000</td>
<td>34-38</td>
<td>3.5</td>
<td>8-9</td>
</tr>
<tr>
<td>&gt;3000</td>
<td>&gt;38</td>
<td>4.0</td>
<td>9 (3000 g) – 10 (4000 g)</td>
</tr>
</tbody>
</table>

Procedure: Confirm that your laryngoscope light is working. Suction field if needed. Make sure the stylet is in but not protruding through ETT or Murphy’s eye (the side opening of the ETT). A 2.0 ETT is rarely used. A stylet cannot be used with a 2.0 ETT. Quick guide for depth is twice tube size plus 1. Example. 3.0 x2 + 1 = 7

Place infant in “sniffing position” with neck slightly extended. Hyperextension leads to tracheal collapse and anterior displacement of the cords. You may use a small neck roll if needed.

Hold the laryngoscope with your left hand and insert ETT in right side of the mouth, sweeping tongue to the left. Advance the blade a few millimeters, passing beneath the epiglottis.

Lift the laryngoscope blade VERTICALLY to elevate the epiglottis and see the glottis. You may require gentle external thyroid cartilage pressure to better see the vocal cords. Wait for the cords to open as passing through closed cords can cause spasm.
Pass ETT along right side of mouth, until the black marks on the ETT are at the cords. Do not advance more than 2-2.5 cm into the trachea to avoid right main stem bronchus placement. Holding the ETT in place, remove the stylet. Continue to hold the tube in place as the team auscultates for symmetric breath sounds and check’s for color change on end tidal CO2 colorimeter. Most will change from purple to yellow or vice versa. Decreased breath sounds on the left may signify right main stem intubation. Pull back as assistant listens closely. Tape and secure tube and confirm proper placement with a chest x-ray.

**Chest Tube Placement:**
*Indications:* evacuation of pneumothorax, relieve tension pneumothorax, draining of significant pleural fluid, postsurgical drainage
*Complications:* infection, bleeding, nerve damage, trauma, subcutaneous emphysema, chylothorax, cardiac tamponade, fluid and electrolyte imbalance/hypoproteinemia
*Equipment:* chest tube tray, sterile gloves and PPE, suction-drainage system, fiber optic light source
  - Standard chest tube PVC type 8 or 10F < 2000 g and 12F > 2000 g requires skin incision
  - Percutaneous tube with pigtail catheter does not require incision. 8F and 10F sizes commonly used.

Look at your A/P and lateral films. Air collects upward and fluid collects in low dependent areas.
If air has collected, place the infant air side up. If fluid has collected, place the dependent side down.
Transillumination with a light source may show hyperlucency of the affected side.

*Emergency needle aspiration* is done first for tension pneumothorax. Place in 2nd intercostal space (ICS) at the mid-clavicular line (above the 3rd rib)
Position the infant supine with arm at a 90 degree angle on affected side.
Whether air or fluid, place chest tube at the midaxillary line
  - AIR → place tube anteriorly toward apex
  - FLUID → insert tube posterior and laterally

**Procedure:** Perform under sterile consitions and cleanse the area with betadine, drape the patient.
If non-emergent, may use 0.5-1% local lidocaine for local anesthesia and consider fentanyl for systemic analgesia.
For Modified Seldinger technique using a pigtaili (Fuhrman) catheter:
1. Insert a 18 gauge needle with the syringe attached
2. Secure the needle and remove the syringe, keep lumen occluded.
3. Straighten the J tip of the guide wire and insert into the hub of the needle or IV catheter.
4. Withdraw the needle or IV catheter while holding the guide wire.
5. Thread the dilator down over the guide wire.
6. Straighten the pigtail catheter and insert over the guide wire.
7. Slowly remove the guide wire while holding the tube in place.

For standard placement:
1. Make small incision the width of tube using scalpel in the skin over the rib just below ICS of insertion.
2. Insert curved hemostat into incision to spread tissues down to the rib. Go gently and avoid subcostal vessels and nerves. You may hear a rush of air or fluid may appear as you penetrate the pleura just overlying the rib.
3. Once the pleura is penetrated, insert chest tube through the opened hemostat, making sure the side holes of the tube are in the pleural cavity.
4. Insert 2-3 cm if small and preterm; 3-4 cm for term infant
5. Hold tube secure and have assistant connect other end to a vacuum system
6. Suture/tape tube in place and obtain AP/lateral chest x-ray

