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If you have any questions or comments, please contact Dr. Irene Jun at irenejun@gmail.com

Re: June 2014
<table>
<thead>
<tr>
<th>Department</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>L &amp; D Laboratory</td>
<td>723-5403</td>
</tr>
<tr>
<td>Chemistry</td>
<td>497-8622</td>
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<tr>
<td>General</td>
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<td>Hematology</td>
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<td>Micro</td>
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<td>Transfusion</td>
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<td>Maternity</td>
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<td>F1</td>
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<td>Hospitalist-1</td>
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<td>Hospitalist -2</td>
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</tr>
<tr>
<td>Resident</td>
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</tr>
<tr>
<td>Fellow</td>
<td>721-9686</td>
</tr>
<tr>
<td>NICU Resource/Charge RN</td>
<td>721-9654</td>
</tr>
<tr>
<td>TL</td>
<td>721-9655</td>
</tr>
<tr>
<td>PICN Resource RN</td>
<td>721-9848</td>
</tr>
<tr>
<td>WBN Resident</td>
<td>721-9889</td>
</tr>
<tr>
<td>NICU Front Desk</td>
<td>497-8800</td>
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<tr>
<td>Paging Operator</td>
<td>288, 723-6661</td>
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<tr>
<td>Paging system</td>
<td>222, 723-8222</td>
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<tr>
<td>Pharmacy</td>
<td>497-8287</td>
</tr>
<tr>
<td>PICN Hospitalist Office</td>
<td>498-5745, 498-5779</td>
</tr>
<tr>
<td>PICN First Floor Nursery</td>
<td>497-8080</td>
</tr>
<tr>
<td>PICN Second Floor Nursery</td>
<td>498-7781</td>
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<tr>
<td>Radiology</td>
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<tr>
<td>CT</td>
<td>724-2706</td>
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<td>497-8376</td>
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<tr>
<td>MRI</td>
<td>724-2676</td>
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<tr>
<td>Reading Rm</td>
<td>497-8757, -8758</td>
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<tr>
<td>WBN</td>
<td>723-8772</td>
</tr>
</tbody>
</table>
Gardner Clinic Contact Info (as of 3/20/2014):

Main: 650-362-2500
Fax: 650-362-2584

Front Desk
   Senior Clerk: 650-362-2508
   Other: 650-362-2509 through 2511

North Wing:
   MD Workroom: 650-362-2532 through 2535
   RN: 650-362-2580

South Wing:
   MD Workroom: 650-362-2550 through 2555
   RN: 650-362-2560
What are the different departments in the Johnson Center?

Obstetrics Clinic (OB Clinic)
The OB Clinic is an Outpatient Clinic located across the street from LPCH at 770 Welch Rd. Ste. 201. In the OB Clinic patients are seen for prenatal care throughout their pregnancy. We provide care for healthy moms and those with high risk pregnancy issues including diabetes. We provide preconception counseling in addition to consults for complications in pregnancy.

Perinatal Diagnostic Center (PDC)
Our six state-approved Perinatal Diagnostic Centers provide a full range of diagnostic, treatment, consultation and counseling services to pregnant women.

Labor and Delivery (L&D)
The Labor and Delivery unit located on the second floor of LPCH cares for low and high risk laboring patients. This unit consists of 10 labor rooms, 3 Operating Room (OR) suites, 3 recovery beds and also 4 ante partum beds in the L&D unit. It also has an ultrasound room and an exam room to triage outpatients.

Maternity F1/F2—Antepartum & Postpartum
F1 & F2 are comprehensive perinatal units consisting of 26 beds on each floor; pt beds located on F2 are configured to care for high-risk antepartum patients. Nursing care is provided for low and high-risk antepartum and postpartum patients.

Well Baby Nursery (WBN)
The WBN is located next to F2 Maternity Unit. This nursery provides comprehensive admission assessment, routine care for healthy newborns and more complex care for less stable transitioning newborns. Procedures such as Baby’s first bath, vitamin K injection, eye prophylaxis and circumcisions take place in the Well Baby Nursery. The WBN is staffed by PICN RN’s to allow an increased level of nursing care to our newborns.

Neonatal Intensive Care Unit (NICU)
The Neonatal Intensive Care Unit (NICU) at LPCH is a 40 bed Level IV tertiary care center. We care for newborn infants, including the tiniest premature babies and infants with a variety of diagnoses such as congenital heart disease, pulmonary hypertension, metabolic disorders and other congenital defects.

Packard Intermediate Care Nursery (PICN)
The PICN is a 34 bed Level II Intensive Care nursery. The PICN is an intermediate level intensive care nursery for babies who are medically stable yet still require extra nursing attention before going home.
PICN Rotation - 5 Minute Curriculum

Contacts:
Rotation Director:
Arun Gupta, MD (arungupta@stanford.edu)

Associate Rotation Directors:
Irene Jun, MD (irenejun@stanford.edu)
Lucy Lee, MD (lucylee@stanford.edu)

Resident Liaisons:
Kaitlyn Le, MD (ple1@stanford.edu)

Phone #s
PICN Intern 1-9712
Long Shift Hospitalist 1-9687
Short Shift Hospitalist 1-9685
WBN Resident 1-9889
PICN 1 7-8080
PICN 2 7-8871
WBN 3-8772
NICU 7-8800
L&D 3-5403

