THE

NEONATAL

SURVIVAL GUIDE

Assimilated by Jenn Michalec, Michael Southgate, Sarah Taylor, Toby Cox, and Carrie Finch

Last update- July 2007
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>NICU Websites</td>
<td>4</td>
</tr>
<tr>
<td>Rotation Information</td>
<td>5</td>
</tr>
<tr>
<td>Rotation Recommendations</td>
<td>6</td>
</tr>
<tr>
<td>Patient Coverage</td>
<td>7</td>
</tr>
<tr>
<td>Delivery Room</td>
<td>9</td>
</tr>
<tr>
<td>Resuscitation</td>
<td>10</td>
</tr>
<tr>
<td>NRP Reference Chart</td>
<td>11</td>
</tr>
<tr>
<td>Thermoregulation</td>
<td>12</td>
</tr>
<tr>
<td>Vital Signs</td>
<td>13</td>
</tr>
<tr>
<td>Ventilator Therapy</td>
<td>15</td>
</tr>
<tr>
<td>Positive Pressure Ventilation</td>
<td>17</td>
</tr>
<tr>
<td>High Frequency Ventilation</td>
<td></td>
</tr>
<tr>
<td>HFOV</td>
<td>18</td>
</tr>
<tr>
<td>HFJV</td>
<td>20</td>
</tr>
<tr>
<td>Surfactant</td>
<td>22</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>23</td>
</tr>
<tr>
<td>Daily Calculations</td>
<td>24</td>
</tr>
<tr>
<td>Nutrition</td>
<td></td>
</tr>
<tr>
<td>Fluids</td>
<td>26</td>
</tr>
<tr>
<td>Parenteral Nutrition</td>
<td>26</td>
</tr>
<tr>
<td>Enteral Nutrition</td>
<td>30</td>
</tr>
<tr>
<td>Discharge Info</td>
<td>30</td>
</tr>
<tr>
<td>Parenteral Nutrition Guideline Sheet</td>
<td>31</td>
</tr>
<tr>
<td>Trophic Feeding Schedule</td>
<td>32</td>
</tr>
<tr>
<td>Feeding Advancement Schedule</td>
<td>32</td>
</tr>
<tr>
<td>Hyper &amp; Hypoglycemia</td>
<td>33</td>
</tr>
<tr>
<td>GIR</td>
<td>34</td>
</tr>
<tr>
<td>Hyperbilirubinemia</td>
<td>35</td>
</tr>
<tr>
<td>Radiology</td>
<td>37</td>
</tr>
<tr>
<td>Sepsis Evaluations</td>
<td>38</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (cont.)

<table>
<thead>
<tr>
<th>Medications</th>
<th>41</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drips</td>
<td>42</td>
</tr>
<tr>
<td>Drug monitoring &amp; levels</td>
<td>43</td>
</tr>
<tr>
<td>Pain and sedation</td>
<td>44</td>
</tr>
<tr>
<td>Respiratory medications</td>
<td>44</td>
</tr>
<tr>
<td>Cardiovascular medications</td>
<td>45</td>
</tr>
<tr>
<td>Vaccinations</td>
<td>46</td>
</tr>
</tbody>
</table>

| Intracranial Hemorrhage  | 48 |

<table>
<thead>
<tr>
<th>Miscellaneous Guidelines</th>
<th>49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developmental Care</td>
<td></td>
</tr>
<tr>
<td>Small Volume Transfusion</td>
<td></td>
</tr>
<tr>
<td>In-and-Out Surfactant</td>
<td></td>
</tr>
<tr>
<td>Craniofacial Protocol</td>
<td></td>
</tr>
<tr>
<td>Ambiguous Genitalia</td>
<td></td>
</tr>
<tr>
<td>Hypoxic Ischemic Encephalopathy</td>
<td></td>
</tr>
<tr>
<td>Apnea Management</td>
<td></td>
</tr>
<tr>
<td>Invasive Procedure Policy</td>
<td></td>
</tr>
<tr>
<td>pH / Impedance Probe</td>
<td></td>
</tr>
<tr>
<td>Ophthalmology Consult for ROP</td>
<td></td>
</tr>
<tr>
<td>Audiology</td>
<td></td>
</tr>
<tr>
<td>Lactation</td>
<td></td>
</tr>
<tr>
<td>Apnea Management/Home Monitors</td>
<td></td>
</tr>
<tr>
<td>Breech Presentation Follow-up</td>
<td></td>
</tr>
<tr>
<td>ECMO Follow-up</td>
<td></td>
</tr>
<tr>
<td>NICU Graduate Clinic</td>
<td></td>
</tr>
</tbody>
</table>

| Discharge Preparation                     | 53 |

| Sharing Bad News                          | 55 |

<table>
<thead>
<tr>
<th>Procedures</th>
<th>59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubation</td>
<td></td>
</tr>
<tr>
<td>Lumbar Puncture</td>
<td></td>
</tr>
<tr>
<td>Umbilical Lines</td>
<td></td>
</tr>
<tr>
<td>Suprapubic Tap</td>
<td></td>
</tr>
<tr>
<td>Radial Artery Puncture</td>
<td></td>
</tr>
<tr>
<td>Chest Tube Placement</td>
<td></td>
</tr>
<tr>
<td>Exchange Transfusion</td>
<td></td>
</tr>
<tr>
<td>Chloraprep</td>
<td></td>
</tr>
</tbody>
</table>
MUSC Neonatology Web Sites

Many MUSC neonatology protocols, guidelines, and information sites are available at: www.musckids.com/residency/neonatal

These sites can be accessed with your MNA login and password.

At this website, look under Evidence-Based Medicine & Best Practice and Resident Tools to find the websites mentioned throughout this guide.

Under Evidence-Based Medicine & Best Practice, you will find:
- MUSC neonatal protocols and practice guidelines

Under Resident Tools, you will find:
- orientation manual
- resident and intern rotation guides
- educational objectives including patient coverage guidelines
- summary of neonatal mechanical ventilation
- links to clinical pathways and practice guidelines
- classification Cochrane database organized by Dr. Southgate. This database offers very easy and fast access to neonatal subjects available in Cochrane.
- example of a discharge summary
- admission and transfer criteria
- example of a discharge summary

REMEMBER - The Neonatal Survival Guide will always be updated on-line. Printed copies may become out-of-date!
THE NICU ROTATION

Rounds and Teaching Conferences
- Be punctual. Discuss the plan and time for rounds with your attending
- Pediatric Morning Report is at 8:00am
- Neonatology Daily Radiology Conference usually around 9am
- Pediatric Noon Conference for residents is at 12:15 pm – 1:15pm
- NICU “Biscuit” is daily at 3:00pm
- Pediatric Grand Rounds is at 8 am Fridays
- Monthly Neonatal Meetings
  - Third Tuesday 3:30pm - Fetal Board
  - Last Tuesday 1:00pm – Morbidity & Mortality
  - Last Wednesday 2:00pm – Case Review

Presentations on Team Rounds
- Be succinct without extensive editorializing.
- “Organ System” approach is suggested to help with organizing patient data:
  - FEN
  - GI
  - Respiratory
  - Heme
  - Cardiovascular
  - CNS/Metabolic
  - ID
  - Social/Discharge Planning
- Think about and make an assessment & plan on each problem before rounds.
  - A good deal of the learning will be by discussions during rounds. Please ask questions, add your knowledge, and disagree as you see fit

Notify Attending/Fellow for:
- ALL ADMISSIONS
  - Very sick- ASAP
  - Very stable - when initial data available but no more than 1-2 hours after patient arrives
- Impending trouble from L&D especially VLBW or multiple gestation
- Deaths/ Impending Deaths/ All “Codes”
- Change in Status - especially if unexpected
- If you need help, are getting overwhelmed, or “politics” are interfering

Charting
- Daily Notes – preprinted progress note templates will be provided by the attending usually the previous day or at least before morning rounds. You are expected to fill out as much of the note as possible before presenting the patient on rounds. An initial assessment and plan should be included. The attending will amend the notes as required.
- Procedure Notes - for lines, chest tubes, intubations, transfusions, etc. – even if unsuccessful. Make sure to include/document that “Time Out” was performed
- Progress Notes ➔ IMPORTANT- document in the progress notes any changes to patient’s condition, medical plan, or family conferences at the time of the occurrence.
- On-going transfer/discharge summary – update on the computer a couple times a week
- Time and date ALL NOTES

Parental Contact
- Speak with the patient’s parents at least twice a week. Contact them with any important changes in the patient’s condition such as intubation, sepsis evaluations, transfusions
- Inform parents were their child is transferred to level II. They are very scared when they call to check on their child and are told that the baby is gone!!!
RECOMMENDATIONS FOR INTERN AND RESIDENT NICU ROTATIONS

1. The goal is to learn
2. To achieve this goal, the intern/resident must take advantage of every available learning opportunity
3. Guidelines for intern/resident duties in the NICU are to maximize the ability to learn
4. The intern/resident must take advantage of all the available instructors in the NICU including the attendings, fellows, NNPs, pharmD, dietician, continuity care manager, social worker, nurses, and respiratory therapist

Deliveries
- A Level III intern will attend all deliveries for which the stab team is called, accompanied by an upper level resident, fellow or an NNP. Exceptions:
  - Deliveries occurring while rounding, unless excused by the attending from rounds to attend the delivery
  - Deliveries occurring when a procedure or resuscitation is underway or cannot be delayed
  - Deliveries occurring while the intern is evaluating a newly admitted patient
- This requirement will be monitored and is an expectation for successful completion of NICU rotations.

Transfer Notes
- If a patient is transferred from Level 3 to Level 2 the transfer summary must be updated and completed
- This note is the same as the ongoing discharge summary that is updated at least weekly and is used for the dictated discharge summary
- Take special care to highlight current problems AND chronic follow-up (head ultrasounds, ROP exams, consulting services)
- Verbal report to accepting resident or NNP is REQUIRED
- The template of the transfer/discharge summary is available at: www.musckids.com/~annibald/resident_tools/neonatal_discharge_summary
PATIENT COVERAGE IN THE NICU

Pediatric Interns and Residents
- The resident team will carry a maximum of 21 patients.
- Each intern (PGY-1) will carry up to 7 patients. The intern will take all patients who are appropriate for his/her NICU experience as outlined in the Neonatology Residency Training Guidelines to achieve the required number of patients.
- The required census for the resident (PGY-2) changes based on the number of interns, the number of PGY-2s, and the experience of the PGY-2s. Each resident will take all patients who are appropriate for his/her NICU experience as outlined in the Neonatology Residency Training Guidelines in order to have the required number of patients.
- The required numbers are considered maximum numbers unless all interns, the residents, and the nurse practitioners are at each individual maximum census. This situation is addressed below.

Neonatal Nurse Practitioners (NNPs)
- The NNP team will carry a maximum of 18 patients.
- Each NNP will carry a minimum of 3 patients. If the NNP team has a low census (<8), the NNP manager can decrease the daytime assignment to one NNP as she deems appropriate.
- New patients are assigned to whichever team is farthest below the maximum numbers.

Special Circumstance: High NICU census
- If the census in the NICU exceeds the totals as outlined above, housestaff and NNPs will alternate admissions according to acuity.
- Outline of Patient Assignment
  - Each individual will take one extra patient at a time in the following order: intern, intern, NNP, NNP, resident.
  - Interns will only accept patients appropriate for their training level (see Neonatology Residency Training Guidelines).
  - Additionally, interns will accept only patients of lowest acuity, according to the acuity guidelines below. Residents and NNPs will accept patients of acuities within the training guidelines.

Special Circumstance: Transfer Between Teams
- If a patient is to be transferred to the other team, this action must be done in a PROFESSIONAL and THOROUGH manner. A comprehensive transfer note and discussion of the patient plan with the new team are both required. If a transfer does not meet these standards, residency or nurse practitioner coordinators will be informed. We expect all members of both teams to maintain an up-to-date discharge summary worksheet on each patient. The worksheet will contain all information pertinent to the patient’s admission, hospital course, and planned discharge. This may be kept on line or as a handwritten summary. The format will match the discharge summary example available at: www.musckids.com/~annibald/resident_tools/neonatal_discharge_summary
Conflict with the System

- Professionalism is required of all personnel in the NICU. Any concerns or problems with this system should be addressed to Dr. Southgate or Annibale. At their discretion, non-professional behavior will be reported to appropriate supervisors.
1. For the VLBW infant in the stabilization room, remember thermal control is a major issue!
   - Raise the air temperature of the stabilization room to a maximum and raise the temperature of the scrub room to 72-74°F
   - As soon as possible after drying the infant, cover with plastic wrap
   - Keep the stabilization unit doors closed

2. Prior to the birth, have all equipment at the bedside and verify that it is functioning properly. It is VITAL to check your equipment and have the appropriate sizes handy!
   - Neopuff with appropriate settings preset and O₂ on
   - Laryngoscope with functioning bulb & correct size blade
   - ETTs
   - Suction
   - CO₂ detector

3. TEAM ASSIGNMENTS
   - Prior to the birth, assign stabilization roles. One person (usually the intern) must put on the plastic gown and be prepared to receive the baby from the L&D nurse.
   - The person “at the head” performs airway functions including clearing the airway, BVM ventilation, and intubation
   - Follow Residency Training Guidelines to assign roles at delivery
     - At the Head of the Bed:
       - Intern if baby expected to be ≥1000g
       - PGY2 in first month if baby expected to be ≥800g
       - PGY2 in 2nd month for all other babies or if airway is expected to be especially difficult
   - Fully stabilize and provide initial support in the stab room prior to transfer to the nursery
   - Remember to assign APGAR scores, sign orders, and document the resuscitation on the infant birth record sheet
   - Notes and orders should be completed in the stabilization unit
     - Please see admission orders at: www.musc.edu/cce/ORDFRMS/pdf/neonateadmit
RESUSCITATION

Please refer to the Neonatal Resuscitation Program (NRP) overview page (page 11). This page of information is posted in the stabilization unit.

High Risk deliveries include:
- \( \leq 36 \) weeks
- meconium staining
- fetal distress
- known congenital malformations
- multiple births
- malpresentation
- maternal complications
- maternal diabetes
- maternal bleeding

A physician and/or NNP is present for all caesarean sections.

General Principles:

The inverted pyramid reflects the approximate relative frequency of neonatal resuscitative efforts. Note that the majority of infants respond to simple measures (American Heart Association).
Neonatal Resuscitation Program - Reference Chart

The most important and effective action in neonatal resuscitation is ventilation of the baby's lungs with oxygen.