Reference:
13. CommonAbbreviations

ABG Arterial Blood Gas
AFOSF Anterior fontanelle open, soft, and flat
AGA Appropriate for gestational age
ALTE Apparent life-threatening event
AOP Apnea of prematurity
AROM Artificial/assisted rupture of membranes
ASD Atrial septal defect
BCx Blood culture
BMZ Betamethasone
BPD Bronchopulmonary dysplasia
BW Birth weight
CAH Congenital adrenal hyperplasia
CCHD Cyanotic congenital heart disease
CLD Chronic lung disease
CMV Cytomegalovirus
CPAP Continuous positive airway pressure
CSS Cranial sector scan (cranial ultrasound)
DAT Direct antiglobulin test
DIC Disseminated intravascular coagulation
DVS D-vi-sol (vitamin D)
C/S C-section
EBM Expressed breast milk
ECMO Extracorporeal membrane oxygenation
EFC Enfacare formula
EGA Estimated gestational age
EHM Expressed human milk
ELBW Extremely low birth weight
ETT Endotracheal tube
FEN Fluids, electrolytes, nutrition
FFP Fresh frozen plasma
GBS Group B Strep
GMH Germinal matrix hemorrhage
HFNC High flow nasal cannula
HFS High frequency ventilation
HLHS Hypoplastic left heart syndrome
HMD Hyaline membrane disease
IDM Infant of diabetic mother
IEM Inborn error of metabolism
IUGR Intrauterine growth retardation
IUFD Intrauterine fetal demise
IVF Intravenous fluids
IVH Intraventricular hemorrhage
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>LGA</td>
<td>Large for gestational age</td>
</tr>
<tr>
<td>LL</td>
<td>Light level</td>
</tr>
<tr>
<td>LP</td>
<td>Lumbar puncture</td>
</tr>
<tr>
<td>MAP</td>
<td>Mean arterial pressure</td>
</tr>
<tr>
<td>MAS</td>
<td>Meconium aspiration syndrome</td>
</tr>
<tr>
<td>MMC</td>
<td>Myelomeningocele</td>
</tr>
<tr>
<td>MRSA</td>
<td>Methicillin resistant Staph aureus</td>
</tr>
<tr>
<td>MRSE</td>
<td>Methicillin resistant Staph epi</td>
</tr>
<tr>
<td>NT/ND</td>
<td>Non-tender/Non-distended</td>
</tr>
<tr>
<td>NEC</td>
<td>Necrotizing enterocolitis</td>
</tr>
<tr>
<td>NGT</td>
<td>Nasogastric tube</td>
</tr>
<tr>
<td>NIPPV</td>
<td>Nasal intermittent positive pressure ventilation</td>
</tr>
<tr>
<td>iNO</td>
<td>Nitric oxide</td>
</tr>
<tr>
<td>NPO</td>
<td>Nil per os (nothing by mouth)</td>
</tr>
<tr>
<td>NRP</td>
<td>Neonatal resuscitation program</td>
</tr>
<tr>
<td>OGT</td>
<td>Orogastric tube</td>
</tr>
<tr>
<td>PDA</td>
<td>Patent ductus arteriosus</td>
</tr>
<tr>
<td>PFO</td>
<td>Patent foramen ovale</td>
</tr>
<tr>
<td>PICC</td>
<td>Peripherally inserted central catheter</td>
</tr>
<tr>
<td>PIH</td>
<td>Pregnancy induced hypertension</td>
</tr>
<tr>
<td>PIV</td>
<td>Peripheral IV</td>
</tr>
<tr>
<td>PKU</td>
<td>Phenylketonuria</td>
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<tr>
<td>Plts</td>
<td>Platelets</td>
</tr>
<tr>
<td>PO</td>
<td>By mouth</td>
</tr>
<tr>
<td>PPHN</td>
<td>Persistent pulmonary hypertension of newborn</td>
</tr>
<tr>
<td>PPROM</td>
<td>Prolonged premature rupture of membranes</td>
</tr>
<tr>
<td>PPV</td>
<td>Positive pressure ventilation</td>
</tr>
<tr>
<td>pRBCs</td>
<td>Packed red blood cells</td>
</tr>
<tr>
<td>Pre-E</td>
<td>Pre-eclampsia</td>
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<tr>
<td>PVL</td>
<td>Periventricular leukomalacia</td>
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<tr>
<td>PVS</td>
<td>Poly-vi-sol</td>
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<tr>
<td>RA</td>
<td>Room air</td>
</tr>
<tr>
<td>ROM</td>
<td>Rupture of membranes</td>
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<tr>
<td>ROP</td>
<td>Retinopathy of prematurity</td>
</tr>
<tr>
<td>SGA</td>
<td>Small for gestational age</td>
</tr>
<tr>
<td>SIMV</td>
<td>Synchronized intermittent mechanical ventilation</td>
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<tr>
<td>SROM</td>
<td>Spontaneous rupture of membranes</td>
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<tr>
<td>SVD</td>
<td>Spontaneous vaginal delivery</td>
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<tr>
<td>TcB</td>
<td>Transcutaneous bilirubin</td>
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<tr>
<td>T/D Bili</td>
<td>Total/Direct Bilirubin</td>
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<tr>
<td>TEF</td>
<td>Tracheoesophageal fistula</td>
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<tr>
<td>TOF</td>
<td>Tetralogy of Fallot</td>
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<tr>
<td>TTN</td>
<td>Transient tachypnea of newborn</td>
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<tr>
<td>UAC/L</td>
<td>Umbilical arterial catheter/line</td>
</tr>
<tr>
<td>UVC/L</td>
<td>Umbilical venous catheter/line</td>
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