Orientation
• Outgoing intern on previous block should provide orientation prior to start of rotation
• Brief delivery room orientation to be provided by Hospitalist on first day of rotation

Team
• Intern from 7:00 AM – 5:30 PM for two weeks
• Long shift Neonatal Hospitalist 1 – here from 7:30 AM- 5:30 PM
• Short shift Neonatal Hospitalist 2 – here for 5 hours (usually ~8:30 AM – 1:30 PM)
• Hospitalist may vary daily

Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday - Saturday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 - 8:00 AM</td>
<td>Sign out, pre-round, deliveries</td>
<td>Sign out, pre-round, deliveries</td>
<td>off</td>
</tr>
<tr>
<td>8:00 - 8:30 AM</td>
<td>Morning report (Friday Grand Rounds 8 -9 AM)</td>
<td>Pre-round and deliveries</td>
<td></td>
</tr>
<tr>
<td>8:30 – 9:30 AM</td>
<td>Pre-round and deliveries</td>
<td>Pre-round and deliveries</td>
<td></td>
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<tr>
<td>9:30 - Noon</td>
<td>Rounds and deliveries</td>
<td>Rounds and deliveries</td>
<td></td>
</tr>
<tr>
<td>Noon – 1:00 PM</td>
<td>Noon Conference</td>
<td>Patient care and deliveries</td>
<td></td>
</tr>
<tr>
<td>1:00 – 4:30 PM</td>
<td>Patient care and deliveries</td>
<td>Patient care and deliveries</td>
<td></td>
</tr>
<tr>
<td>4:30 – 5:30 PM</td>
<td>Sign out</td>
<td>Sign out</td>
<td></td>
</tr>
</tbody>
</table>

Add PICN Blue Team to your Personal List
• Click Patient Lists Icon (top left corner)
• Click Available Lists (left column)-> Provider List -> Service Team
• Right-click “PICN Blue” and select “Send To” and send to your personal list
• Similarly, add the following services to your list for this rotation:
  • 2 West (NICU)
  • F1 – Maternity
  • F2 – Maternity
  • Labor & Delivery
  • PICN 1
  • PICN 2
  • Well Baby Nursery

Sign out
• Brief update on major overnight events (if any) with Night Hospitalist at 7:15 AM
• Brief sign out & patient assignment with day shift Neonatal Hospitalist 1 at 8:30 AM
• Afternoon sign out at 4:30 PM
• How to Print Out a Sign-Out Sheet:
  o Open PICN Blue Team List
  o On top right corner, select “Print” and then “Handoff”
  o (Note: Prior to your first time printing the PICN team handoff, you may have to first click on the “write handoff” button in the tool bar toward the top left, with any patient's name highlighted. Then, on the right side where the handoff pops up, search for "Neonatology" in the search bar. Then, click on the down arrow of the print icon in the top right corner and select "Handoff").

Progress Notes
• Select New Note
• Under Type, choose “Progress Notes”
• Service should be “Neonatology”
• In the Insert SmartText box, choose “NEO PROGRESS NOTE”

Delivery Room Notes
• Select New Note
• Under Type, choose “Progress Notes”
• Service should be “Neonatology”
• In the Insert SmartText box, choose “PEDIATRICS DELIVERY ROOM NOTE”
• Info from mother’s chart will pull in from the OB records, but you should browse through mother’s H&P/notes to ensure all necessary info is obtained for the delivery room note

Rounds
• Aim for 9:30 AM. If possible, may start with short shift Hospitalist’s patients and discharges
• Include bedside nurse and family in discussion
• Will likely get interrupted by deliveries

Deliveries
• PRIORITY! Attend all deliveries that are called
• Will be announced on Ascom phone. Hospitalist and TL are to respond first, followed by intern.
• Grab yellow gown and gloves for vaginal deliveries
• For c-sections, tell NICU RN your glove size, scrub, and then put on sterile gown and gloves. Then, ask the scrub nurse for the sterile blanket.
• Residents are expected to take the lead in the delivery room when appropriate, with supervision and guidance provided as needed
• Before leaving, provide L&D RN with your name and APGAR scores
• Complete note titled “Peds Team Delivery Note” and send to Hospitalist who attended delivery. (Try to complete as soon as possible after delivery so note is in chart for other providers taking care of patient.)
• Keep track of your deliveries by grabbing Mom’s sticker and record it in “The Delivery Room Log Book” (located in the resident drawer next to the computer).

Discharges
• All patients discharged (or transferred out) from the PICN need a Discharge Summary (or Transfer Summary).
• Update “Detailed Hospital Course” under Discharge Tab (found in ADT Navigators) as frequently as possible.
• Complete “Neonatal Discharge Summary” (Detailed Hospital Course will pull in)
• Update “Brief Hospital Course – For After Visit Summary” (this summary will be provided to parents)
• Ensure PMD follow up date and time. Contact PMD for verbal sign out. Make sure to record that PMD contacted (under PCP Follow Up section in ADT Navigators).
• Complete discharge prescriptions (if any) and med reconciliation
• Discharge order (found under Discharge Tab in ADT Navigators).