Endotracheal intubation

<table>
<thead>
<tr>
<th>Gestational Age (weeks)</th>
<th>Weight (kg)</th>
<th>ET Tube Size (ID, mm)</th>
<th>Depth of Insertion* (cm from upper lip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;28</td>
<td>&lt;1.0</td>
<td>2.5</td>
<td>6 - 7</td>
</tr>
<tr>
<td>28 - 34</td>
<td>1.0 - 2.0</td>
<td>3.0</td>
<td>7 - 8</td>
</tr>
<tr>
<td>34 - 38</td>
<td>2.0 - 3.0</td>
<td>3.5</td>
<td>8 - 9</td>
</tr>
<tr>
<td>&gt;38</td>
<td>&gt;3.0</td>
<td>3.5 - 4.0</td>
<td>9 - 10</td>
</tr>
</tbody>
</table>

*Depth of insertion (cm) = 6 + weight (in kg)

Medications for Neonatal Resuscitation

<table>
<thead>
<tr>
<th>Medication</th>
<th>Concentration to Administer</th>
<th>Preparation</th>
<th>Dosage Route*</th>
<th>Rate/Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephrine</td>
<td>1:10,000</td>
<td>1:10,000 solution in 1 mL syringe</td>
<td>0.01 - 0.05 mg/kg (0.1 - 0.3 mL/kg)</td>
<td>ET or IV</td>
</tr>
<tr>
<td>Volume expanders</td>
<td>Normal saline (recommended)</td>
<td>Ringer’s Lactate 0 negative blood</td>
<td>Estimated volume drawn into large syringe(s)</td>
<td>10 mL/kg</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>0.5 mmol/L (4.2% solution)</td>
<td>Estimated volume drawn into prefilled or prepared syringe(s)</td>
<td>2 mmol/L (4 mL/kg)</td>
<td>IV (Umbilical vein)</td>
</tr>
</tbody>
</table>

Postresuscitation medications (including post delivery room):
- Naloxone hydrochloride.......... 0.1 mg/kg; give rapidly; IV or ET (preferred); IM, SQ (acceptable)
- For narcotic-induced respiratory depression
- Glucose/D5W.......................... 2 mL/kg (200 mg/kg) IV over 1 - 2 minutes; followed by continuous IV glucose infusion
- Phenobarbital (for seizures).... 20 mg/kg slow IV push (1 mg/kg/min); may depress respiratory effort
- Dopamine (for hypotension)....... 2 - 20 mcg/kg/min by continuous IV Infusion

Drip Calculation: D X Wt (kg) X desired mcg/kg/min = mg in 100 mL D5W desired mL/hr

**IM - Intramuscular; ET - Endotracheal; IV - Intravenous; SQ - Subcutaneous

*Endotracheal intubation may be considered at several steps.****
THERMOREGULATION

Admission
- In the stabilization unit, every newborn is placed under a warm radiant warmer with patient temperature control. Infant is dried and hat is placed
- VLBW infants are covered with plastic wrap or placed in plastic bag
- Infants <30 weeks are admitted to a “maximally humidified” incubator (80% humidity) with patient temperature servo control
  - Patient temperature servo control means that a temperature probe on the infant’s skin controls the changes in temperature of the incubator
  - I.e. if the infant starts to get cool, the incubator will heat up
- Infants >30 weeks and <34 weeks are admitted to a 40% humidity incubator with patient temperature servo control
- Infants >34 weeks are admitted to a radiant warmer that also has patient control of the temperature

Transition
- The nursing staff follows a VLBW Temperature Support Algorithm. See the website: children.musc.edu/%7Eannibald/vep/clinical_guidelines/temp
- When a VLBW infant has achieved a weight of 1600g and 31 weeks PCA, and the average air temperature is <30 degrees then the infant enters this algorithm
- The algorithm transitions the patient to air control until the average air temperature is <28 degrees, and then the infant is swaddled (don’t forget the hat!) and transferred to a crib
  - Air control means that we set the incubator temperature
- It is VERY important to monitor patient temperature and weight gain in the open crib for the initial few days
  - An infant who is working hard to maintain temperature will burn calories and loose weight
**VITAL SIGNS**

**Temperature**
- Normal axillary temperature range: 36.5 - 37°C (97.9 - 98.3°F)
  - Hypo/hyperthermia:
    - environmental factors
    - sepsis
    - prematurity
    - postasphyxial insult

**Heart Rate**
- Normal range 80-160 bpm; rate is lower during sleep & more rapid during crying
  - Persistent bradycardia (HR <80) = abnormal
    - congenital heart block
    - sepsis
    - asphyxia
    - hypoxemia
  - Persistent tachycardia (HR >180) = abnormal
    - anemia
    - hypoxemia
    - hypovolemia
    - sepsis
    - hyperthermia

**Heart Sounds:**
- S1 ("lub"): closure of tricuspid/mitral valves after atrial ejection of blood
- S2 split ("dub"): closure of aortic/pulmonary valves after ventricular ejection of blood
  - slight separation of valve sounds is evident after 24-48 hours of age resulting in normal split sound
  - single S2 with click and SBP differential of >20mmHg between upper & lower extremities may indicate coarctation.
- S3: produced by vibration during ventricular filling → can be normal in newborn
- S4: gallop rhythm is always abnormal

**Respiratory Rate**
- Normal range 30-60 breaths/min
  - Apnea = cessation of breathing for >15 seconds
    - prematurity
    - CNS injury
    - sepsis
    - metabolic abnormalities (hypoglycemia, hypocalcemia, hypermagnesemia)
    - anemia
  - Tachypnea = RR >60 breaths/min
    - pulmonary, cardiovascular, metabolic disease
Blood Pressure

- Neonatal blood pressure is affected by gestational age, birth weight, and day of life
- In the first few days of life, we follow Mean Arterial Pressure to assess for hypotension
  - A general starting rule is that the MAP should be ≥ the gestational age.
  - This rule can be changed depending on the cardiac function and whether pulmonary hypertension is present
- A widened pulse pressure can be a sign of a **patent ductus arteriosus**
  - Widen pulse pressure is (systolic BP − diastolic BP) > ½ of systolic BP

Hypertension in Neonates

- **For All Infants** → Verify that the correct size cuff is used and that the infant is quiet during the assessment. May need to look at trends over a few days.
- **For Term Newborns:**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Significant Hypertension</th>
<th>Severe Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn - 7 days</td>
<td>systolic BP &gt; 96</td>
<td>systolic BP &gt; 106</td>
</tr>
<tr>
<td>8 - 30 days</td>
<td>systolic BP &gt; 104</td>
<td>systolic BP &gt; 110</td>
</tr>
</tbody>
</table>

*Published by Second Task Force on Blood Pressure in Pediatrics 79(1) 1987*

- **For Preterm Neonates**
  The following graph published by Zubrow et al in Journal of Perinatology vol. 15 1995 demonstrates the normal range of blood pressure for postconceptional age (gestational age). Measurements above the 95% confidence limit are considered hypertension.
VENTILATOR THERAPY

For ventilator definitions and classifications please see: www.musckids.com/~annibald/resident_tools/Classification_of_Mechanical_Ventilation.doc

Initial Ventilator Therapy
- Give FiO₂ to achieve desired saturations of:
  - 85-94% for the first 28 days
  - 90-94% for the premature infant
- Start with rate of 40-60 (can also consider adding pressure support)
- Give pressure to achieve adequate tidal volumes (4-6cc/kg) with good chest rise and breath sounds
- Target ABG’s are pH 7.25-7.4; pCO₂ 40-50, pO₂ 60-90

Bronchopulmonary Dysplasia
- Note that management varies with each baby
- General Goals: pH>7.25 and pO₂>60 or O₂ sat 92-96%.
- Avoid desaturation with feedings, suctioning, agitation, etc

Pulmonary Hypertension
- Defined by evidence of shunting by pre/post-ductal O₂ saturation difference ≥ 7% or evidence of pulmonary hypertension by echocardiogram
- Keep O₂ sats >96% and pO₂ 80-100
- Keep pH 7.35-7.45
- Avoid hypotension
- Avoid agitation of patient
- Wean FiO₂ VERY slowly
- Consider Inhaled Nitric Oxide
  - iNO is a pulmonary vasodilator
  - The respiratory therapists have iNO guidelines (see next page)
  - iNO can be given with the JET as long as the servo pressure stays less than 8
  - Start at 20 ppm and follow guidelines unless discussed with fellow/attending

Initial Ventilator Settings
- FiO₂ of 21-100%
  - Remember to wean FiO₂ to maintain O₂ sats >90%
- PIP to give TV of 4-6 ml/kg
  - Write the order in the chart for the desired PIP and the RT will ensure that it is achieved
  - Adjust based on chest expansion, air entry and blood gasses
- PEEP of 4-5 cm H₂O
- Rate of 30-40 bpm

Example Settings – what to order
- If your goal PIP is 18 with PEEP of 4 cm and SIMV rate of 45 (and Pressure Support of 6 cm), depending on the vent you would order the following settings:
  - VIP Bird: PIP=18, PEEP=4, Rate=45, (PS is not available on the Bird)
  - Avea: IP=14, PEEP=4, Rate=45, PSV=6
    - Remember, IP=PIP-PEEP or PIP=IP+PEEP
• Minimum PIP guidelines:

<table>
<thead>
<tr>
<th>Weight (grams)</th>
<th>Minimum PIP (cm H₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;750</td>
<td>13</td>
</tr>
<tr>
<td>750-1000</td>
<td>14</td>
</tr>
<tr>
<td>1001-1500</td>
<td>15</td>
</tr>
<tr>
<td>&gt;1500</td>
<td>16</td>
</tr>
</tbody>
</table>

**General Vent Management Guidelines**

• Should be used for preterm infants less than 7 days of age with RDS
• Incorporate findings on exam, CXR, trends of minute ventilation & tidal volumes

<table>
<thead>
<tr>
<th>Blood Gas Results</th>
<th>Possible Pathophys reason</th>
<th>Possible vent changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>pCO₂ OK/low; PaO₂ low</td>
<td>Atelectasis with V/A mismatch</td>
<td>Consider ↑ PEEP</td>
</tr>
<tr>
<td>pCO₂ OK/low; PaO₂ OK/high</td>
<td>Overventilated</td>
<td>Consider ↓ PIP OR ↓ PIP and PEEP (with ↓ ΔP), or ↓ rate</td>
</tr>
<tr>
<td>pCO₂ OK/high; PaO₂ low</td>
<td>Atelectasis with resultant low TV</td>
<td>Consider ↑ PIP OR ↑ PIP and PEEP (with ↑ ΔP)</td>
</tr>
<tr>
<td>pCO₂ OK/high; PaO₂ high</td>
<td>Inadequate minute ventilation with at least adequate FRC</td>
<td>Consider ↓ PEEP, ↑ rate, or ↑ PIP</td>
</tr>
</tbody>
</table>

• Targeting minute ventilation (MV) to achieve desired PaCO₂
  • Target MV = PaCO₂ x current MV ÷ desired PaCO₂
    • Example: Target MV = 40 x 160 ÷ 50 = 240 cc/kg/min

• If your tidal volumes are acceptable, then you will want to change your rate (RR) to achieve the desired MV
  • Target RR = PaCO₂ x current RR ÷ desired PaCO₂
    • Example: Target RR = 40 x 30 ÷ 50 = 24 breaths per minute

**Weaning**

• Gradual reduction in rate allows patient to slowly adjust to increasing workload
• Appearance of respiratory distress, hypoxemia, hypercarbia are indications to halt further weaning
POSITIVE PRESSURE VENTILATION

- provides the force necessary for the generation of tidal breath
- alters the end expiratory lung volume in order to improve oxygenation
- Functional Residual Capacity (FRC) = lung volume at end of spontaneous exhalation
  - FRC is the lung volume critical for oxygenation
  - In order to improve oxygenation, must optimize FRC

- Application of Positive End Expiratory Pressure (PEEP) alters the end expiratory lung volume
  - PEEP = constant pressure that is applied to the respiratory system during exhalation
  - PEEP aids in opening & maintaining the patency of alveoli through the respiratory cycle

- Inspiration begins (A) with the application of positive pressure (PP)
- PP reaches a peak level (B) called Peak Inspiratory Pressure (PIP)
- Inspiratory Time (IT) is the pressure sustained for the duration of inspiration
- The pressure drops back to where it started as exhalation begins (C)
- PEEP is maintained throughout the expiratory phase
- Oxygenation correlates best with Mean Airway Pressure (MAP)
  - MAP = total areas of the individual rectangles + PEEP:
    \[ MAP = \frac{(PIP-PEEP) \times IT \times RR}{60} + PEEP \]
  - (PIP-PEEP) x IT → this is the area of the individual rectangles
  - IT is expressed in seconds
  - RR (respiratory rate) or ventilatory rate = total number of rectangles per minute
  - 60 = mathematical factor since ventilatory rate is in breaths per minute & IT is in seconds
  - PEEP is the end-expiratory pressure which is always there during PPV with PEEP
HIGH FREQUENCY VENTILATION

- HFV is defined as ventilation rate >150 bpm with tidal volume less than dead space
- Various types of HFV vary in rates, TV, system used to deliver gas
  - High Frequency Oscillator Ventilation (HFOV)
  - High Frequency Jet Ventilation (HFJV)

<table>
<thead>
<tr>
<th>MODE</th>
<th>RATE (FREQ)</th>
<th>TV</th>
<th>EXHALATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFOV</td>
<td>up to 2400</td>
<td>&lt;3 ml</td>
<td>active</td>
</tr>
<tr>
<td>HFJV</td>
<td>100-150</td>
<td>2-5 ml</td>
<td>passive</td>
</tr>
</tbody>
</table>

HFOV
- Oscillations are generated by a to-and-fro movement of a piston
- On inspiration a column of gas is pushed into the airway
- During exhalation gas is drawn out of the airway
- Both inspiration and expiration are active
- Oxygenation is a function of FiO₂ and MAP
- Ventilation is a function of the pressure amplitude (ΔP) and the ventilatory rate
- Inspiratory time is usually constant and set at 0.33
- HFOV is defined by the “high frequency” (2.5-15 Hz) and low tidal volume (0.5-5ml/kg)

MAP = mean airway pressure
ΔP = pressure amplitude
Hz = frequency (60 cycles/min)

Pressure amplitude oscillates around the MAP at the preset ventilatory frequency expressed in Hertz (Hz)
  - One Hz = 60 cycles/minute or 60 bpm
Starting the patient on HFOV:
- Start at a MAP that is 20-30% higher than the MAP on the conventional ventilator
- Increase the MAP repeatedly in increments of 1-2 cmH₂O until adequate oxygenation is achieved
- Keep MAP at the optimal value until are able to decrease the FiO₂ <60%
- Obtain CXR soon after initiating HFOV to evaluate for hyperinflation
  - Baseline lung volume goal = 7-8 rib expansion
  - Flattening of diaphragms will be seen if hyperinflation
  - If signs of overinflation, decrease MAP by 2cm H₂O and re-evaluate
  - Follow-up CXR in 2-4 hours after changes made in MAP
- Start ΔP at 10-15 cm H₂O higher than PIP on CMV
  - Watch chest movement to assure adequate chest wiggle
  - Increase ΔP by 5cm H₂O increments
  - If maximum ΔP is reached and PaCO₂ is still high, decrease frequency in order to decrease PaCO₂
- Frequency (Hz) guidelines:
  - 10-12 Hz for birthweight between 2-5 kg
- Obtain blood gas ~20-30 minutes after the patient has been stable on HFOV

Making adjustments once on HFOV:
<table>
<thead>
<tr>
<th>Poor Oxygenation</th>
<th>Over Oxygenation</th>
<th>Under Ventilation</th>
<th>Over Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑ FiO₂</td>
<td>↓ FiO₂</td>
<td>↑ amplitude (ΔP)</td>
<td>↓ amplitude (ΔP)</td>
</tr>
<tr>
<td>↑ MAP (1-2cm H₂O)</td>
<td>↓ MAP (1-2cm H₂O)</td>
<td>↓ frequency (1-2Hz) if amplitude maximal</td>
<td>↑ frequency (1-2Hz) if amplitude minimal</td>
</tr>
</tbody>
</table>

Weaning from HFOV:
- Reduce FiO₂ to <40% before weaning MAP
  - Exceptions ➔ overinflation ➔ air leak syndromes where ↓ MAP takes priority over ↓ FiO₂
- Reduce MAP in 1-2cm increments to 8-9
- Wean amplitude (ΔP) in 2-4cm increments
- Don’t wean the frequency
HFJV
- Short pulses of air delivered at high velocity to the upper airway
- Pulses stream down center of airway & penetrate dead space gas
  - Dead space gas simultaneously swirls outward along periphery of airway (passive)
- Gas exchange occurs by diffusion in distal airways

- Conventional ventilator used in tandem with HFJV to generate PEEP and backup rate (sigh breaths)
- Amplitude of jet breaths determined by difference between jet PIP and PEEP controlled by CV
- *Proximal monitoring adaptor (PMA)* connected to patient’s ETT
  - PMA also connected to FiO₂, pressure, and temp monitors