Admissions
• All admissions from L&D and WBN require an H&P. Use the “Neonatal Admission Note”
• Complete or review admission order set (Can use “Neonatal Admission Intermediate Care” order set for most PICN admits)
Transfers
- Transfers to the NICU or WBN (or other LPCH units) require the "Neonatal Transfer/Accept Note"
- For transfers, review and reconcile all orders

Procedures
- Document lumbar punctures, circumcisions, etc. in separate Procedure Note (under Procedure Note tab).
- Intubations in delivery room are included in delivery room note
- Keep MedHub procedure log updated

Conferences
- Try to attend Morning Report (8-8:30a) and Noon Conference (12p-1p) if/when there are no deliveries or other urgent patient care issues
- Expect to leave conference to attend deliveries
- Try to sit near door during conference – so you can leave quickly and easily when deliveries are called
- Remember to walk out of the room before responding back on the phone.

Feedback/Evaluation
- Since Hospitalists may vary daily, the attendings will attempt to provide you with feedback on a regular basis during the rotation. Please feel free to request feedback from the attendings during the week as well as at the end of the rotation.
- Complete Medhub online evaluations

Last re: Sept 2014
## Competency-based Goals and Objectives

### Resident Objectives

<table>
<thead>
<tr>
<th>Objective</th>
<th>Instructional Strategies</th>
<th>Assessment of Competence</th>
<th>ACGME Competency Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess equipment preparation prior to delivery</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>SBP</td>
</tr>
<tr>
<td>Obtain pertinent information of maternal/fetal status</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>PC, ICS</td>
</tr>
<tr>
<td>Receive infant from obstetrician</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>P, ICS, PC</td>
</tr>
<tr>
<td>Appropriately assess infant’s condition (obtain heart rate, feature chest)</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC</td>
</tr>
<tr>
<td>Assign appropriate AFGAR scores</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Prepare necessary equipment for meconium stained amniotic fluid management</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>SBP</td>
</tr>
<tr>
<td>Properly intubate and aspirate meconium stained amniotic fluid from newborn</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, PBLI</td>
</tr>
<tr>
<td>Determine appropriate disposition</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>SBP, MK</td>
</tr>
<tr>
<td>Document thorough and relevant events</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Understand thermal stabilization</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Understand NRP guidelines</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
</tbody>
</table>

### General Objective

Recognize and manage newborns need for advanced resuscitation.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Instructional Strategies</th>
<th>Assessment of Competence</th>
<th>ACGME Competency Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare necessary equipment check for intubation</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>SBP</td>
</tr>
<tr>
<td>Perform adequate airway stabilization</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, PBLI</td>
</tr>
<tr>
<td>Position and obtain seal with face mask</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, PBLI</td>
</tr>
<tr>
<td>Apply CPAP with proper pressure</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, PBLI</td>
</tr>
<tr>
<td>Perform positive pressure ventilation correct PIP, PEEP, rate</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, PBLI</td>
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<tr>
<td>Intubate infant with correct size tube and laryngoscope</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, PBLI</td>
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<td>--------------------------------------------------------</td>
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<tr>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>Self assessment</td>
<td>P, ICS</td>
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<tr>
<td>Perform chest compressions</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>PC, PBLI</td>
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<td>Assess need for UVC placement</td>
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### Goal 3. Diagnose and manage newborns at risk for sepsis.

<table>
<thead>
<tr>
<th>Resident Objectives: Obtain appropriate obstetric history and assess for risk factors for neonatal sepsis</th>
<th>Instructional Strategies: Patient care Clinical teaching</th>
<th>Assessment of Competence: Direct observation</th>
<th>ACGME Competency Goals: MK</th>
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</thead>
<tbody>
<tr>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>Self assessment</td>
<td>P, ICS</td>
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<tr>
<td>Understand criteria for maternal chorioamnionitis</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Understand guidelines for GBS screening and prophylaxis</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Understand implications of prolonged rupture of membranes (PROM)</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Understand implications of preterm premature rupture of membranes</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Perform a complete history and physical</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>ICS, P, PC</td>
</tr>
<tr>
<td>Monitor for signs and symptoms of neonatal sepsis</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK, PC</td>
</tr>
<tr>
<td>Perform lumbar puncture when necessary</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>PC, PBLI</td>
</tr>
<tr>
<td>Treat with appropriate antibiotics</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK, PC</td>
</tr>
<tr>
<td>Understand how to utilize and monitor CRP values</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
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</table>

### Goal 4. Manage care of late preterm infants. Understand and manage special needs of late preterm infants.

<table>
<thead>
<tr>
<th>Resident Objectives: Recognize normal newborn physical examination</th>
<th>Instructional Strategies: Patient care Clinical teaching</th>
<th>Assessment of Competence: Direct observation</th>
<th>ACGME Competency Goals: MK</th>
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</thead>
<tbody>
<tr>
<td>Recognize normal newborn physical examination</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Manage feeding problems associated with prematurity</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK, PC</td>
</tr>
<tr>
<td>Understand fluid management requirements of premature infants</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Recognize unique nutrition needs of premature infants</td>
<td>Patient care Clinical teaching</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td>Resident Objectives</td>
<td>Instructional Strategies</td>
<td>Assessment of Competence</td>
<td>ACGME Competency Goals</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------</td>
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<td>--------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Monitor apnea, bradycardia, and desaturation episodes</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Recognize effects of prematurity on infant development</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Recognize and manage hyperbilirubinemia of prematurity</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Appreciate and manage anemia of prematurity</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Understand temperature instability associated with low birthweight</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td><strong>Goal 5: Recognize, evaluate, and manage hypoglycemia of the newborn</strong></td>
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<tr>
<td>Resident Objectives</td>
<td>Instructional Strategies</td>
<td>Assessment of Competence</td>
<td>ACGME Competency Goals</td>
</tr>
<tr>
<td>Obtain relevant maternal history and recognize associated risk factors placing infants at increased risk for hypoglycemia</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>P, ICS, MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Understand glucose requirements of premature infants</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Understand complications of hypoglycemia</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Appropriately treat infants with hypoglycemia</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, PC, SBP</td>
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<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
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<tr>
<td>Recognize when to consult endocrinology</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>P, PC, MK, ICS</td>
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<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Ensure proper follow up in HRIF Clinic as outpatient if hypoglycemia meets criteria</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
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<tr>
<td><strong>Goal 6: Manage and treat jaundice of the newborn</strong></td>
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<tr>
<td>Resident Objectives</td>
<td>Instructional Strategies</td>
<td>Assessment of Competence</td>
<td>ACGME Competency Goals</td>
</tr>
<tr>
<td>Recognize risk factors placing infants at increased risk for hyperbilirubinemia</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK</td>
</tr>
<tr>
<td></td>
<td>Clinical teaching</td>
<td>Self assessment</td>
<td></td>
</tr>
<tr>
<td>Utilize Bhutani nomogram when appropriate</td>
<td>Patient care</td>
<td>Direct observation</td>
<td>MK, SBP</td>
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<td>Clinical teaching</td>
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<tr>
<td>Understand ABO incompatibility</td>
<td>Patient care</td>
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<td>Clinical teaching</td>
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<tr>
<td>Understand use and mechanism of phototherapy</td>
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Key:

- PBLI = practice based learning and improvement
- ICS = Interpersonal and communication skills
- P = professionalism
- MK = medical knowledge
- PC = patient care
- SBP = systems based practice
Packard Intermediate Care Nursery (PICN) Rotation

Rotation Contacts and Scheduling Details

Rotation Director: Arun Gupta, MD
arungupta@stanford.edu
750 Welch Road, Suite 315
(650) 723-5711

Associate Director: Irene Jun, MD (irenejun@stanford.edu)
Lucy Lee, MD (lucylee@stanford.edu)

Resident Liaisons: Kaitlyn Le, MD (ple1@stanford.edu)

PICN Rotation Office: Located in the PICN, 2nd Floor

Positions Available: 1 intern resident will be accommodated per 2 week block.

Months Rotation Offered: every block.

Introduction
Pediatric housestaff in the Department of Pediatrics at the Stanford University School of Medicine are offered the opportunity to enrich their neonatal management training and delivery room skills during the Neonatal Hospitalist/Intermediate Care Nursery (PICN) core rotation. The focus of the housestaff experience is to strengthen their knowledge about newborn management in the delivery room, followed by stabilization of the newborns in the nursery. This rotation provides housestaff with the opportunity to develop competent delivery room and resuscitation skills necessary to stabilize newborns, as well as to assume the primary role in managing the infant’s medical needs in the intermediate care nursery.

Weekly Schedule

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<td>7:00 - 8:00</td>
<td>Pre-Round, Deliveries</td>
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<td>8:00 - 8:30</td>
<td>Morning Report</td>
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<td>Grand Rounds</td>
<td>Pre-Round, Deliveries</td>
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<td>Rounds, Patient Care, Deliveries</td>
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<td>Conference, Perinatal M&amp; M Conference</td>
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<td>13:00 - 16:30</td>
<td>Patient Care, Deliveries, Teaching</td>
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Rotation Specifics

Orientation
Residents are expected to read this rotation summary and review NRP guidelines prior to the start of their rotation. (If needed, a copy of the NRP Manual should be available in the Housestaff office). Orientation should be provided by the outgoing resident prior to the start of the rotation. An additional Delivery Room orientation will take place on the first day of the rotation. The resident should find the attending in Neonatal Hospitalist office, which is on the second floor of the Packard Intermediate Care Nursery (PICN). The resident should come prepared in appropriate clean LPCH scrub attire, ready to attend deliveries in the OR.

Resident workspace: A separate PICN Resident workstation has been designated for the use of the PICN resident only, and will serve as the primary workspace for the resident throughout the rotation. The resident workstation is located in the area between the WBN and the PICN2.

Reading materials: A PICN handbook will be provided to the resident on the first day of the rotation and will provide information about newborn care and relevant topics that will be discussed during the rotation. In addition, the NICU guide is available on the LPCH Intranet (https://intranet.lpch.org/departments/nicu/nicuGuide/index.html) and serves as an excellent resource tool for all aspects of newborn management.

Call Schedule
There are no call responsibilities associated with this rotation. As a core inpatient rotation, residents will be expected to come in Monday through Saturday during their 2-week PICN block. Residents will not be expected to come in on Sundays.

Pagers and Team Phones
There are two ASCOM phones designated for the two Neonatal Hospitalist Attendings that are on service during the day: the Hospitalist-1 phone (721-9687) and the Hospitalist-2 phone (721-9685). The resident will be expected to carry the PICN Resident ASCOM phone (721-9712) and should respond to all delivery calls.

Rounds
Residents will be expected to arrive at 07:00 am to begin pre-rounding and attend deliveries. Often times, C-sections are scheduled starting at 07:30 am, and it is expected that the residents will be available to attend these deliveries. The residents should attend Morning Report at 8am, and then return to the PICN to finish pre-rounding on their patients. Formal rounds will begin at 09:30 am (if there are no deliveries occurring at this time). Residents may be asked to first present patients to Hospitalist-2 (as Hospitalist-2 is a half-day attending), and then present the remainder of the patients to Hospitalist-1. The residents and attending(s) will walk-round in the nursery and will attempt to update bedside nurses and family members who are present as to the plan of care for the day.