**Patient management on HFJV**
- HFV ΔP (PIP-PEEP) is primary determinant of PaCO₂
  - HFV rate is secondary
- Resting lung volume (FRC supported by set PEEP) & MAP are determinants of PO₂
- Avoid hyperinflation and hypoxemia by using optimal PEEP
- Minimize IMV at all times
  - use low rates (0-3 bpm) unless IMV being used to dilate airways or temporarily recruit collapsed airways
  - in general, keep IMV PIP 20-50% < HFJV PIP
- To overcome atelectasis, can ↑ conventional vent rate up to 10 for 10-30 minutes
  - after, ↓ IMV rate back down to 0-3 bpm
  - in general, keep IMV I-time=0.4-0.6 sec
- If lowering conventional vent rate worsens oxygenation, PEEP is probably too low
  - higher PEEPs and lower IMV rates reduce the risk of iatrogenic lung injury
- Lower FiO₂ before PEEP when weaning FiO₂ until FiO₂ less than 50%
- If patient has an AIR LEAK:
  - if oxygenation is compromised, ↑ PEEP (even if lungs are overexpanded)
    - something has to be raised and PEEP is less hazardous than IMV breaths
<table>
<thead>
<tr>
<th>SETTING</th>
<th>USUAL</th>
<th>WHEN TO ↑</th>
<th>WHEN TO ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFJV PIP</td>
<td>Whatever produces desired PCO₂</td>
<td>To lower PCO₂</td>
<td>To raise PCO₂ (raise PEEP simultaneously to keep MAP and PO₂ constant)</td>
</tr>
<tr>
<td>HFJV Rate</td>
<td>420 bpm</td>
<td>To decrease PCO₂</td>
<td>To eliminate inadvertent PEEP by lengthening exhalation time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To increase MAP and PO₂</td>
<td>To increase PCO₂ when weaning</td>
</tr>
<tr>
<td>IMV Rate</td>
<td>0-3 bpm</td>
<td>To reverse atelectasis or dilate</td>
<td>To minimize volutrauma, especially when air leaks are present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>restricted airways</td>
<td>To decrease hemodynamic compromise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>↑ to 5-10 bpm temporarily</td>
<td></td>
</tr>
<tr>
<td>IMV PIP</td>
<td>PIP necessary to get</td>
<td>To reverse atelectasis or dilate</td>
<td>To minimize volutrauma, especially when air leaks are present</td>
</tr>
<tr>
<td></td>
<td>adequate chest rise</td>
<td>restricted airways</td>
<td>To decrease hemodynamic compromise</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEEP</td>
<td>7-12 cm H₂O</td>
<td>To improve oxygenation</td>
<td>When it appears cardiac output is being compromised</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To decrease hyperventilation</td>
<td>When oxygenation is inadequate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TO FIND OPTIMAL PEEP:</td>
<td>When lowering PEEP does NOT ↓ PaO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>raise PEEP until SaO₂ stays constant</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>when switching from IMV to CPAP</td>
<td></td>
</tr>
<tr>
<td>FiO₂</td>
<td>&lt; 60%</td>
<td>Raise as needed AFTER optimizing PEEP</td>
<td>Lower in preference to PEEP when weaning until FiO₂ &lt;30%</td>
</tr>
<tr>
<td>Servo Pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>changes in servo pressures is an early warning of changes in patient condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>watch trends in servo pressures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>servo pressures increase with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o improving compliance or resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o leak around ETT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o tube leak</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>servo pressures decrease with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o worsening compliance or resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o obstructed ETT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o tension pneumothorax</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o right mainstem intubation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o patient needs suctioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusting the Jet Rate</td>
<td>420 bpm</td>
<td>&lt;420 bpm</td>
<td>&gt;420 bpm</td>
</tr>
<tr>
<td></td>
<td>appropriate rate for majority</td>
<td>MAS</td>
<td>not usually required</td>
</tr>
<tr>
<td></td>
<td>Of NICU patients</td>
<td>360 = preemies with airleaks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 = &gt; than 2kg with airleaks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>240 = BPD / CLD</td>
<td></td>
</tr>
<tr>
<td>Weaning to CPAP</td>
<td>Wean PIP in response to improved PaCO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o When PIP &lt;20 can lower JET rate → at 240 bpm, I:E = 1:12, so pt basically on CPAP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once PIP ≤16, MAP &lt;8 and FiO₂ &lt;30% &amp; baby breathing regularly, consider switching to CPAP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Can try short trial of ET CPAP on CMV to see how pt will tolerate NCPAP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SURFACTANT

- produced by Type II pneumocytes
  - production decreased by asphyxial insults in perinatal period
  - maturation of cell line delayed in presence of fetal hyperinsulinemia
  - maturity enhanced by administration of antenatal corticosteroids
  - maturity enhanced by chronic intrauterine stress:
    - twin gestation
    - pregnancy induced hypertension
    - IUGR
- synthesis begins ~ 24-28 weeks gestation
- composed of phospholipids (75%) and protein (10%)
- functions to decrease surface tension and maintain alveolar expansion
- lack of surfactant → collapse of small airways → progressive atelectasis → progressive cellular damage → exudative proteinaceous material & epithelial debris collect in airways → ↓ total lung capacity

Who gets Survanta?
- All infants <30 weeks GA get intubated and given survanta in STAB within 15 minutes of birth
  - DOSE: 4ml/kg/dose via ETT
  - Can get up to 4 doses total – spaced 6 hours apart if meets eligibility criteria:
    - MAP >7
    - FiO₂ >30%
- For infants with RDS 30-36 weeks, consider in-and-out survanta
  - See guidelines at: www.musc.edu/cce/ORDFRMS/pdf/neonateadmit
  - Criteria:
    - First 24 hours of life
    - 30-36 weeks
    - RDS by history & exam (confirmed by CXR)
    - O₂ requirement ≥ 30% or CPAP
  - Procedure:
    - Intubate & confirm placement with pediaicap
    - Administer survanta 4ml/kg via ETT
    - PPV or Neopuff
    - Rapid extubation
      - must occur within one hour of intubation
      - FiO₂ < than when intubated &/or <50%
      - infant is breathing spontaneously
      - exam stable
  - Transfer to NNICU is indicated after delivery of surfactant if unable to extubate to CPAP in L2 or after initial transition to CPAP, the following occur:
    - RR ≥100 or increasing
    - >6cm H₂O of CPAP
    - FiO₂ requirement >50%
    - Worsening clinical exam
      - In these patients, consider placement of UAC if:
        - FiO₂ ≥40%
        - RR ≥80
VITAMIN A

- Promotes normal lung growth and repair
- Vitamin A deficiency can cause:
  - impaired lung healing
  - ↑ loss of cilia
  - ↑ squamous cell metaplasia
  - ↑ risk of infection
  - ↓ number of alveoli
- VLBW infants have low plasma and tissue concentrations of Vitamin A² & at ↑ risk of chronic lung disease
  - Vitamin A supplementation has been shown in several studies to decrease the incidence of CLD in at risk infants

Who gets Vitamin A?
- Infants <1000g

Vitamin A Dosing:
- 5000 IU (international units) = 0.1ml IM every Monday, Wednesday and Friday for a total of 12 doses
  - given IM because Vitamin A is felt to be poorly absorbed enterally, and has unreliable delivery when given with crystalloid solutions
  - mark appropriate box on page 4 of admission order form
- if a patient is to be started on steroids during the time of Vitamin A administration, then Vitamin A should be held
  - toxicity has been associated with concomitant use of Vitamin A and steroids
    - symptoms of toxicity include the following:
      - ↑ intracranial pressure → full-bulging anterior fontanelle
      - vomiting
      - irritability
      - lethargy
      - peeling of the skin
DAILY CALCULATIONS

% CURRENT WEIGHT BELOW BIRTH WEIGHT
- Divide current weight by birth weight
- Subtract from 100
- i.e: birth weight = 2600g & current weight 2500g
  - 2500g/2600g = 0.96
  - 1.00-0.96 = 0.4 → 4% below birth weight

URINE OUTPUT (UOP)
- Take total amount of urine out over 24hr or whatever time frame you are using
- Divide that amount by the # of hours
- Divide that # by the infants weight in kg
- i.e.: 100cc uop in 24 hr & 2kg wt
  - 100cc/24hr = 4.16 cc/hr
  - 4.16 cc/hr / 2kg = 2cc/kg/hr

URINE ELECTROLYTES
- Urine lytes are reported in mEq/L & need to change that to mEq/100cc
- Take total UOP for last 24 hrs and set up proportion:
  \[
  \frac{\text{Urine electrolyte}}{100cc} \times \frac{\text{"X"}}{\text{infant's UOP}}
  \]
  Divide “X” by infant’s wt → mEq/kg/d

DAILY FLUID REQUIREMENT
- Wt (kg) x cc/kg/d → total cc/day
- IV Fluids: cc/d ÷ 24h → cc/hr
- PO intake: cc/d ÷ # feeds/day → cc/feed

KNOWN FLUID INTAKE
- IV Fluids: \(\frac{\text{cc/hr} \times 24\text{hr}}{\text{wt in kg}} = \text{cc/kg/d}\)
- PO intake: \(\frac{\text{cc/feed} \times \text{feeds/day}}{\text{wt in kg}} = \text{cc/kg/d}\)

DEXTROSE CALORIES
- 1g dextrose = 3.46 calories
- So with 10% dextrose:
  - 10g or 34.6 calories/100cc
  - 1g or 3.46 calories /10cc
  - 0.346 calories/cc
- Total cc/d x calories/cc of dextrose solution
  - D5 = 0.173 (0.2) cal/cc
  - D10 0.346 cal/cc
- Divide total glucose calories by wt in kg → calories (glucose)/kg/d
**CALCULATION OF CALORIES**
- IV Fluids: \[
\frac{cc/d\times cal/cc}{wt\ in\ kg} = cal/kg/d
\]
- PO Intake: \[
\frac{total\ cc\ of\ formula}{30cc} = ounces\ of\ formula/d
\]
  \[
  ounces/d\times cal/oz = cal/kg/d
  \]
  \[wt\ in\ kg\]

**PERCENT DEXTROSE**
- \[
mg/kg/min\ (desired)\times kg \rightarrow mg\ glucose/min
\]
- \[
mg/min \div 1000\ (mg/g) = gm/min
\]
- \[
g/min\times 1440\ (min/day) = g/day
\]
- \[
g/day\times cc/d \times 100 = \%\ dextrose
\]

**GLUCOSE INFUSION RATE**
- \[
(dextrose\ %\times 100)\times ml/day = g/day
\]
- \[
g/day\times 1440\ (min/day) = g/min
\]
- \[
g/min\times 1000\times kg = mg/kg/min
\]

**CALCULATION OF ELECTROLYTES**
- To determine amount of electrolyte that you want to give per kg/d
  - determine total amount of IV fluids/d
  - set up proportion & cross multiply:
    \[
    \frac{mEq/d}{X}\times \frac{X}{total\ fluids\ \times 100cc}
    \]
- To determine amount of electrolytes in the IV solution (usually amt / 100cc)
  - Determine amount of IV fluids received over past 24 hr
    \[
    \frac{mEq\ electrolyte/IV\ solution}{100cc\ IV\ fluid}\times \frac{X}{amt\ IV/24\ hr}
    \]
    - Divide “X” by wt to \[mEq/kg/d\]

**SERUM OSMOLALITY**
- Normal serum osmolality is 270-300 mOsm
- Sodium x 2 usually gives close estimation
- Formula:
  - \[
  (2\times Na) + (10\times BUN\div 28) + (10\times glucose/180)
  \]
Fluids

Initial Management
- Patients admitted to the NNICU or Level 2 Nursery on DOL 1 weighing >1500 grams should be given D10W until parenteral nutrition (PN) can be ordered.
- Patients who weigh $<$1500 grams should be given an “After Hours” PN bag (aka DOL 1 Bag) until PN can be ordered.
  - “After Hours” PN bags contain D10W and 2.5% TrophAmine (protein) which provides a glucose infusion rate (GIR) of ~5.5 mg/kg/min and 2 g/kg/d of protein when run at 80 cc/kg/d.
  - The order form can be found online under: Clinician Order Forms/Neonatology/After Hours PN Orders.
- The initial total fluid goal is usually 60-80 cc/kg/day for term patients; 80 cc/kg/day for preterm patients.
- In patients beyond DOL 1, D10W or D12.5W with electrolytes (usually Na and K) will be hung until PN may be ordered.
- Any combination of electrolytes can be added to the bag if necessary, except a combination of calcium and phosphorus cannot be added to the same bag of IV fluids because of precipitate formation.
- As mentioned above, the “After Hours” PN bag should be ordered for patients admitted weighing $\leq$ 1500 grams.
  - These bags are not optional for qualifying patients since it is so important to initiate the order as soon as possible. These bags will be the initial intravenous fluids started until parenteral nutrition arrives.
  - Call Pharmacy (2-6307) at least 1 hour in advance to let them know to prepare a bag (the bags are refrigerated and need to be pulled out 1 hour before hanging). Fax the order to Pharmacy.
  - These bags are available 24 hours a day and may also be used for qualifying patients in the event that a bag of PN is damaged or wasted.

Parenteral Nutrition
- Requirements vary, but approximately 60 non-protein kcal/kg/day with ~2.5 g/protein/kg/d are required before protein is utilized for growth (protein-sparing).
- Average total caloric requirements (parenteral) for neonates are 80-110 kcal/kg/day.
- It is suggested that optimal nitrogen retention results when nonprotein kcal/kg are provided at 60-70% carbohydrate and 30-40% fat. (In: Nutritional Care for High-Risk Newborns, 3rd ed., 2000.)
- Before writing parenteral nutrition (PN), it is necessary to know what IV access the patient has.
  - Central PN may be run through UVC and PICC lines unless otherwise indicated.

Carbohydrates: 3.4 kcal/g
- Peripheral line: maximum dextrose concentration = 12.5%
- Central line: maximum concentration is 30-35%
- Carbohydrate is delivered at infusion rates of 4-12 mg/kg/min.
  - This is the rate at which the liver oxidizes carbohydrate to be utilized for energy.
  - Delivery of $>$12 mg/kg/min can result in hyperglycemia, hypertriglyceridemia, fatty liver, and excess CO2 production.
• Glucose infusion rate (GIR) may be initiated at 6 mg/kg/min assuming the patient is euglycemic (initiate ELBW 4-6 mg/kg/min)

*Monitoring parameters: blood glucose (<150), CO₂ (from blood gas)

**To calculate glucose infusion rate:**

\[
\text{% dextrose} \div 100 = \text{g dextrose/mL PN} \\
\text{_____ g/mL} \times \text{_____ mL/d} \div 1440 \text{ min/d} \times 1000 \text{ mg/g} \div \text{wt} = \text{mg/kg/min}
\]

**Lipid:** 2 kcal/mL (20% Intralipid)

- Lipid is delivered up to 3 g/kg/day
- Lipid kcals should not exceed dextrose kcals
- Symptoms of essential fatty acid deficiency can be seen within 72 hours if no lipid is administered
- Essential fatty acid requirements can be met with 0.5 g lipid/kg/day
- For patients requiring phototherapy, lipids may need to be limited to < 1.5 g/kg/day
  - 0.5 g/kg/d max if approaching exchange level, as lipids displace bilirubin from albumin binding sites

*Monitoring parameter: Triglycerides (<150-200) - particularly in ELBW infants
  - First check in ELBW infants should be when infant is on 2 g/kg/d of lipids

**Protein:** 4 kcal/g (Trophamine)

- Peripheral line: maximum amino acid concentration is 2.5 %
  - if dextrose is ≤ 10%, then amino acids may be 2.5%;
  - if dextrose is >10%, then amino acids can’t be more than 2%
- Central line: maximum concentration is 5%
- Delivery of greater than 4 g/kg/day may result in azotemia
  - BUN should be routinely monitored during advancement
- Preterm infants require up to 3.5-4 g/kg/day for growth
- Term infants require less — 2.5-3 g/kg/day maximum
- Preterm infants (<1500g) should be started on protein-containing fluids on DOL 1
- Protein should be initiated at 1.5-2 g/kg/day to help prevent a negative nitrogen balance in these pts

**Electrolytes:**

**Daily Electrolyte and Mineral Requirements:**

- Sodium 2-4 mEq/kg/d (except in the first several days of life)
- Potassium 2-4 mEq/kg/d (except in the first several days of life)
- Chloride 2-5 mEq/kg/d
- Phosphorus 1-2 mmol/kg/d (35-70 mg/kg/d)
- Magnesium (elemental) 0.3-0.5 mEq/kg/d (6-10 mg/kg/d)
- Calcium (elemental) 1-4.5 mEq/kg/d (20-90 mg/kg/d)
Electrolyte panels on the PN order form:

- Peripheral electrolyte panel (Chloride:Acetate ratio is 4:1)
- Minimal electrolyte panel (includes minimal amounts of Na, Phos, Ca & Mg only)
  - this panel is used for the first few days of life only
- Central electrolyte panel (Maximum Chloride; no Acetate)
- if Magnesium Sulfate was administered prior to delivery then leave Mg out of PN until pts serum level returns to WNL

**Calcium and Phosphorus:**

- Peripheral line: maximum amount of calcium is 1 mEq/100 mL.
- Central line: The sum of calcium (mEq/100 mL) and phosphorus (mmol/100 mL) may not exceed 5 in order to avoid precipitation
- When the sum is > 4, cysteine must be added (40 mg/g protein) to the PN solution to increase the solubility of calcium and phosphorus
- To promote proper bone accretion, Calcium:Phosphorus molar ratio should be 1.3:1
- Remember that hypoalbuminemia makes the total calcium look low when actually the free calcium is fine!