The Hospitalist will assign appropriate patients for the resident to follow, and thereafter the resident will follow the patient until discharge. If the census is low, the resident may be asked to follow all the patients with the attending. Residents are expected to attend all deliveries with the Hospitalist team, and therefore rounds may occur at variable times, depending on the timing of the deliveries. Residents will assume primary care of their patients and will be expected to update the families, as well as to update the online sign-out report form.

Sign-out rounds are held in the PICN beginning at 4:30 pm and are intended to inform the on-call Hospitalist of problems that may develop that night. Routine diagnostic and therapeutic procedures are to be performed by the primary housestaff and are not to be signed-out to the on-call team.

Delivery Room Attendance
Resuscitation skills are, arguably, the most important skill set for future general pediatric practice to be gained during this rotation. As such, delivery room attendance is a top priority and housestaff are expected to attend all deliveries. A delivery room note must be written for all deliveries and should summarize pertinent prenatal
information, the indication for delivery room attendance, description of resuscitation procedures, a brief physical examination, and recommendations for disposition.

Resident Roles and Responsibilities
- Attend all deliveries
- Perform necessary resuscitation in the delivery room
- Admit sick newborns to the Intermediate Care Nursery
- Assume primary care for infants in the Intermediate Care Nursery
- Pre-round on patients and write daily progress notes and orders
- Update the sign-out sheet daily

Evaluation and Feedback
House officers are encouraged to solicit feedback from the supervising Hospitalists at the mid-point of their rotation to discuss areas for improvement and again at the end of the rotation to gain an overall evaluation. House officers are likely to work with several different Hospitalists during their rotation; hence, there is potential for feedback from a variety of sources. Formal evaluations will be provided through the MedHub system.

Last updated 9/14


**Newborn Examination**

**SKIN**

**Skin Color**

**Cyanosis**  
Peripheral cyanosis of hands, feet, circumoral area is common during the first 48 hours.

Central cyanosis needs urgent investigation. Obtain pre- and post-ductal O2 saturations.

**Pallor**  
Unusual in the newborn. May indicate anemia or poor perfusion. Check cap refill (n<3 sec) and Hb, particularly if hx maternal hemorrhage.

**Jaundice**  
Jaundice in first 24 hrs is abnormal and needs investigation.

**Skin Texture**

**Peeling**  
Common in post term babies

**Edema**

- Pitting – check for hypoalbuminemia.
- Non-pitting – (particularly of feet) consider Turner’s Syndrome in females.

**Skin Rashes / Birthmarks**

**Salmon Patch (Nevus simplex)**  
Common capillary malformations present at birth. Eyelid spots (“angel kisses”) generally fade over several months. Lesions on the glabella may take several years to resolve, and occasionally the outlines can be seen into adulthood, especially when face is flushed.

Lesions on nape of the neck (“Stork Bite Marks”) become less intense with time, but are frequently visible into adulthood.
<table>
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<tr>
<th>Condition</th>
<th>Description</th>
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<td>Port wine stains (Nevus flammeus)</td>
<td>Congenital pink patches that are typically more intense and purple-red in color than salmon patches. Port wine stains on the face may be associated with Sturge-Weber syndrome, and those on the extremities may be associated with Klippel-Trenaunay-Weber syndrome in which overgrowth of an extremity may occur.</td>
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<td>Hemangioma</td>
<td>Will increase in size over 1-2 years and then resolve.</td>
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<td>Bruising</td>
<td>Normal after instrumental deliveries, but spontaneous petechiae, purpura or ecchymoses need immediate investigation.</td>
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<tr>
<td>Mongolian blue spot</td>
<td>Slate coloured mark over the lower spine and buttocks. More common in babies of non-caucasian parentage. No medical significance.</td>
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**FACE**

**Eyes**

History: Infants at risk of eye problems because of family history are congenital cataract, congenital glaucoma, retinoblastoma, metabolic or genetic disease should be referred to Ophthalmology.

Evaluate for: Red Reflex

Normal Red Reflex:

Abnl Red Reflex:

Conjunctivitis: Mild/mucoid discharge – common, needs topical care

Purulent – urgent swabs for Gonocoeci/Chlamydia.
Nose

Nares
Check for patency
Flaring indicates respiratory distress and needs evaluation.

Mouth

Cleft lip +/- palate
May be unilateral/bilateral

Epstein’s Pearls
White cysts on gums/palate – of no significance

Short frenulum/“tongue-tie”
No significance if does not impair feeding. Consider frenotomy if impedes feeding.

Natal Teeth
Rare. Poses a potential risk from inhalation, or discomfort to the mother whilst breast feeding.

Ears

- Look at general shape, size, position of ears.
- Check auditory meatus for patency but do not attempt to visualize drum.
- Tags are often familial/ family may want removal.

Head

Caput Succedaneum
Non-fluctuant swelling of the presenting part of the head
Cephalohematoma

Fluctuant swelling confined by suture lines – cephalohematoma does not need treatment but may take several weeks to settle fully.

Subgaleal hemorrhage

Fluctuant swelling of a large area of scalp – can be associated with significant blood loss and needs urgent assessment. Midline swellings should be treated with suspicion.