**Chloride:Acetate:**

- Chloride acts as an acid; acetate a base
- The amounts of chloride and acetate to be added in PN is expressed as a ratio, not a numeric amount
  - Usual ratios include 4:1, 3:1, 2:1, 1:1, 1:2, 1:3, 1:4, Max Cl, Max Acetate
- Cl & Bicarb levels on pt’s BMP will be guide in choosing an appropriate ratio for the PN
- Remember Bicarbonate levels on a BMP are more reliable than those on a blood gas
  - Levels on a blood gas are calculated; levels on a BMP are not

**Other additives:**

- **Carnitine** should be added if a patient continues to require PN after 10 days and where PN constitutes more than 50% of a patient’s nutrition
  - Premature infants of < 34 weeks gestation receiving PN have limited carnitine stores and can develop a deficiency 6-10 days after birth, so adding carnitine to PN within the first week of life for these pts is generally recommended
  - Carnitine is essential for optimum oxidation of fatty acids (for energy) in the mitochondria. (In: Nutritional Care for High-Risk Newborns, 3rd ed., 2000.)
  - Dose: 10-20 mg/kg
- **Selenium** acts as an antioxidant and should be added early in the administration of PN (within the first week of life).
  - Dose: 1.5-2 ug/kg
- **Molybdenum** is only indicated for patients on long-term PN who are NPO > 30 days.
  - Dose: 0.25 ug/kg
- **Chromium, Selenium, and Molybdenum** excretion are impaired with renal disease and impaired renal function and should be removed from PN until renal function is improved
- **Copper and Manganese** are excreted via bile. Elimination will be impaired with cholestasis (indicated by direct bilirubin >2) These should be removed from parenteral nutrition until the direct bilirubin <2
- If a trace mineral is removed from PN daily, it is recommended that it be given on a weekly basis to prevent any deficiencies from occurring
Lab Monitoring:
- Electrolytes should be monitored routinely when initiating PN until stabilized
- A Basic Metabolic Panel (BMP) is usually ordered at least every other day in the first week of life until electrolytes are stable
- You can discuss the plan for labs during rounds
- At 2 weeks on PN, “nutrition labs” should be checked and subsequently monitored every 2 weeks while PN continues
  - “Nutrition labs” include:
    - Comprehensive Metabolic Panel (CMP). (includes: Na, K, Cl, Bicarb, Glu, BUN, creat, Ca, Tbili, AST, ALT, AlkPhos, total protein, alb), Magnesium, Phosphorus, & Direct Bilirubin

Weaning note with central PN:
- Please see guidelines for weaning PN at: children.musc.edu/%7Eannibald/vep/clinical_guidelines/PN_Weaning_2004
- When pt is tolerating 70-80 cc/kg/d of enteral feeds, begin weaning the parenteral amounts of dextrose, protein and lipid to avoid making a very concentrated bag of PN as well as overfeeding the patient!
- Remember, total kcal (from PN and EN — including parenteral protein!!) on your PN order sheet should never exceed 120 kcal/kg/d
- When you see total kcals/kg >110, you need to begin weaning lipids/dextrose in the PN.
- If you are giving electrolytes above what a standard panel provides, particularly Na and K, be mindful of how much (per 100 mL) you are actually providing
- In general, when a patient advances to 80-100 cc/kg/d of enteral feeds, stop giving IV lipids. At 120 cc/kg/d of feeds, stop writing PN

Other Miscellaneous Tips for writing Parenteral Nutrition:
- Make sure to enter pts medical record #, and patcom# into the computer when beginning a PN order
- Birth weight should be used as the daily wt until the pt regains it
- Note any large weight shifts from day to day. It may not be appropriate to write PN based on a weight that has changed more than 10% in a day
- Include any “other” fluids in your total fluid volume. This includes UAC, PAL, and any other continuous drip fluids
- When adjusting Na and K in PN, increase/decrease by ~ 1 mEq/kg/d
  - (0.5 mEq/kg/d for K with renal dysfunction)
- When adjusting Ca and P in PN, increase/decrease by ~0.5 mEq (mmol)/kg/d
- When adjusting Mg in PN, adjust by 0.1 mEq/kg/d increments
- For PICC lines only--if PN rate < 2 mL/h then 100 units of heparin should be added to the PN
- If a change needs to be made to a PN after it has been sent to Pharmacy, call Pharmacy first (2-6307)!!
- Do not remove the original order from the chart, but write ‘Void’ across it
- Write ‘Revision’ on the revised PN order
- After writing any PN order, place one signed copy on the chart and one signed copy in the PN folder (on the table in the resident rounding room) for Pharmacy to pick up
- Orders should be placed on the chart at the same time it is sent to Pharmacy!
- Remember, PN orders are due by 2 pm daily!
Enteral Nutrition

Estimation of Enteral Energy Requirement for the Preterm Infant (kcal/kg/day):
• The energy requirement of infants is determined by the following 3 variables listed below.
• Energy storage includes both fat and lean body mass accretion
• Energy losses are often due to incomplete digestion and absorption
• Approximately 70 kcal/kg, on top of the maintenance energy requirement of ~ 50 kcal/kg, should support a daily weight gain of 15 g/kg/d

Energy Expended kcal/kg/day
- Resting Metabolic State 50
- Activity 15
- Cold Stress/Synthesis/
  Thermic Effect of Food 18
- Energy Stored 25
- Energy Excreted 12


Goals and Guidelines for Enteral Nutrition
• Goal volume for preterm infants is generally 160 cc/kg/d of fortified breast milk or premature formula concentrated to 24 kcal/oz
  o This volume will provide estimated nutritional needs of ~128 kcal/kg/d and 3.5 g protein/kg/d
  o It also provides increased amounts of calcium, phosphorus, and fat soluble vitamins needed by these infants
• When pt is tolerating 120 cc/kg/d of breast milk or formula, then it is time to fortify or concentrate to 24 kcal/oz
  o It is typically not advised to increase volume the same day kcal density is increased
  o To Fortify Breast Milk with Human Milk Fortifier (HMF):
    o Add 1 packet fortifier per 25 cc breast milk = 24 kcal/oz
    o Add 1 packet fortifier per 50 cc breast milk = 22 kcal/oz
• If a pt is receiving breast milk (fortified or not), supplemental iron is indicated at 30 days of age
  o (2 mg elemental iron/kg/d—usual dose)
  o Infants on erythropoetin also need iron
• Premature infants require an additional multivitamin supplement particularly for additional Vitamin D
  o Polyvisol 0.5-1 cc/d
• Infants who are >1800g and ≥34 wks may receive breast milk (unfortified) or term formula unless otherwise indicated. Consult RD if unsure
• Please see algorithm at: [children.musc.edu/%7Eannibald/vep/clinical_guidelines/po_feeds](http://children.musc.edu/%7Eannibald/vep/clinical_guidelines/po_feeds) about transitioning to PO feeds

Discharge Information
• A transitional formula is an appropriate choice for the preterm infant who is ready for discharge
• Premature formulas are no longer appropriate (for most pts), not available in grocery stores, and are very, very expensive!
• Human milk fortifier is also no longer appropriate (for most pts) post d/c, not readily available, and extremely expensive
• If an infant on breast milk still requires the “extra calories” then this alternative may be used:
  o For 22 kcal breast milk: Add ½ teaspoon Neosure powder to 90 cc BM
  o For 24 kcal breast milk: Add 1 teaspoon Neosure powder to 90 cc BM
Parenteral Nutrition Guide Sheet

An After Hours Bag provides a **GIR of 5-5.5 and 2 grams/kg of Protein**! Do not initiate a PN order at less than these amounts unless a restriction is warranted!

<table>
<thead>
<tr>
<th>Category</th>
<th>Initiate</th>
<th>Advance</th>
<th>Goal</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Fluids (TF)</strong></td>
<td>usually 80 cc/kg</td>
<td>~20 cc/kg/d</td>
<td>150 cc/kg/d</td>
<td>Discuss plan for TF in rounds qd</td>
</tr>
<tr>
<td><strong>Dextrose (GIR)</strong></td>
<td>Premie (&lt;1000g): 4.5-6 (1000-1500g): 5.5-6 Term: 6-7</td>
<td>1-2 mg/kg/min (<strong>suggest ↑ by only 1 if &lt;1000 g</strong>)</td>
<td>12 mg/kg/min</td>
<td>this assumes pt is euglycemic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Amino Acids</strong></td>
<td>2-2.5 g/kg/d (usually ~2.5% a.a.)</td>
<td>1 g/kg/d</td>
<td>premie: 3.5-4 g/kg/d term: 3 g/kg/d</td>
<td>monitor BUN for tolerance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lipid</strong></td>
<td>0.5-1 g/kg/d</td>
<td>0.5-1 g/kg/d</td>
<td>3 g/kg/d</td>
<td>monitor triglycerides limit &lt;1.5 g/kg if on phototherapy</td>
</tr>
<tr>
<td><strong>Electrolytes</strong></td>
<td>Minimal lytes panel (the middle one)</td>
<td>Standard panel (use left one for peripheral, right one for central)</td>
<td></td>
<td>try to use standard panels if possible</td>
</tr>
</tbody>
</table>

*GIR = Glucose infusion rate*
**OTHER FEEDING GUIDELINES**

### TROPHIC FEEDING SCHEDULE

<table>
<thead>
<tr>
<th>Weight (g)</th>
<th>Feeding Schedule</th>
<th># of Days on Trophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-750</td>
<td>0.5-1 cc q 3h</td>
<td>7</td>
</tr>
<tr>
<td>751-1000</td>
<td>1 cc q 3h</td>
<td>5</td>
</tr>
<tr>
<td>1001-1250</td>
<td>1.5 cc q 3h</td>
<td>3</td>
</tr>
<tr>
<td>1251-1500</td>
<td>1.5 cc q 3h</td>
<td>1</td>
</tr>
</tbody>
</table>

### Feeding Advancement Schedule

<table>
<thead>
<tr>
<th>Weight (g)</th>
<th>Enteral Type</th>
<th>Interval</th>
<th>Initial Volume cc/kg/d</th>
<th>May advance by (cc/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 750</td>
<td>BM/Preterm 20</td>
<td>q 3h</td>
<td>≤ 10</td>
<td>10-15</td>
</tr>
<tr>
<td>750-1000</td>
<td>''</td>
<td>q 3h</td>
<td>≤ 15</td>
<td>15-20</td>
</tr>
<tr>
<td>1001-1500</td>
<td>''</td>
<td>q 3h</td>
<td>≤ 20</td>
<td>20-30</td>
</tr>
<tr>
<td>1501-1800</td>
<td>''</td>
<td>q 3h</td>
<td>≤ 30</td>
<td>30-50</td>
</tr>
<tr>
<td>&gt; 1800</td>
<td>BM or Term 20</td>
<td>q 3h</td>
<td>≤ 50</td>
<td>≥ 50</td>
</tr>
</tbody>
</table>

**When should you stop PN?**

STOP Lipids when feeds are 80-100 cc/kg/day  
STOP PN when feeds are 100-120 cc/kg/day

**When do you concentrate formula/fortify BM to 24 kcal/oz?**

Once pt is off PN (anywhere from 120-150 cc/kg/day of feeds)

**When can a pt try a PO (bottle) feed?**

They may begin trying 1 PO attempt/day at 31 weeks (see pathway for how to advance)

**Full Enteral Feeds for ≤1800 grams = 150-160 cc/kg/day of a 24 kcal/oz preterm formula or fortified BM (breastmilk)**

**Full Enteral Feeds for >1800 grams = 150-160 cc/kg/day of a 20 kcal/oz term formula or BM**
HYPER and HYPOGLYCEMIA

• Risk factors for HYPOGLYCEMIA:
  o IUGR
  o Intrapartum treatment with terbutaline, propranolol, or ritodrine
  o Infants large or small for gestational age
  o Infants <37 weeks or >42 weeks
  o Infants with respiratory distress
  o Infants requiring resuscitation (including intubation for meconium staining)
  o Multiple gestation (twins, triplets)
  o Fetal distress
  o Infants with apgars <5 at 1 minute or <7 at 5 minutes
  o Admission temperature of <97°F (35.1°C) axillary
  o Infants of diabeteic mothers
  o Sepsis evaluation
  o Infants with hematocrit ≥ 65%
  o Congenital heart disease

• Symptoms of HYPOGLYCEMIA:
  o Lethargic or jittery infants
  o Apnea
  o Seizures
  o Tremors
  o Increased respiratory rate

• Intervention for HYPOGLYCEMIA:
  1. if not included on initial admission orders, write the order to initiate hypoglycemia protocol
  2. with any symptom of low glucose, check glucose by point of care testing (I-Stat)
  3. If >25 but <40, and baby able – can attempt PO feeding
  4. If <40 and baby unable to PO, give 2cc/kg bolus of D10W, start maintenance IVF & recheck glucose
  5. increase IVF rate / GIR to maintain normal blood glucose (>40-50)
  6. level should be monitored every 30-60 minutes until stable
  7. remember → the highest concentration of glucose that can be infused through a PIV is 12.5%

• Risk factors for HYPERGLYCEMIA:
  o Prematurity
    ▪ ↓ insulin response to a glucose load
    ▪ relative insulin resistance
  o Excess glucose administration
  o Medications → caffeine, theophylline, corticosteroids, phenytoin
  o Sepsis
  o Post surgery / “stress” conditions

• Long-term effects of HYPERGLYCEMIA:
  o Osmotic diuresis
  o Dehydration
  o Weight loss
  o Cerebral hemorrhage

• Intervention for HYPERGLYCEMIA:
  1. decrease GIR by ~20% - not advised to go below GIR of 3.5 - 4
  2. low dose insulin → ALWAYS check with attending or fellow before starting!!!
This graph may be used in your management of neonates as an aid for determining:

- the i.v. rate needed to achieve a desired glucose infusion rate
- determining the glucose infusion rate of an existing i.v. to determine an infant's caloric intake
  - As an example, a 2.5 kg infant whom you would like to have receive 6 mg/kg/min of glucose should be receiving 9.5 cc/hr of D10W (equivalent to 90 cc/kg of i.v. fluid)
HYPERBILIRUBINEMIA

- For the evaluation and management of jaundice and hyperbilirubinemia in a healthy newborn See the websites:
  - children.musc.edu/%7Eannibald/vep/clinical_guidelines/bilirubin_pathway_9-27-01
  - children.musc.edu/%7Eannibald/vep/clinical_guidelines/4-11-06_cpg-bill_term_near_term_infants

- For hyperbilirubinemia in preterm infants, follow the guidelines for phototherapy shown below. These are only guidelines and phototherapy is often appropriate for a lower total bilirubin depending on the clinical situation.