Neck

Shape

Webbed neck can be associated with various syndromes including Turner’s/Noonans Syndromes

Swellings

Cystic hygroma – soft, transilluminable, fluctuant swelling in the posterior triangle.

Sternocleidomastoid tumor – “swelling” in the muscle, often associated with torticollis.

Chest and Cardiovascular System

Evaluate rate and pattern of respiration:

Periodic breathing

Not uncommon in babies, with apneic spells of 5-10 seconds. Longer spells are significant and need investigating.

Tachypnea

Sign of pulmonary/cardiac pathology
(normal respiratory rate: 40-60/minute).

Assess for murmur

Transient grade 1-2/6 ejection systolic murmurs are very common in first 48 hours
### Abdomen

**Observe**
For distension

**Palpate**
For organomegaly.
Any enlargements warrant investigation.
Liver edge up to 2 cm, and spleen 1 cm is WNL.

**Umbilicus**
Hernia not uncommon.
Resolves spontaneously, within few months

**Inguinal hernia**
Risk of strangulation. Consult pediatrics surgery.

### Genitalia

**Males**
Check position of meatus for hypo/epispadias

Testicles - Check each one for descent and note whether well descended in the scrotal sac or not.

Hydroceles. Usually resolve spontaneously. No treatment required.

**Females**
Inspect vulva for anatomical abnormalities.
Blood stained vaginal discharge common. Equivalent of “withdrawal period.”

**Ambiguous genitalia**
Consult pediatrics endo.

**Anus**
Check position and patency
**Spine**
Inspect for curvature and midline abnormality.

The presence of a hairy patch, naevus, lipoma, dermoid, deep sinus (base not visible) warrants a detailed neurological assessment of the lower limbs.

Dimples with easily visible floor situated in the buttock cleft are common and not of any consequence.

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**Upper Limbs**
Inspect arms For shape, posture and symmetry

Observe arms For spontaneous arm movements. Lack of active movements suggests palsy. Lack of active movements and pain on passive movements suggest a fracture or infection.

Examine hands Accessory digits

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**Lower Limbs**
Positional talipes Common. Due to abnormal position of the foot. Can be corrected passively.

True talipes (calcaneovalgus or equinovalgus) Requires orthopaedic attention

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**Hips**
Perform: Barlow/Ortolani Maneuvers to assess hip stability
"Late-Preterm" Infants: A Population at Risk

William A. Engle, MD, Kay M. Tomashek, MD, Carol Wallman, MSN, and the Committee on Fetus and Newborn

ABSTRACT
Late-preterm infants, defined by birth at 34% through 36½ weeks' gestation, are less physiologically and metabolically mature than term infants. Thus, they are at higher risk of morbidity and mortality than term infants. The purpose of this report is to define "late preterm," recommend a change in terminology from "near term" to "late preterm," present the characteristics of late-preterm infants that predispose them to a higher risk of morbidity and mortality than term infants, and propose guidelines for the evaluation and management of these infants after birth.

INTRODUCTION
Infants born at 34% through 36½ weeks' gestation, or "late-preterm" infants, are often the size and weight of some term infants (born at 37½–41½ weeks' gestation). Because of this fact, late-preterm infants may be treated by parents, caregivers, and health care professionals as though they are developmentally mature and at low risk of morbidity. They are often managed in newborn level 1 (basic) nurseries or remain with their mother after birth.

Late-preterm infants are physiologically and metabolically immature.2-6 As a consequence, late-preterm infants are at higher risk than are term infants of developing medical complications that result in higher rates of mortality and morbidity during the birth hospitalization.6-8 In addition, late-preterm infants have higher rates of hospital readmission during the neonatal period than do term infants.2,6,10-12 During the last 15 years, the proportion of all US births that were late preterm increased from 7.3% in 1990 to 9.1% in 2005.10 In 2005, late-preterm births accounted for more than 70% of all preterm births (<37 weeks' gestation), or approximately 377,000 infants.10-12 In fact, much of the increase in the preterm birth rate in recent years can be attributed to increases in late-preterm births.12,13

The reason for the increase in late-preterm births during the last decade is not well understood. One hypothesis is that it may be attributable, in part, to increased use of reproductive technologies and, as a result, an increase in multifetal pregnancies.2,14-16 Another hypothesis is that advances in obstetric practice have led to an increase in surveillance and medical interventions during pregnancy.11,12,17 As a result, fetuses considered to be at risk of stillbirth, including those with intrauterine growth restriction, fetal anomalies, and intrapartum asphyxia, may be identified earlier, which results in more deliveries at 34 to 36 weeks' gestation. For example, between 1989 and 2003, the use of electronic fetal monitoring and prenatal ultrasonography increased substantially from 68.1% to 85.4% and 47.6% to 67%, respectively.10 Rates of labor induction and cesarean delivery also in-
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<td>296</td>
<td>297</td>
<td>298</td>
</tr>
<tr>
<td>38</td>
<td>294</td>
<td>295</td>
<td>296</td>
<td>297</td>
<td>298</td>
<td>299</td>
<td>300</td>
</tr>
<tr>
<td>39</td>
<td>296</td>
<td>297</td>
<td>298</td>
<td>299</td>
<td>300</td>
<td>301</td>
<td>302</td>
</tr>
</tbody>
</table>

Late-preterm gestation is defined as medical convention as 34 weeks (239 days) through and including 36 weeks (259 days) after the beginning of the mother's last normal menstrual period. This is indicated in days with a red background. For comparison, term gestation spans from 37 to 40 weeks (266-296 days) after the beginning of the mother's last normal menstrual period, which is indicated in days with an aqua background.