### For term or near-term infants:

<table>
<thead>
<tr>
<th>Birth Weight (g)</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&lt; 1000</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>1000-1249</td>
<td>&gt; 5</td>
</tr>
<tr>
<td>1250-1499</td>
<td>&gt; 8</td>
</tr>
<tr>
<td>1500-1749</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>1750-1999</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>2000-2499</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>&gt; 2500</td>
<td>&gt; 10</td>
</tr>
</tbody>
</table>

• Use total bilirubin. Do not subtract direct reacting or conjugated bilirubin.
• Risk factors = isoimmune hemolytic disease, G6PD 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 (35-50 mmol/L) below those shown but home phototherapy should not be used in any infant with risk factors.
GUIDELINES FOR THE MANAGEMENT OF HYPERBILIRUBINEMIA

- Check total bilirubin levels in all preemies at least every 24 hrs in the 1st few days of life
- In high risk infants you may need to check earlier after birth and more frequently

- Risk Factors for Severe Hyperbilirubinemia:
  - Rh isoimmunization with positive Direct Coombs Test
  - ABO incompatibility (positive or negative Direct Coombs Test)
  - Positive maternal antibody screen, other hemolytic conditions
  - Previous sibling requiring phototherapy or exchange transfusion
  - Cephalohematoma
  - Significant bruising
  - Exclusive breastfeeding planned after discharge
  - East Asian ethnicity

- In infants with hyperbilirubinemia, assess for the presence of risk factors (ABCDE):
  - Acidosis, albumin level low
  - Blood brain barrier disruption (e.g. intracranial hemorrhage, asphyxia, sepsis, meningitis)
  - Coombs positive, G6PD deficiency (i.e., hemolysis)
  - Displacers of bilirubin (e.g. free fatty acids from intralipid, drugs)
  - Encephalopathy

- The presence of one or more risk factors should lower the threshold for treatment
- The table below provides guidelines on when to initiate phototherapy in preterm infants less than 35 weeks gestation at birth
- Note that levels are not dependent on baby’s day of life
- Note that total serum bilirubin is used for treatment decisions. Note that suggested treatment levels are lower in sick babies than in “healthy” babies (because of greater risk of disrupted blood brain barrier).

### Suggested Guidelines for Phototherapy

<table>
<thead>
<tr>
<th>Birthweight</th>
<th>Total Serum</th>
<th>Bilirubin (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1000g</td>
<td>Healthy Infant</td>
<td>Sick Infant</td>
</tr>
<tr>
<td>1001-1500g</td>
<td>7-10</td>
<td>6-8</td>
</tr>
<tr>
<td>1501-2000g</td>
<td>10-12</td>
<td>8-10</td>
</tr>
<tr>
<td>2001-2500g</td>
<td>12-15</td>
<td>10-12</td>
</tr>
</tbody>
</table>

RADIOLOGY

X-Rays
- You must write the order in the chart and complete an online radiology request
- The online request MUST have a clinical indication and history or the tech cannot shoot the film.
- For most X-rays in the NICU, we don’t fax down the order form, but instead page the radiology tech at 17510 (unless the system is down)

Head Ultrasounds
- Performed routinely if infant is born at <32 weeks.
- Performed at DOL 7 (R/O IVH).
- Perform a second head ultrasound at 34-36 weeks gestation
- A head ultrasound may be performed earlier in the first week of life if IVH is clinically suspected.
- If abnormality is found, repeat every 1-2 weeks until normal.
- For ultrasounds, fax the order form to 2-9185.

CT/MRI
- Discuss with the CT/MRI tech or radiologist if sedation will be needed and who will be in charge of it (us or anesthesiology)
- If we are responsible for sedation, remember to obtain consent for conscious sedation from parents. If the infant is not intubated, make sure the parents know that respiratory depression is a side effect of sedation and that the patient may require intubation.
- Don’t hesitate to approach your fellow or attending with questions concerning sedation for studies.

- The number for the X-Ray reading room is 2-2056
- The number for the radiology dictation line is 2-6062
  - You will be prompted to enter the patient’s MRN followed by the pound (#) sign
  - The latest dictation will be given – if you want to hear previous dictations, press 8
SEPSIS EVALUATION

EARLY ONSET SEPSIS
- See asymptomatic sepsis pathway at:
  children.musc.edu/%7Eannibald/vep/clinical_guidelines/sepsis_pathway_2006

LATE ONSET SEPSIS
- **Definition:** evaluation beyond 1st 72 hours of life excluding sepsis associated with a known source (e.g. not NEC, omphalitis, etc.)
- **Indications for evaluation:** Work group considered use of a scoring system to identify infants requiring a late onset sepsis evaluation based on clinical, laboratory, and risk factor criteria. Only one such scoring system was found in the literature. The investigators who developed this system recommend external validation of the scoring system in individual units before implementation of its use (Mahieu 2000, 2002). Recommendation of the work group is to defer the use of such a scoring system at this time in order not to delay implementation of a late onset sepsis pathway
- Complete online late onset sepsis forms: www.musc.edu/cce/ORDFRMS/pdf/pedsepsisorders
  www.musc.edu/cce/ORDFRMS/pdf/pedsepsis

**Evaluation - Cultures:**
- **BLOOD**
  - minimum blood culture volume = 1 ml
  - minimum of 2 blood cultures for each sepsis work-up
  - sources:
    - With **CENTRAL LINE:** One blood culture should be obtained from all central lines (excluding UAC and UVC) and one blood culture should be obtained by peripheral stick
    - No central line: 2 peripheral blood cultures
  - Consideration should be given to holding blood cultures for fungus if:
    - a) patient birth weight < 1000 g
    - b) there is evidence of thrombocytopenia
    - c) history of frequent or prolonged antibiotic use
- **URINE**
  - catheter or suprapubic, not bagged
- **CSF**
  - Obtain if patient able to tolerate procedure. If patient is too unstable to tolerate procedure, a future attempt should be made as soon as possible after patient has been stabilized
  - All cultures should be obtained prior to starting antimicrobial therapy.
  - Once a decision is made to initiate a sepsis evaluation, cultures should be obtained and antibiotics started as soon as possible.
  - Unnecessary delays should be avoided. If cultures cannot be obtained within 2 hours after the initiation of a sepsis evaluation, attending physician should be notified.
- Nursing to document source of all cultures on laboratory forms
  - Blood = central or peripheral; catheter or stick
  - Urine = catheter or suprapubic
• **Choice of antimicrobial therapy**
  o Use of any antimicrobial requires assessment for potential contraindications to therapy prior to starting treatment
  o Hemodynamically unstable or central line in place ≥ 10 days (Maki 2002)
    ▪ Vancomycin + piperacillin/tazobactam
    ▪ “Hemodynamically unstable” is defined as requiring fluid boluses or vasopressors to maintain blood pressure
  o Hemodynamically stable and central line, if present, in place < 10 days
    ▪ Nafcillin and gentamicin
  o Consider addition of antifungal therapy for patients with birth weight ≤ 1,000 grams, thrombocytopenia, significant drop in platelet count from previously known values, or history of frequent or prolonged antibiotic use
  o All antimicrobials should be infused through central line if present. Nursing should notify MD or NNP if drug compatibility issues preclude this

• **Analysis of culture results**
  o See: [children.musc.edu/%7Eannibald/vep/clinical_guidelines/LateOnsetSepsisPathwayChart](children.musc.edu/%7Eannibald/vep/clinical_guidelines/LateOnsetSepsisPathwayChart)
  o We recommend that methods be developed to distinguish true infection with coagulase negative staphylococci (CoNS) from contaminated blood cultures. Potential options include colony counts and species identification on all positive blood cultures for CoNS. The Microbiology Laboratory is not currently set up to perform these functions; however, there is the potential that they could be.
  o **All cultures negative at 48 hours** → d/c antibiotics (antifungals may be continued x 72 hours (Schelonka 2003) pending negative results)
  o **All positive urine and CSF cultures** should be treated based on organism identification and susceptibility.
  o **Positive blood cultures**
    ▪ Practitioner notified by Microbiology Laboratory of Gram Positive organism
      1. Change nafcillin to vancomycin pending definitive ID.
      2. Repeat blood culture before changing antibiotics.
      3. Final antibiotic therapy should be guided by organism identification and susceptibility.
      4. if meningitis possible, consider adding cefotaxime for CNS penetration
    ▪ Contaminant organisms requiring no further antibiotic therapy
      1. Corynebacterium
      2. Propionibacterium
      3. Penicillium (Stoll 2002)
      4. Diphtheroids were also included among contaminant organisms in this reference; however, according to Dr. Johnson some may be true pathogens
    ▪ Culture positive (other than contaminant organisms)
      • Follow recommendations on LOS blood culture interpretation table (link above)
      • Patients with positive central line cultures due to the following organisms require **immediate line removal**:
        1. S aureus (Benjamin 2001)
        2. Gram-negative rods (Benjamin 2001)
        3. Fungi – (IDSA guidelines)
o Antibiotics of choice = Nafcillin & Gentamicin unless any of the following criteria met in which case patient should be started on Vancomycin & Cefotaxime:
   - Hypotension severe enough to require boluses or pressor support
   - PICC access especially if in place for prolonged time (>2 weeks)

o Consider antifungal coverage for patients with low platelets or recent history of antibiotic usage, especially if prolonged course or broad-spectrum agents.
   - If a patient is on PN and Amphotericin is ordered, PN & IL should be held during Ampho infusion
   - Please consult RD and PharmD on how to write orders for TPN and Ampho respectively if you are not familiar with how to do so

o Take into consideration previous infections, organism(s) isolated, and organism susceptibilities

o Gram-negative infections, Enterococcal infections, and Listeria require “double coverage”

o Antibiotics should not be discontinued based on gram stain alone; wait until organism definitively identified by the microbiology lab

**NEC**
- Vancomycin and Zosyn is the acceptable antibiotic combinations for patients with suspected NEC
- If perforation is documented, clindamycin or metronidazole should be added.
- If a specific organism is identified from a surgical swab, antibiotics should be tailored appropriately based on ID and susceptibilities
- Treatment should be continued for 10-14 days
**NEONATAL MEDICATION INFORMATION**

**REMINDERS:**

- Please put thought into each medication you prescribe (no medication is without potential side effects or toxicities, some of which are not acutely recognizable). At least weekly, consider whether medications are producing the desired outcome in your patient and whether their use is still warranted.

- The *Pediatric Dosing Handbook* is the reference used for drug dosing in the Children’s Hospital. An exception list sticker is available for the nurseries. When applicable, it should be followed preferentially over recommendations given in the dosing handbook. (In some cases, the exception list simply clarifies information in the Dosing Handbook i.e. when multiple dosing options are available.) If you need a copy of the exception list, please consult Dr. Southgate or the unit Pharm.D.

- If you need assistance from a pharmacist:
  - NICU & SCN– Toby Cox (Pager 1-2445) or Sandra Garner (Pager 1-1108)
  - Level 2 – covered by Pharm.D. on call
  - Patient Care Unit Pharmacist – 2-6307

- Order writing policies: There are specific order writing policies for all pediatric patients <40 kg at MUSC. These include order components as well as accepted medical abbreviations. Accepted medical abbreviations are printed on cards provided by the MUSC Drug Information Service. If you need a replacement card, please contact the DI Service at 2-3896. This information may also be accessed on line (go to Neonatology Home Page). All medication orders must include the following:
  - Date & Time Order Written
  - Patient Weight
  - Drug Name
  - Route of Administration
  - Frequency of Administration (This includes prn orders)
  - Amount of Dose per kg (e.g., mg/kg/dose, mg/kg/day, micrograms/kg/min, etc.)
  - Indication for prn orders (e.g., “for agitation,” “for pain,” etc.)
  - Duration of Infusion for drug boluses (i.e., calcium, bicarbonate, etc.)
  - Your Name & Beeper Number

- Please note there is a list of accepted drug name abbreviations. DO NOT use abbreviations that are not on the list.

- Please take into consideration the concentration of the drug so that practical doses can be written for. For example, it is not necessary to write for 148 mg of Ampicillin when 150 mg would be acceptable.

- Do not carry medication orders out to 3 decimal points. For example, pharmacists and nurses cannot measure 0.135 mg of lorazepam. These considerations should also be taken into account for patients being discharged home so that doses will be easily measurable for parents.
• If you need assistance with deciding on a dose, please check with the Pharm.D. for the unit or the patient care unit pharmacist. If a dosing range is acceptable for a chronic medication, please choose a dose that your patient will not outgrow the first time he or she gains weight. **Example order:** Pt wt 1.2 kg → Morphine 0.06 mg IV q 3 hours prn pain (0.05 mg/kg/dose)

**Volume & Diluent for Drips**

• Drip cards are available to assist with calculating drips
• Some common drips used in the NICU are:

<table>
<thead>
<tr>
<th>Drug</th>
<th>Standard Concentration &amp; Rate</th>
<th>Average Starting Dose</th>
<th>Dose Range</th>
<th>Maximum Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dobutamine</td>
<td>30mg/kg in 50ml at 0.5ml/hr</td>
<td>5mcg/kg/min</td>
<td>2-20 mcg/kg/min</td>
<td>5mg/ml</td>
</tr>
<tr>
<td>Dopamine</td>
<td>30mg/kg in 50ml at 0.5ml/hr</td>
<td>5mcg/kg/min</td>
<td>2-20 mcg/kg/min</td>
<td>6mg/ml</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>3mg/kg in 50ml at 0.1 ml/hr</td>
<td>0.1 mcg/kg/min</td>
<td>0.05-1mcg/kg/min</td>
<td>64mcg/ml</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>250mcg/kg in 25ml at 0.2ml/hr</td>
<td>2mcg/kg/hr</td>
<td>2-12mcg/kg/hr</td>
<td>50mcg/ml</td>
</tr>
<tr>
<td>Midazolam</td>
<td>30mg/kg in 50ml at 0.2ml/hr</td>
<td>2mcg/kg/hr</td>
<td>2-6mcg/kg/hr</td>
<td>5mg/ml</td>
</tr>
<tr>
<td>Morphine</td>
<td>25mg/kg in 50ml At 0.1ml/hr</td>
<td>0.05 mg/kg/hr</td>
<td>0.05-0.15mg/kg/hr</td>
<td>1mg/ml</td>
</tr>
<tr>
<td>Prostaglandins</td>
<td>500mcg in (83/wt in kg)ml at 1ml/hr <em>can also order 500mcg in 100ml at 1ml/hr</em></td>
<td>0.1 mcg/kg/min</td>
<td>0.01-0.1mcg/kg/min (usually start at 0.03mcg/kg/min)</td>
<td>See standard concentration</td>
</tr>
</tbody>
</table>

• Please note maximum concentrations. **Example order:** Pt Wt 3 kg → Dopamine 90 mg in 50 ml D10W to run at 0.5 ml/hr = 5 micrograms/kg/min

• **Always** put zeros before decimal points. **Never** put zeros after decimal points. Ten-fold errors in drug strength and dosage have occurred with decimals due to trailing zeros or absence of a leading zero. Decimal point errors are very significant in neonates.

**Adverse drug reactions**

• It is MUSC policy that an adverse drug reaction report is filled out on any patient with an adverse event believed to be secondary to a medication.
• As the patient’s care provider, it is your responsibility to see that this report is filled out and placed in the medical record.
• Reports may be filled out by anyone witnessing the event including physicians, nurses, pharmacists, respiratory therapists, etc.
• Please notify patient care unit pharmacist of any adverse drug reaction that would preclude a patient from receiving a particular medication or class of drugs in the future.

**Medication Incidents**

• Medication incident reports must be filled out on all medication occurrences.
- The medication error reporting system can be reached hospital-wide by using the UHC PSN icon on unit computers.

**THERAPEUTIC DRUG MONITORING**

**Aminoglycosides and Vancomycin**

<table>
<thead>
<tr>
<th>DRUG</th>
<th>PEAK</th>
<th>TROUGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gentamicin &amp; Tobramycin</td>
<td>5 – 12 mg/L*</td>
<td>&lt; 2 mg/L</td>
</tr>
<tr>
<td>Amikacin</td>
<td>20 – 30 mg/L</td>
<td>5 – 10 mg/L</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>NA</td>
<td>5 – 15 mg/L**</td>
</tr>
</tbody>
</table>

*Lower peak concentrations acceptable for patients with UTI (3-5 mg/L)
Higher concentrations desired for treatment of pneumonia (8-12 mg/L)
**Higher trough concentrations desired to clear central line infections (10-15 mg/L)

- Make sure serum concentrations are adequate before repeating cultures or adding on additional antibiotic coverage.