* Completed week of gestation indicates the number of 7-day intervals that have passed since the beginning of the mother's last normal menstrual period. For example, the first completed week occurs after 1 seven-day internal (7th week or 7 days) has passed. The 37th completed week occurs after 37 seven-day intervals (259 weeks or 259 days) have passed.

* Fraction of a week indicates the number of days in each gestational week as a fraction. For example, the first day of gestation is the first day of the mother's 36th week of gestation and ends on the 36th week of gestation.

* Statistical day indicates that the first day of the mother's last menstrual period begins as day 0 and is not complete until the beginning of day 1.

* This statistical view of gestational age differs by 1 day from the conventional medical count of days, which indicates that the first day of the mother's last menstrual period begins as day 1. This important difference is indicated by the statistically defined days that have a gray background and conventionally defined days having no background or a red or aqua background.

It is important to understand why these infants are being born early as well as the unique problems that this growing population of infants may experience. A clearer understanding of the underlying risk factors, associated etiologies, and their relative effects on delivery at 34%

creased during the last decade. It is important to note, however, that the increased intensity of care provided to pregnant women has been accompanied by significant reductions in stillbirths, perinatal mortality, and births beyond 40 weeks' gestation.
through 36% years' gestation on the mother and fetus is needed to develop interventions to prevent unnecessary late-preterm births and to improve the management of infants who are born late preterm. Thus, additional research is needed to determine the gestational age at delivery that optimally balances the risk of fetal morbidity or death against risks associated with late-preterm birth for both the mother and the fetus.

The purpose of this report is to define "late preterm," recommend a change in terminology to "late preterm" from the previously used "near term," describe the medical complications and health risks commonly encountered by late-preterm infants, suggest guidelines to identify and manage these complications and risks during the birth hospitalization and after discharge, and identify gaps in knowledge concerning the medical and developmental outcomes of these infants.

**Definition of Late Preterm**

The gestational age attributed to a newborn infant can be confusing, because the first day of a mother's last normal menstrual period is counted as either day 0 or day 1 depending on whether a statistical or conventional medical definition, respectively, is used. This difference in definition of gestational age accounts for a 1-day variation among data systems when determining the chronologic age of a newborn infant on the first day after birth (Table 1). The day of birth is counted as day 1 when using the conventional medical definition and day 0 when using the statistical definition. The use of conventional medical terminology is illustrated in the definitions of gestational age recommended by the American Academy of Pediatrics, the American College of Obstetricians and Gynecologists, and the World Health Organization. For example, "preterm" is defined as birth that occurs on or before the end of the last day of the 37th completed week (i.e., 36% years' gestation) after the onset of the mother's last menstrual period, which equates to 259 days in common medical terminology. The statistical definition for the last day of the 37th completed week of gestation is 258 days. Understanding these definitions is complicated further by financial systems that define the first day of age as delivery before 12:00 AM (midnight) and the subsequent day beginning immediately after 12:00 AM.

The use of the term "completed week" is also confusing. Completed weeks of gestation are defined by the number of 7-day intervals after the first day of the last menstrual period (Table 1). For example, the end of the 37th completed week of gestation is 36% years' gestation, because 37 seven-day intervals (259 days) have transpired. To further clarify, the end of the 37th completed week is not 37% years' gestation; the beginning of the 38th week of gestation is designated as 37% years' gestation (260 days).

A variety of terms have been used to describe preterm infants born at a number of different intervals between 32 and 37 weeks' gestation ("late preterm," "near term," "marginally preterm," "moderately preterm," "mildly preterm," and "mildly preterm"). In contrast, preterm, term, and postterm are mutually exclusive categories that have each been defined precisely according to week and day of gestation (counting the first day as day 1) by the American Academy of Pediatrics, the American College of Obstetricians and Gynecologists, and the World Health Organization (Fig 1). As previously described, "preterm" is defined as a birth that occurs on or before the end of the last day of the 37th week (259th day) after the onset of the mother's last menstrual period. "Term" is defined as a birth that occurs on the first day (260th day) of the 38th week through the end of the last day of the 42nd week (294th day) after the onset of the last menstrual period (Table 1). "Postterm" describes the birth of an infant that occurs on or after the first day (295th day) of the 43rd week after the onset of the last menstrual period.

The 2005 workshop "Optimizing Care and Outcome of the Near-Term Pregnancy and the Near-Term Newborn Infant" sponsored by the National Institutes of Health recommended that infants born at 34% through 36% years' gestation after the onset of the mother's last menstrual period be referred to as late preterm to emphasize that these infants are preterm and, as such, are at risk of immaturity-related medical complications (Tables 2 and 3). Furthermore, use of the term "near term," which connotes that the infant is almost term and,
**TABLE 2** Late-Preterm Infants and the Most Frequent Complications of Prematurity During the Birth Hospitalization