**Caffeine 5-25 mg/L**
- Routine monitoring of caffeine serum concentrations is not necessary
- Monitoring of caffeine concentrations may be considered if there is lack of clinical response on an adequate dose or in cases of suspected toxicity
- Patients with frequent or severe events may do better with higher rather than lower levels (10 mg/L)
- Levels to assess for toxicity may be obtained at any time after initiation of therapy
  - If the concentration is being obtained to assess for clinical response after initiation or dosing change, a minimum of 1 week should have elapsed before drawing a level

**Phenobarbital 15 – 40 mg/L**
- Most neonates with acute seizures respond better to serum concentrations ≥ 30 mg/L. Higher target serum concentrations may be requested by Neurology
- Phenobarbital concentrations should be obtained 2 hours post-load in acutely seizing patients
- Patients on maintenance dosing should have a trough checked 5 days after starting therapy assuming patient is stable with no further seizures within that time frame
- Please consult Pharm.D. regarding need for repeat serum concentration monitoring in patients on chronic therapy

**Serum concentration monitoring...when to order levels**
- Patients started on antibiotics for sepsis evaluation:
  - Do not automatically order aminoglycoside or vancomycin levels when you prescribe antibiotics.
  - Levels should only be obtained when the decision has been made to treat the patient with a full course for presumed or culture proven infection.
  - The exception to this rule is the patient with renal dysfunction who may need early serum concentration monitoring to avoid toxicity.
  - In patients with normal renal function, troughs are usually obtained with the 3rd or 4th treatment dose.
  - It’s always a good idea to take into account the time of day the level will be drawn as well as the duration of therapy when deciding between the 3rd or 4th dose.
  - Please consult Pharm.D. regarding need for repeat serum concentration monitoring if a patient is on a prolonged course of antibiotics.
MISCELLANEOUS DRUG INFORMATION

Pain and Sedation

NARCOTICS
- Morphine is the agent of choice for pain control
  - takes longer to develop tolerance vs Fentanyl, less expensive, not associated with chest wall rigidity
- Fentanyl should be reserved for patients with PPHN, CDH, or those on high pressor support
- Morphine may also be used for sedation
  - initial doses for opiate naïve patients should not exceed 0.05 mg/kg

BENZODIAZEPINES
- Lorazepam is the benzodiazepine of choice for sedation
  - longer half-life vs midazolam
  - reserve midazolam for procedures
- When ordering prn sedation for benzo naïve patients, initial doses should not exceed 0.05 mg/kg or be more frequent than q 4 hours
- If scheduled consider starting out with q 6 or q 8 hour dosing
  - If more frequent dosing is required, continuous infusion midazolam should be used
- NEVER start a neuromuscular blocking agent (“paralysis”) without 1st assuring the patient is adequately sedated

WEANING
- Patients on scheduled or continuous infusion narcotics may require weaning following prolonged exposure to avoid drug withdrawal
- These include those treated with benzos or morphine for >1 week or fentanyl >5 days
- Please consult unit Pharm.D. for weaning plan
- Any patient being weaned from narcotics should have Neonatal Abstinence Scores (NAS) ordered q 6 hours
- Please evaluate reasons for “high” scores as underlying disease states may influence scores assigned by nursing (i.e. chronic lung disease)

Respiratory Medications

SURFACTANT – see page 22 of this Guide

VITAMIN A for BPD Prophylaxis - see page 23 of this Guide
- Vitamin A should be started in premature neonates who are ≤ 1000 grams at delivery and require supplemental O₂ at 24 hours of age (this includes patients on NC and NCPAP)
- Dosing = 5,000 IU IM on Monday, Wednesday, Friday x 12 doses
- Consider holding in patients with coagulopathies or significant pressor support
METHYLXANTHINE THERAPY
- Premature neonates ≤29 weeks should be started on caffeine for prevention of apnea of prematurity
  - See guidelines at: children.musc.edu/%7Eannibald/vep/clinical_guidelines/apnea_2004
  - at MUSC, all caffeine dosing is based on caffeine citrate (not caffeine base)
  - patients who are caffeine naïve should be loaded with 20mg/kg
  - neonates started on a maintenance dose in the 1st week of life should receive 5mg/kg/d
  - please consult Pharm.D. for loading and maintenance doses for patients who are being restarted on caffeine or those who are older than 1 week of age at initiation of therapy
  - consider continuing caffeine for 5 days after discontinuation of positive airway pressure even if the patient has not had apnea for >7 days
  - refer to discharge planning section for information on discontinuing or discharging patients home on caffeine

CORTICOSTEROIDS
- The decision to use corticosteroids for BPD must be made by an attending
- Please do not start without attending permission
- Usual regimen for reducing airway edema prior to extubation:
  - Dexamethasone 0.25 mg/kg po or iv q 12 hrs x 4 doses
  - 2 doses prior to extubation and 2 after
  - this regimen may vary based on attending preference
- Patients who have been on chronic steroids (or recently d/c’d) will require stress dosing for surgery → These should be started within the 24 hours prior to surgery

DIURETICS FOR CHRONIC LUNG DISEASE
- Discuss choice of diuretic and frequency of administration with attending
  - Furosemide (Lasix) – most effective but has many side effects
    - hypercalciuria → renal calcifications
    - rickets
    - electrolyte abnormalities (pts often require K supplementation)
    - ototoxicity
    - when switching from iv to po, dose should be doubled
    - it is not necessary to always give Lasix following a blood transfusion. Need should be assessed on patient specific basis
  - Hydrochlorothiazide/Spironolactone (Aldactazide) – less potent, less side effects.
    - HCTZ reduces Ca++ excretion
    - Spironlactone K+ sparing

Cardiovascular Drugs
INDOMETHACIN - Used for PDA closure and IVH prophylaxis.
- Note: dosing is different for these two indications
- IVH prophylaxis → Follow Indocin Pathway: children.musc.edu/%7Eannibald/vep/clinical_guidelines/revised_ich
- PDA closure:
  - ensure absence of ductal-dependent cardiac lesion prior to prescribing
  - Use of indocin should be discussed with attending prior to prescribing
  - Monitor platelet count, renal function (Scr, UOP), potassium
    - always prior to 2nd & 3rd doses; before 1st in some patients
PRESSORS
• Always discuss with attending prior to ordering
• Please follow drip card for ordering – initial infusion rates, concentrations, etc.
• If you need assistance with concentrating drips, please consult unit Pharm.D. or patient care unit pharmacist
• Dopamine is generally pressor of choice for hypotension
  o If patient is requiring >10 micrograms/kg/minute consider adding Dobutamine to avoid side effects associated with high doses of dopamine

PROSTINS
• Used to promote dilation of the ductus arteriosus in infants with congenital heart disease dependent on ductal shunting for oxygenation/perfusion
• Always discuss with attending prior to ordering
• Please follow drip card for ordering – initial infusion rates, concentrations, etc.
• If you need assistance with concentrating drips, please consult unit Pharm.D. or patient care unit pharmacist
• Side effects to watch for include: apena, fever, leukocytosis, cutaneous flushing, bradycardia

Immunizations
HEPATITIS B
• There is a risk of both vertical perinatal transmission to the newborn from a mother who is HBsAg positive, and horizontal transmission to the infant during the first 5 years of life
• It is critical that the infants born to mothers who are HBsAg-positive are recognized and therapy initiated

<table>
<thead>
<tr>
<th>Maternal HBsAg Status</th>
<th>Hep B Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HBIG</td>
</tr>
<tr>
<td>Positive</td>
<td>Within 12 h of birth</td>
</tr>
<tr>
<td>Unknown</td>
<td>Determine maternal HBsAg status: if positive, HBIG within 7 days. If negative, no HBIG</td>
</tr>
<tr>
<td>Negative</td>
<td>No</td>
</tr>
</tbody>
</table>

*Neonates born to mothers who are Hepatitis B positive:*
• Need to receive Hepatitis B vaccine and HBIG within 12 hours of birth
• Premature newborns who weigh <2 kg and receive Hepatitis B vaccine at birth must receive 3 more vaccine doses starting at 1-2 months of age to complete the series

*Neonates born to mothers of unknown Hep B status:*
• Should receive Hepatitis B vaccine within 12 hours of birth unless the mother’s status can be determined within that time frame
  o Please keep track of the time elapsed since birth; don’t put off until after rounds if time will be >12 hours
• For preterm newborns <2 kg, babies should also receive HBIG if mother’s status cannot be determined within 12 hours of delivery
• For term newborns, you have 7 days within which to give HBIG
• Please see AAP web site for the current Routine Immunization Schedule for the year
  ○ Note: Premature neonates should be vaccinated at the appropriate chronological age
  ○ exception Hepatitis B vaccine → see below
• complete the MUSC online immunization form: www.musc.edu/cce/ORDFRMS/pdf/pedsimmun
• acetaminophen typically given to relieve discomfort & prevent fever associated with immunizations
  ○ 15 mg/kg q 6 hours with 1st dose prior to immunization
  ○ can be ordered using the online immunization form – a separate order is not required
• Consult Pharm.D. for dosing recommendations for patients with liver dysfunction
• Don’t forget to Hepatitis B vaccine administration as part of your discharge planning unless the baby has already received it prior to transport to MUSC
• For premature neonates being discharged before they receive their 2 month immunizations, Hepatitis B vaccine may be given to infants under 2kg at discharge as long as they are at least 1kg and consistently gaining weight

**Palivizumab (Synagis)**
• Synagis should be administered prior to discharge if a qualifying baby is going home during RSV season
• In order to decrease wastage of this very expensive agent, Synagis is only dispensed on Mondays & Thursdays
• Patients should be immunized > 48 hours before discharge in order to be adequately protected so you need to plan ahead
• Please contact Melissa Brown, CCM to assure funding is available
• Note: Specific order forms are available for ordering Synagis
  ○ order forms should be filled out as early in the day as possible
  ○ www.musc.edu/cce/ORDFRMS/pdf/palivizumab
• Eligibility criteria for administration of Synagis:
  ○ ≤28 weeks gestation at birth (and <1 year old)
  ○ 29–32 weeks gestation at birth (and <6 months old)
  ○ 32–25 weeks gestation at birth with >2 risk factors or certain cardiac diseases (see pre-printed order form or consult Melissa Brown)
  ○ BPD (on O2 >28 days, requiring medical therapy in last 6 months, & <2 years old)
INTRACRANIAL HEMORRHAGE

- Originates in the periventricular subependymal germinal matrix with subsequent entrance of blood into the ventricular system
  - Germinal matrix is a weakly supported, highly vascular area located between caudate nucleus and thalamus
  - Watershed area of blood vessels are prone to hypoxic-ischemic injury and rupture
- Incidence and severity are inversely proportional to gestational age
- Risk factors:
  - Extreme prematurity
  - Presence of labor
  - Birth asphyxia
  - Need for vigorous resuscitation at birth
  - Pneumothorax
  - Seizures
  - Sudden elevation in arterial blood pressure
    - rapid volume expansion
    - administration of hypertonic sodium bicarb
- Classification:
  - GRADE I: GM hemorrhage
  - GRADE II: IVH without ventricular dilatation
  - GRADE III: IVH with ventricular dilatation
  - GRADE IV: Periventricular venous infarction
- Diagnosis = head ultrasound
  - 7 days post natal life
  - 32-34 weeks adjusted age
  - If HUS abnormal; follow-up is:
    - Grade I-II: 7-10 days and DOL 28
    - Grade III-IV: q7-10 days until stable
- Prophylaxis: Indocin
  - given to patients with birthweight <1000g
    - Dose: 0.1mg/kg/dose at 6hr of age then q24hr x2 additional doses
    - monitor UOP, platelet count and serum creatinine
  - contraindications to initial dose of indocin:
    - overt bleeding
    - maternal indomethacin
    - thrombocytopenia <50,000
    - CHD
    - Renal disease
    - Lethal diagnosis or DNR
  - contraindications to 2nd and 3rd doses of indocin:
    - overt bleeding
    - thrombocytopenia <50,000
    - UOP <0.5cc/kg/hr
    - NEC
    - Non-capillary K+ of 7.0
    - Creatinine >1.4
- See the algorithm at: children.musc.edu/%7Eannibald/vep/clinical_guidelines/revised_ich
MISCELLANEOUS NICU GUIDELINES

Developmental Care
- When turning on a bright light for a procedure or exam, please shield the baby’s eyes
- Replace snugglies, blankets, and pacifiers after examining a baby
- Remember to close isolette doors when you are done
- Use heat lamp when the isolette doors need to be open for awhile
- Don’t tap on the isolette or use it as a writing surface → noise is much louder inside than outside
- For tiny babies, ask the nurse when would be a good time for you to examine the baby or perform a procedure → Try to group “hands on” procedures
- Keep the noise level down
- LISTEN CAREFULLY to the nurse when she/he tells you that a baby is not tolerating a procedure (bradycardia/desats)
- None of these guidelines should be practiced at the expense of good safe medical care
- Please see the developmental care handout from Kathie Chase for further information

Small Volume Transfusion Guidelines
- Do not transfuse for phlebotomy losses alone (i.e. “blood out”)
- Transfuse for hematocrit <21% with reticulocyte count <100,000
- Transfuse for shock not responsive to initial crystalloid therapy
- Infants with cyanotic heart disease → maintain a hemoglobin level which will provide an oxygen carrying capacity equivalent to a fully saturated level of 11-12 grams
  - For example: To keep a level of O₂ carrying capacity in an infant with heart disease with an O₂ sat of 75% equivalent to a normal infant with 95% saturation and a hemoglobin = 11g/dl, try to maintain a hemoglobin level of ~14 → (.95 x 11 / .75)
- Transfuse for hematocrit <30 (required) - 40% (optional)
  - In babies with severe pulmonary disease (requiring >35% ambient oxygen or CPAP/mechanical ventilation with MAP >6 cm H₂O)
  - Babies with congestive heart failure where anemia is thought to be contributing to the problem
- Transfuse for hematocrit ≤ 25 (required) – 30% (optional)
  - Requiring CPAP of ≤6cm H₂O, ambient oxygen of <35% or 100% NC at a flow > .25 lpm
  - Having significant (>9 episodes in 12 hours or 2 episodes in 24 hours requiring BMV while receiving therapeutic doses of methylxanthines) apnea & bradycardia (HR<80 bpm) unrelated to feedings
  - Persistent HR >180 or RR >80, without other explanation, for 24 hours
  - Weight gain is unacceptable (an average of 10g/day over a period of 4 days) despite adequate caloric intake without other explanation such as known increased metabolic demands or known losses (malabsorption)
  - For infants undergoing surgery, in consultation with the surgical team
- Please see the website: children.musc.edu/%7Eannibald/vep/clinical_guidelines/transfusion

Criteria for In-and-Out Surfactant
- Guidelines at: children.musc.edu/%7Eannibald/vep/clinical_guidelines/early_rescue_surfactant-followed_by_cpap
Craniofacial Protocol (eg. Cleft Lip/Cleft Palate)
• Page speech pathology (11147) for immediate feeding intervention
  o This service is available 24/7
• Call 2-3251 to make a referral to the Craniofacial Team

Evaluation of Ambiguous Genitalia
• Ambiguous genitalia of the newborn is a MEDICAL EMERGENCY because of the need for accurate
  sex assignment (don’t guess or bluff) and the risk of severe electrolyte disturbances due to
  Congenital Adrenal Hyperplasia (CAH).
• Upon admission (week-ends and holidays included):
• Consult on the day of admission:
  o Pediatric Endocrinology
  o Pediatric Urology
  o Genetics
• To be ordered:
  o Karyotype (should be done STAT, including weekends)
    ▪ Put 2 ml of blood in a green tube and keep at room temperature.
    ▪ Send sample to lab and page the Cytogenetic Tech on-call.
    ▪ Turnaround time is approximately 48 hours.
  o Electrolytes prn → look for increased K & decreased Na
  o Strict I’s & O’s
  o Discuss other labs and ultrasounds with the Endocrine Service
    ▪ They may recommend CAH profile, LH, FSH, genitogram, and/or abdominal ultrasound

Hypoxic-Ischemic Encephalopathy
• Guidelines / order set:
  children.musc.edu/%7Eannibald/vep/clinical_guidelines/orders_hypothermia_hie_11-06
• Neurological exam form:
  children.musc.edu/%7Eannibald/vep/clinical_guidelines/neurologic_exam_hie_11-06
• Transport protocol:
  children.musc.edu/%7Eannibald/vep/clinical_guidelines/transport_protocol_hypothermia

Apnea Management
• Guidelines for evaluation and the management of apnea are available at:
  children.musc.edu/%7Eannibald/vep/clinical_guidelines/apnea_2004

Policy for Invasive Procedures
• Infection Control is extremely important in the NICU where patients have immature barriers and
  immune system
• Follow the policy for preparation and attire for procedures given at:
  www.musckids.com/~annibald/vep/clinical_guidelines/invasive_procedures
**pH-Probe/Impedance Probe**
- Write an order in the chart
- Page Janice Freeman 12488 or
- Call the Esophageal function lab 6-0439
- Remember to complete a CXR request form and to check placement → The probe should be 3cm above the GE junction

**Ophthalmology Consultation for ROP**
- Birth wt <1500g OR gestational age <30 weeks PMA
- Routine screening should be done at the earlier of:
  - 7 wks postnatal life
  - 33 wks postmenstrual age (but NOT earlier than 5 wks postnatal life)
- Screening prior to 33 wks post conceptual age will also be considered for unusually high risk infants ≤ 25 wk gestational age at birth, subject to satisfactory medical condition
- Birth wt 1500-1800g will be screened at the request of the neonatology attending, if felt patient to be at unusual risk for developing ROP
- For the latest guidelines, please see: [www.musckids.com/~annibald/vep/clinical_guidelines/rop_screening](http://www.musckids.com/~annibald/vep/clinical_guidelines/rop_screening)
- The ROP nurse coordinator is Linda Stevens pager 12939

**Audiology Consultation**
- Every baby has a hearing screen performed by Automated Auditory Brainstem Response (AABR) prior to discharge. The baby has 3 chances to pass the test in both ears. If the infant does not pass, the infant will have audiology follow-up within 30 days
- If a baby has any of these risk factors, the baby will have audiology follow-up:
  1. Stigmata of other findings associated with a syndrome known to include sensorineural or conductive hearing loss, or Eustachian tube dysfunction
  2. Family history of permanent childhood hearing loss
  3. In-utero infection such as CMV, herpes, toxoplasmosis, or rubella
  4. Postnatal infections associated with sensorineural hearing loss including bacterial meningitis
  5. Hyperbilirubinemia at a serum level requiring exchange transfusion
  6. Persistent pulmonary hypertension of the newborn requiring mechanical ventilation
  7. Conditions requiring the use of ECMO (sepsis, meconium aspiration syndrome, diaphragmatic hernia)
  8. Syndromes associated with progressive hearing loss such as Down’s, neurofibromatosis, osteopetrosis or Usher’s
  9. Neurodegenerative disorders
- If the baby passes the hearing screen but has a risk factor, then f/u is 3 months after discharge
- If the baby fails the hearing screen and has a risk factor, then f/u is within 30 days after discharge
- The unit secretary or nurse usually arranges the follow-up appointment prior to discharge but it is the physician’s responsibility to verify this
Lactation Consultation
- Barbara Haase, Pamela Murphy, Jean Rhodes and Jeanne Barreira are our lactation consultants
- They are available 7 days/week
- Please write an order for lactation consult
- Lactation line for referrals or call backs is 792-0780
- The Lactation Clinic is Monday and Wednesday afternoons → you or the infant’s mom can call for an appointment: 876-0444
  - For moms of infants in the NNICU, problems like milk supply issues, sore nipples, engorgement etc. are seen in the clinic (i.e problems/services that are not directly related to the infant)
- The mother’s milk club meets every week on Thursdays from 4 pm to 5:30 pm in room 841 (right by the NNICU)
  - “support group” for moms who are breastfeeding / interested in breast feeding

Apnea Monitoring
- If an infant is going home on apnea/bradycardia monitors, call 2-8651 or page 17855 to arrange home monitors and parent education
- To order a 5-channel study in the evaluation of apnea, call 2-8651 or page 17855

Breech Presentation Follow-up
- If patient is in the breech position at birth and is female, she needs an ultrasound of hips at 46 weeks gestation
- An ultrasound is optional in male patients if physical exam is concerning

ECMO Follow-up
- MRI of the brain with contrast
- Audiology Consultation
- EEG prn (necessary if seizure history)
- High Risk Clinic Follow-up Appointment

Criteria for NICU GRADUATE CLINIC “High Risk Clinic”
1. Birth Weight ≤ 1250 grams
2. Grade III or IV IVH and/or PVL
3. 5 Minute Apgar of ≤ 3
4. Cocaine positive at birth (mom or baby), methadone exposure, other + drug screens
5. Assisted Ventilation ≥ 10 days
6. SGA (head ≤10 percentile) or IUGR
7. HFOV ≥ 7 days
8. ECMO
9. Neuro Suspect: HIE, seizures, hypotonia/hypertonia, Lenticulostriate, Meningitis, CMV (others as determined by Dr. Pappu).

- Please notify Amy Ruddy, 2-8901 or pager 1-2352, prior to patient discharge (as close to d/c as possible) to arrange the appointment, this ensures that family will be informed before going home. **Also, note that patients are seen in clinic for first visit at 3-4 months adjusted age. Please contact Amy with any questions or Dr. Pappu (Director of Clinic) at 2-2112.
DISCHARGE PREPARATION

- Contact Melissa Brown, Continuing Care Manager, at 2-2788 or pager 11895 about an impending discharge or discharge questions
  - Discuss with Melissa Brown if the patient qualifies for or needs home health visits
  - For patients being discharged home on medication, discuss with Melissa Brown arranging for parental education

- Make sure that you contact the parents about the potential for discharge and to arrange rooming-in and all training.
  - CPR training for parents → Think of this training a few weeks prior to discharge because classes are only twice a week
  - Apnea monitor training for parents if patient requires home apnea/bradycardia monitoring or is going home on supplemental oxygen
    - Call 2-8651 or page 17855 to arrange home monitors and parent education

- Ask parents of male patients about circumcision. Call 5th floor nursery 2-5303 to have patient placed on circ list. Have phone number where parents can be reached for consent

- Hearing screen: See Miscellaneous Protocol section for information on hearing screen and audiology risk factors

- Hepatitis B vaccination. Must inform parents prior to immunization and give the vaccine information sheet. If the patient is > 2 months of age, verify that immunizations are up to date. Complete vaccine order form under clinician order forms

- Upright test if <37 weeks at birth, if patient fails then parents need a car bed. Melissa Brown can help with this arrangement

- Synagis → active season October through March
  - Given ONLY on Monday and Thursday
  - should be administered at least 2 days prior to discharge
  - For private insurance, check with Melissa Brown to verify that Synagis is covered
  - Must inform parents of Synagis, prior to ordering
  - See the medication section of Survival Guide for criteria to receive Synagis
  - Document administration of Synagis in d/c summary during active season
  - Document status of patient in d/c summary during off season for PCP

- Notify consulting services that a patient is being discharged so that follow-up visits can be arranged (ie. ophthalmology, cardiology, ENT, etc.)

- Check if the patient qualifies for NNICU Grad Follow-up Clinic. See guidelines on page 53

- Complete a WIC prescription and place on pt’s chart if infant is being discharged home on any formula other than term formula
  - Rx form can be found at: www.musc.edu/cce/ORDFRMS/pdf/wicprescription

- Have a pediatrician appointment made. If the baby has significant medical problems, try to speak to the pediatrician personally
• Inform the pediatrician or schedule bilateral hip ultrasound at 46 weeks PCA for all female patients born breech. Consider ultrasound for breech males if there are concerns with the physical exam.

• Ensure patient has a follow-up head ultrasound scheduled at 34-35 weeks GA, if was born <32 weeks and not done prior to discharge.

• Discharge summaries should be completed 48 hours prior to anticipated discharge. Have copy faxed to NICU so that you can proofread and fax it to the pediatrician. There is no need to do “STAT” dictations – even if it is only 24 hours before discharge. Discharge summaries MUST BE DICTATED (a preprinted copy of the updated summary template cannot be sent to the pediatrician) so they can be accessible via Oasis.

• Dictation guidelines can be found at: www.musckids.com/~annibald/resident_tools/Newborn-Medicine-Dictations
SHARING BAD NEWS WITH PARENTS

Admission of a neonate to the NICU is always stressful for parents. Nervous and frightened, parents encounter unfamiliar and unexpected people, schedules, words and technology. Miscommunication of information, whether good or bad, can increase this stress and cause serious problems immediately or in the future parental / MD and nurse encounters. Below are some suggestions to facilitate communication.

**Where should I meet with parents?**
Preferably in a quiet, private area like the conference room, NNP office or mother’s room. A sign posted on the door stating “Conference, Do not disturb” will help decrease interruptions and distractions. If possible, coverage for other responsibilities should be arranged to avoid distractions like a pager going off or nursing questions about other patients. There should be sufficient room for everyone, including the speaker, to be SEATED comfortably.

Thought should be given to expression and demeanor (smiling, agitation about another matter, hurried vs. calm, competence, caring); and appearance (blood stained scrubs). Body language as well as words communicate and will be remembered by parents.

**When should I meet with parents?**
As soon as possible. Communication of bad news casually, unexpectedly, and from an unexpected source (i.e. mom calls in for an update and the nurse reviews the HUS results) can raise concerns that the medical team is not being forthright or respectful.

When parents are aware that special tests have been performed (HUS, Echo), call and report NORMAL results to alleviate fears.

**Who should be present at conferences?**
Whenever possible, the mother and the father or the person she has identified as her support person, should receive the bad news together in person. Parents may or may not wish certain family members to be present. Remember the role of the family members is supportive – final decisions are made by the parents. In addition, social workers, chaplains (or family pastor or priest), nurses involved in the patient’s care, and other physicians can, and frequently should, attend conferences to provide additional information or support. Encourage parents to leave young children with relatives or friends so both parents can give their undivided attention.

**What if the parents cannot be present?**
Under certain circumstances, communication must be by telephone. In these cases, offer to talk to both people (i.e. both on the line or serially) rather than having one report to the other.

**What should I say?**
Treat their child as a person: Call the baby by the correct sex & his/her name; don’t say “the baby”
Speak normal English!
- Avoid abbreviations → explain IVH, PDA, BPD
- Avoid medicales
- Avoid jargon/slang (“Your son’s belly blew up so we stopped feeds & gave him a shave”)
- Avoid detailed technical conversations even with medical parents
- Use pictures when this will help and explain equipment, lines (that scalp IVs do not go into the brain, etc.) and procedures
Assess, in a nonthreatening way, the parents’ knowledge. Consider starting by asking the parents what they understand about their son or daughter’s clinical condition, treatment, the cause of his/her problems, and what these problems mean to their infant.

Talk slowly, allowing questions.

Anticipate questions and answer them when possible, explaining the limitations of projections at this time. Most parents want to know:

- Is my baby going to die?
- Is my baby suffering or in pain?
- Will my baby be “damaged”?
- When can my baby come home?
- What usually happens with babies with these problems?

It is very important to recognize parents’ religious and cultural beliefs. If death is anticipated, ask parents if they would like their baby baptized, dedicated, a simple prayer, etc. Chaplains are available 24 hours a day and should be involved as early as possible, if the family desires, so that a relationship can be established. Some may prefer their own priest or minister be present and this should be facilitated.

It is important to remember that at the first encounter, parents & family hear very little from the point in time that the bad news is clearly stated for the first time. This is not because they don’t want to listen, but because their minds are simply swamped with images of emotional origin. Be aware of this and the parents’ expressions, comments, and body language as you provide explanations and details at the initial encounter. It may be more informative to answer questions simply and defer all discussions of implications. Don’t be surprised if any information imparted is lost and must be repeated later. Assure parents that members of the medical team will be available to answer questions and that information usually has to be repeated several times before parents fully understand.

**What if the patient dies?**

The death of a neonate is an event that affects and saddens all of the individuals involved in the baby’s care. Except in those few cases where a baby dies very quickly after admission, there has usually been a chance to develop a relationship with the family. All members of the staff who have an established relationship with the family should be involved in their support. This also includes the obstetrician and the baby’s family physician, both of which should be informed of the patient’s death for family support at that time and to avoid embarrassing encounters in the office.

In many cases, the family will want to hold the baby for a period of time after the infant has died. This can be very helpful to families, and it should be encouraged. It promotes healthy grieving response and fulfills a deep emotional need on the part of many families. Typically, after removing equipment and after bleeding has stopped, the infant is placed in a blanket and brought to the family in a private area. Initially one of the staff members stays with the family and may do so throughout this period, but sometimes families request some private time with their baby. Other members of the extended family may want to be present at this time, and this is also encouraged, assuming the parents agree. Remember to be sensitive to the parents’ needs – offer them time alone with their child excusing other family members and the staff. Sometimes parents will have a difficult time saying, “No, I don’t want you here.”
After the family has had a period of time to cope with the immediate emotional impact of the loss, they may turn to the staff for information regarding issues such as autopsy and funeral arrangements and/or may want to discuss again the medical aspects of the infant’s case. It is important to share information on grieving with the parents.

**What about an autopsy?**
Generally, permission for an autopsy is obtained after the parents have held their child and questions regarding the hospital course have been answered. An autopsy does not delay funeral or burial plans, nor does it interfere with an open casket. Parents will need to sign consent forms in order for an autopsy to be performed.

**What about a funeral?**
A funeral for a baby can provide an opportunity to receive support from friends. The period of visitation and funeral gives others an opportunity to visit with the parents in a socially acceptable way so they may express their love and concern. This will also allow the immediate family the chance to say goodbye. Usually it is possible to see the baby at the time of the funeral. However, some parents may not want to share their grief publicly and may want to have a private funeral or burial service.

Sometimes after an infant has died, the mother is confined to the hospital. In the interest of her health and well being, some people may attempt to shield her by not informing her of the plans and arrangements being made for the funeral. As much as possible, both parents should be included in the planning and, if at all possible attend the final rites. The service can be delayed for a few days.

A common reason people do not choose a funeral for a baby is a feeling that a funeral will be very expensive. This is usually not the case. Costs vary. In general, the costs of a funeral will start around $500 and varies depending on the funeral home and choices parents make. For questions regarding cost, please refer the parents to the unit social worker who will assist them.

**Grieving:**
Encourage both parents to express and share emotions and feelings, which can be discussed and understood instead of buried inside causing bitterness, family discord or illness. Although most friends and family want to be patient and supportive, others expect grieving to be completed in a short time or feel uncomfortable discussing the child. Parents can be reassured that their ongoing grief isn’t abnormal. It is good for them to initiate discussions with friends and family about their son or daughter. Methods to deal with grief can be encouraged and/or expected: crying, actively taking some time to reflect, decreasing other responsibilities, accepting help, finding a support system. Recognize that people grieve differently and at different rates.

**What support groups are available?**
Some parents find it helpful to interact with other parents with similar experiences. The Compassionate Friends, Inc and KinderMourn are national support groups.

<table>
<thead>
<tr>
<th>The Compassionate Friends, Inc.</th>
<th>Kinder-Mourn, Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Office</td>
<td>1320 Harding Place</td>
</tr>
<tr>
<td>P.O. Box 3696</td>
<td>Charlotte, NC 28204</td>
</tr>
<tr>
<td>Oak Brook, IL 60522-3696</td>
<td>704-376-2580</td>
</tr>
<tr>
<td>630-990-0010</td>
<td></td>
</tr>
<tr>
<td>877-969-0010</td>
<td></td>
</tr>
</tbody>
</table>
What about the health care professional?
As one of the people working closely with the family, don’t be surprised or embarrassed by your own emotions. Sadness, confusion, fear, defensiveness, and avoidance are not uncommon and certain feelings may increase depending on your relationship with the family, the family’s response, and your own comfort and personal opinions regarding life and death. Periods of reflection and discussions with peers, attendings, etc. can help you develop a healthy perspective on death.

Further information is available at:

- www.compassionatefriends.org
- www.kindermourn.org
INTUBATION

INDICATIONS: To provide airway for mechanical respiratory support

EQUIPMENT:

1. Laryngoscope/straight blades
   - No. 00 for babies <1000g
   - No. 0 for babies 1-3kg
   - No. 1 for babies >3kg

2. ET tube of appropriate size:

<table>
<thead>
<tr>
<th>TUBE SIZE (I.D. mm)</th>
<th>WEIGHT (grams)</th>
<th>GA (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>&lt; 1000</td>
<td>&lt; 28</td>
</tr>
<tr>
<td>3.0</td>
<td>1000 - 2000</td>
<td>28 - 34</td>
</tr>
<tr>
<td>3.5</td>
<td>2000 - 3000</td>
<td>34 - 38</td>
</tr>
<tr>
<td>4.0</td>
<td>&gt; 3000</td>
<td>&gt; 38</td>
</tr>
</tbody>
</table>

3. suction catheters #8, #10 / suction apparatus
4. Neopuff or bag & mask, oxygen
5. CO₂ detector
6. stethoscope
7. mask, eye shield
8. gloves, scissors, tape

TECHNIQUE

1. Extend infant’s neck slightly – avoid hyperextension; consider roll of line to support shoulders
2. Clear oropharynx / empty stomach with gentle suctioning (esp. if BMV >2min)
3. Ventilate with Neopuff or bag & mask with 100% FiO₂ before starting, if necessary
4. Hold laryngoscope in left hand, open infant’s mouth & move tongue with right forefinger
5. Insert laryngoscope blade in midline; advance until its tip is between base of tongue & epiglottis within vallecula, position blade to visualize glottis
6. Suction if necessary
7. Hold tube with concave curve anterior, pass down right side of mouth (outside the blade) through the cords approximately 2cm into trachea
8. Stop procedure to ventilate with bag & mask anytime heart rate drops below 100 or if the infant becomes cyanotic
9. Check correct placement with CO₂ detector → color change from purple to yellow with correct placement
10. After intubation, listen for breath sounds in both lungs and over stomach
11. In general, correct placement is: birthweight + 6

<table>
<thead>
<tr>
<th>WEIGHT (kg)</th>
<th>DISTANCE (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

12. Secure tube
13. Confirm appropriate tube placement with CXR
LUMBAR PUNCTURE

INDICATION: to obtain specimen of CSF for exam and culture

EQUIPMENT:
1. LP tray → use 25g Neonatal LP needle
2. sterile gloves, gown, mask, cap

TECHNIQUE:
1. position infant on side with back rounded, parallel to table or sitting with back rounded and perpendicular to table
2. cleanse area 3 times with betadine beginning at desired interspace & wash with enlarging circles to include iliac crest
   • allow betadine to dry or blot excess with sterile towel
3. drape
4. insert needle into 3rd or 4th lumbar interspace at level of top of iliac crest aiming slightly cephalad
5. advance needle slowly to a depth of 1-1.5cm in term newborn, less in preemie
6. remove stylet frequently to check for fluid – it is ok to remove stylet after needle is through the skin and just manipulate the needle
7. collect ½ - 1ml of CSF in each of 3 tubes
8. replace stylet and remove needle
9. apply gentle pressure until fluid stops leaking
10. send CSF for the following:
   • Tube #1 – gram stain, culture and sensitivities
   • Tube #2 – protein and glucose
   • Tube #3 – cell count and differential
   • Tube #4 – any additional studies

COMPLICATIONS:
1. hypoxemia from positioning / aspiration
2. bleeding
3. infection
4. herniation

Positioning landmarks used for lumbar puncture. The iliac crest (dotted line) marks the approximate level of L4
UMBILICAL VESSEL CATHETERIZATION

INDICATIONS:
- **Umbilical Artery Catheterization**
  1. monitoring of arterial blood gases and/or direct BP monitoring
- **Umbilical Venous Catheterization**
  1. resuscitation
  2. to monitor central venous pressure
  3. transport when peripheral IV cannot be placed

EQUIPMENT:
1. sterile gloves, gown, mask, cap
2. chloroprep
3. umbilical catheter tray
4. umbilical catheters
   - 3.5F for <1200g
   - 5.0F for >1200-1500g
5. infusion pump with appropriate IV solution
6. sterile saline + heparin or premixed heparin solution
7. 3-way stop cock with Luer-lok
8. restraints
9. radiant warmer

TECHNIQUE:
1. restrain neonate
2. prepare catheter(s)
   - place stopcock at each lumen & flush each port with saline/heparin solution
3. prep cord with chloroprep
   - assistant can hold the cord clamp
   - use sterile saline to wash off any excess chloroprep in micropreemies to avoid skin burns
4. position sterile umbilical tape around base of cord and loosely tie
   - this can be pulled tight for hemostasis should any bleeding occur
5. cut the cord horizontally across with a scalpel to leave approximately 1-3cm of umbilical cord above the abdomen
   - a clean cut usually doesn’t bleed since the arteries spasm
6. drape the neonate – clear drape and avoid obscuring the infant’s face
7. with forceps pick up side of umbilical stump ➔ identify 2 arteries & 1 vein
8. dilate umbilical vessel carefully with curved non-toothed Iris forceps
   - initial dilation of artery lumen is most important step since creation of false lumen will result in failure to catheterize vessel & increase risk of perforation
9. introduce catheter into vessel & advance
   - never use force ➔ gentle, constant pressure will overcome vessel spasm
10. calculate length of catheter:
    - **UAC:** 1/3 body length + 1 cm or \([bw(kg) \times 3] + 9\)
    - **UVC:** 1/3-2/3 perpendicular distance from infant’s shoulder to level of umbilicus or \([bw(kg) \times 2] + 5\)
    - Marks on catheter are every 1cm
    - Remember catheter can be pulled back if it’s in too far; it CANNOT be advanced if not in far enough once sterile field is broken
11. always verify placement of catheter with XRay
   - **UAC**: between T6-T9 if high UAC or L3-L4 if low lying
   - **UVC**: between T8-T9 @ diaphragm
12. secure catheter with 4.0 silk suture

**COMPLICATIONS:**

- **UAC**
  1. malpositioned catheter → vessel perforation, peritoneal perforation, false aneurysm
  2. vascular accident → thrombosis, infarction/embolism, vasospasm, hypertension
  3. hemorrhage
  4. infection
  5. NEC
  6. IVH

- **UVC**
  1. air embolism
  2. hemorrhage
  3. infection

Normal radiographic appearance of UVC & UAC. Frontal radiograph of abdomen shows that UVC enters abdomen at umbilicus (**small arrowhead**), travels in cephalad direction in umbilical vein (**double black arrows**) (note that catheters cross just above umbilicus), courses through left portal UAC also enters abdomen at umbilicus (**single black arrow**) but extends inferiorly (**white arrow**) and posteriorly into iliac artery before coursing superiorly in aorta (**large arrowheads**).
SUPRAPUBIC TAP

INDICATION: to obtain urine specimen under sterile conditions

CONTRAINDICATION: question of GI disease, GI obstruction or bleeding disorder

EQUIPMENT:
1. sterile gloves
2. gauze pads
3. #22g 1” needle
4. 3 or 5 cc syringe
5. chloraprep

TECHNIQUE:
1. determine presence of urine in bladder
2. restrain infant in supine, frog leg position
3. cleanse lower abdomen with Chloraprep
4. locate symphysis pubis with index finger
5. insert needle 1-2cm above the pubic symphysis at a 90° angle
6. advance the needle while aspirating at the same time
   • don’t advance the needle once urine is seen in the syringe
   • don’t advance the needle more than 1 inch
7. withdrawal the needle & maintain pressure over the puncture site
8. transfer specimen to sterile urine cup

COMPLICATIONS:
1. Bleeding → microscopic hematuria may occur after bladder aspiration – usually transient
2. Infection → unlikely if sterile technique is used
3. Bowel perforation → rare if landmarks identified properly; if occurs, will aspirate bowel contents into syringe. Consider antibiotics & close observation.
RADIAL ARTERY PUNCTURE

INDICATION:
- Blood draw for lab studies
- Intermittent monitoring of arterial blood gasses when indwelling catheter is not in place

EQUIPMENT:
1. Transilluminator
2. 25g butterfly, 3/8” or ¾”
3. syringe
4. chloraprep
5. dry 2x2 gauze

TECHNIQUE:
1. Extend wrist (supine)
2. Visualize radial artery with transilluminator or palpate radial pulse at proximal wrist crease
3. Perform Allen test
   - Elevate infant’s hand
   - Occlude both radial and ulnar arteries at the wrist
   - Massage palm toward wrist
   - Release ulnar artery occlusion
   - Look for return in hand color in less than 10 seconds, indicating adequate collateral supply
     o Do not puncture radial artery if color return requires >15 seconds
4. Cleanse site with chloraprep
5. Insert needle through skin, bevel up, at 10-45 degree angle positioning against direction of blood flow
6. Maintain gentle suction on syringe as advance needle
   - If artery is not entered on initial stick, withdraw needle slowly & advance again guided by the light source or palpation
   - If withdrawn from skin, use fresh needle and repeat skin prep
7. When artery is entered, assistant will aspirate obtaining desired specimens
8. Remove needle & apply pressure to the artery for at least 5 minutes to achieve complete hemostasis
9. Verify satisfactory peripheral blood flow
CHEST TUBE PLACEMENT

INDICATIONS:
1. Tension pneumothorax
2. Pneumothorax compromising ventilation
3. Drainage of pleural effusion or to obtain pleural fluid

EQUIPMENT:
1. Sterile gloves, mask, hat & gown
2. Chloraprep
3. Pleur-Evac
4. CT tray & 10F (<2000g) or 12F (>2000g) chest tube
5. Can also use pigtail catheter kit

TECHNIQUE:
1. Select appropriate site of CT insertion:
   • For air collections (anterior CT placement) → 2nd-3rd intercostal space @ midclavicular line
   • For fluid collections (posterior placement) → 4th, 5th or 6th intercostals space @ anterior axillary line
   • REMEMBER: nipple is landmark for 4th intercostal space
2. Pre-treat with Morphine
3. Put on sterile gown, gloves, hat and mask
4. Clean area of insertion with chloraprep

For 10 or 12F CT insertion:
5. Make a small incision (~ width of tube) in the skin over the rib just BELOW the intercostal space where the chest tube is to be inserted
6. Insert closed, curved Kelly (hemostat) into incision. Spread the tissue down to the rib
7. Using the tip of the hemostat, puncture the pleura just above the rib (REMEMBER neurovascular bundle runs BELOW the rib!)
8. Insert the chest tube through the open hemostat → 2-3 cm for preemie; 3-4 cm for term infant
   • Be sure that side holes of tube are within the pleural cavity
   • Do not necessarily need to use trocar
9. Have bedside nurse attach tube to Pleur-Evac
   • Place on 5-10cm H2O suction
10. Secure the chest tube with suture
11. Obtain CXR to verify placement of chest tube and residual pneumo or pleural fluid

For Pigtail Catheter insertion:
5. Insert needle in skin OVER top of rib into intercostals space where chest tube is to be inserted
6. Insert guide wire into needle into space
7. Withdrawal needle, keeping guide wire in place
8. Thread dilator over guide wire & with “twisting” motion, enter skin until tract is form that allows for easy passage of dilator
9. Withdrawal dilator, keeping guide wire in place
10. Thread pigtail over guide wire (may need assistance) and into pleural space – ensure all holes on side of pigtail are within pleural cavity
11. Withdrawal guide wire
12. Have bedside nurse attach tube to Pleur-Evac
13. Secure the pigtail
14. Obtain CXR
COMPLICATIONS:
1. Infection
2. Bleeding – to tamponade intercostals vessel bleeding, withdrawal chest tube, place foley catheter into intercostals space; inflate the balloon and pull back in the foley until resistance
3. Nerve damage
4. Trauma
5. Diaphragmatic paralysis
6. Subcutaneous emphysema
EXCHANGE TRANSFUSION

INDICATION:
1. To remove toxins (bilirubin, ammonia, drugs, bacterial toxins)
2. to ↓ antibody-antigen levels → removal in isoimmune disease, maternal autoimmune disease
3. Partial Exchange Transfusion → to alter Hgb concentration (severe anemia, polycythemia)

EQUIPMENT:
1. radiant warmer
2. resuscitation equipment & meds
3. infant restraints
4. blood warmer
5. sterile gown, gloves, cap & mask
6. exchange transfusion tray & umbilical catheter tray
7. CMV negative PRBCs reconstituted with FFP to a Hct of 50-55% with potassium concentration of 4-5mEq/l
   - Amount needed for double volume exchange is 170-200 cc/kg
   - Remember to obtain extra blood for dead space in tubing & blood warmer
8. Anemia: use PRBCs for partial exchange:
   \[
   \text{Volume exchanged (ml)} = \frac{\text{Blood volume} \times (\text{Hgb desired} - \text{Hgb initial})}{\text{Hgb PRBC} - \text{Hgb initial}}
   \]
9. Polycythemia: use normal saline for partial exchange:
   \[
   \text{Volume replaced (ml)} = \frac{\text{Blood volume} \times (\text{observed Hct} - \text{desired Hct})}{\text{Observed Hct}}
   \]

TECHNIQUE: (Double volume exchange)
1. Ensure patient NPO for 4 hours prior to procedure
2. Place infant under radiant warmer, restrain
3. Blood should be placed in warmer & agitated gently every 10-15 minutes during procedure to ensure settling does not occur
4. Place UVC as previously described
5. Properly arrange stopcock, syringe and drainage bag; clear lines of air
6. Exchange in aliquots of 5-10ml (NEVER exceed 7% blood volume)
   - average time for push-pull technique is ~3-5 minutes
   - entire procedure should take ~90-120 minutes
7. Send initial blood withdrawn from infant for:
   - Hct & total bilirubin
8. Send last syringe of blood withdrawn from infant for:
   - fractionated bilirubin
   - CBC (looking for thrombocytopenia)
   - BMP (hypocalcemia, hypo/hyperkalemia)
   - Type and Coombs
9. During procedure, vitals should be monitored; along with chemstrips every 30 minutes
10. At end of procedure, UVC can be removed, if no longer needed; leave if 2\textsuperscript{nd} exchange anticipated
11. Watch for abdominal distention and check stools for blood (risk of NEC)
12. check stools for blood

COMPLICATIONS:
1. NEC
2. Electrolyte disturbances
3. Thrombus / emboli
4. Death
**CHLORAPREP**

- **ChloraPrep®** is 2% chlorhexidine gluconate and 70% isopropyl alcohol
- The persistent activity provided by chlorhexidine is highly recommended for use in more than 13 evidence-based guidelines, including guidelines published by the CDC
- The rapid acting, persistent and superior preoperative skin preparation ChloraPrep kills more bacteria than traditional iodophors or alcohol
- Rapid activity against gram-positive and gram-negative bacteria
- Persistent antibacterial activity—prevents regrowth of microorganisms on the skin for at least 48 hours
- Unlike povidone iodine, ChloraPrep remains active in the presence of blood, serum, and other protein-rich biomaterials
- 50% reduction in the incidence of catheter-related bloodstream infections compared to povidone iodine *(as shown in randomized, controlled trials)*

For prepping the umbilicus of infants >25 weeks:
1. Use ChloraPrep 3ml applicator
2. Squeeze the wings to break the ampule and release the Chloraprep onto the sponge
3. Use back-and-forth strokes for ~30 seconds to cover the designated umbilicus and area to be prepped
4. Let dry for 30 seconds before proceeding with procedure
5. After procedure is completed and catheter is anchored, wipe area with a 2x2 moistened with sterile saline/water to remove excess ChloraPrep and allow to dry

For prepping the umbilicus of premature infants ≤24 weeks:
1. Use ChloraPrep single SWABSTICK to prep the smallest preemies. **DO NOT** use the bullet applicator
2. Using the swabstick packet, squeeze the swabstick applicator to remove excess solution. Keep packet with its excess solution away from baby
3. Using overlapping pats, pat the skin and umbilicus with the ChloraPrep swabstick making sure to cover the designated umbilicus and area to be prepped. **DO NOT** use back-and-forth friction for these babies
4. Allow solution to dry for 30 seconds
5. Place catheter per protocol
6. After procedure is completed and catheter is anchored, wipe area with a 2x2 moistened with sterile saline/water to remove excess ChloraPrep and allow to dry