<table>
<thead>
<tr>
<th>Outcome During Initial Birth Hospitalization</th>
<th>Late-Preterm Morbidity</th>
<th>Term Morbidity</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Feeding difficulties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>29</td>
<td>32.2</td>
<td>7</td>
<td>7.4</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>14</td>
<td>15.6</td>
<td>5</td>
<td>5.3</td>
</tr>
<tr>
<td>Jaundice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>49</td>
<td>54.4</td>
<td>36</td>
<td>37.9</td>
</tr>
<tr>
<td>Temperature instability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>9</td>
<td>10.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Apnea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henderson-Smart (^{3}(34-35% \text{ wk}))</td>
<td>—</td>
<td>7.0</td>
<td>—</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Merchant et al (^{3}(35-36% \text{ wk}))</td>
<td>6</td>
<td>12.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>4</td>
<td>4.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escobar et al (^{3}(34-36% \text{ wk}))</td>
<td>345</td>
<td>10.7</td>
<td>925</td>
<td>2.7</td>
</tr>
<tr>
<td>Gilbert et al (^{3}(34-36% \text{ wk}))</td>
<td>1167</td>
<td>3.6</td>
<td>843</td>
<td>0.8</td>
</tr>
<tr>
<td>Rubaltelli et al (^{3}(34-36% \text{ wk}))</td>
<td>314</td>
<td>9.6</td>
<td>359</td>
<td>0.6</td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>26</td>
<td>28.9</td>
<td>4</td>
<td>4.2</td>
</tr>
<tr>
<td>Received Intravenous Infusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>24</td>
<td>26.7</td>
<td>5</td>
<td>5.3</td>
</tr>
<tr>
<td>Underwent sepsis evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al (^{3}(35-36% \text{ wk}))</td>
<td>33</td>
<td>36.7</td>
<td>12</td>
<td>12.6</td>
</tr>
<tr>
<td>Received mechanical ventilation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gilbert et al (^{3}(34-36% \text{ wk}))</td>
<td>1103</td>
<td>3.4</td>
<td>950</td>
<td>0.9</td>
</tr>
</tbody>
</table>

OR indicates odds ratio; CI, confidence interval; —, data not reported.

Therefore, almost fully mature, should be discouraged, because it might lead health care professionals to underestimate the inherent risks to these infants.\(^{5,9}\)

Workshop members acknowledged that the definition of "late preterm" was arbitrary.\(^{3}\) The day after the end of the 34th completed week of gestation (i.e., 239th day or 34½ weeks' gestation after the onset of the mother's last menstrual period) was recommended as the lower limit, because it is frequently used as a cutoff point for obstetric decision-making, as a criterion for admission to a level 2 or 3 NICU, and for epidemiologic and clinical research. The upper limit of gestational age for prematurity was previously established as 36½ weeks' gestation (259th day after the onset of the mother's last menstrual period). Thus, it was recommended that this same upper limit be applied to the late-preterm category of infants.

**DEVELOPMENTAL AND PHYSIOLOGIC IMMATURITY OF LATE-PRETERM INFANTS**

Late-preterm infants have not been studied frequently, and understanding of the developmental biology and mechanisms of disease experienced by these infants is largely incomplete.\(^{6,7,8,22-30}\) Management strategies, therefore, are based on general principles, clinical experience, and extrapolation from knowledge of very preterm and term infants. Recently, descriptive studies that detailed the epidemiology, medical problems, and risk of mortality experienced by late-preterm infants have stimulated interest in exploring the comparative biology and basic mechanisms of disease in these infants.\(^{6,9}\) Several important factors that may predispose late-preterm infants to medical conditions associated with immaturity, such as respiratory distress, apnea, temperature instability, hypoglycemia, hyperbilirubinemia, and poor feeding, are reviewed briefly in this report. However, a comprehensive review of the physiologic and functional deficits that predispose late-preterm infants to these conditions is beyond the scope of this report.\(^{5}\)

After birth, infants with fetal lung structure and immature functional capacity are at greatest risk of respiratory distress, need for oxygen and positive-pressure ventilation, and admission for intensive care.\(^{5,23-33}\) From 34½ through 36½ weeks' gestation, terminal respiratory units of the lung evolve from alveolar sacs lined with both cuboidal type II and flat type I epithelial cells (terminal sac period) to mature alveoli lined primarily with extremely thin type I epithelial cells (alveolar period).\(^{34,35}\) During the alveolar period, pulmonary capillaries also begin to bulge into the space of each terminal sac, and adult pool sizes of surfactant are attained.\(^{26}\) Functionally, this immature lung structure may be associated with delayed intrapulmonary fluid absorption, surfactant insufficiency, and inefficient gas exchange.\(^{24,25}\)

Apnea occurs more frequently among late-preterm infants than term infants. The incidence of apnea in

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TABLE 3. Late-Preterm Infants and Rates of Readmission to the Hospital After the Birth Hospitalization

<table>
<thead>
<tr>
<th>Description of Comparison Groups by Study</th>
<th>Readmitted to Hospitala</th>
<th>Required Hospital Careb</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All NICU survivors from 6 Kaiser Permanente hospitals, N = 6054 (Escobar et al46)</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>&lt;33 wk, all LOS</td>
<td>20</td>
<td>3.4</td>
<td>—</td>
</tr>
<tr>
<td>33–36 wk, LOS &lt; 96 h</td>
<td>31</td>
<td>5.7</td>
<td>—</td>
</tr>
<tr>
<td>33–36 wk, LOS ≥ 96 h</td>
<td>26</td>
<td>2.2</td>
<td>—</td>
</tr>
<tr>
<td>Term, LOS ≥ 96 h</td>
<td>32</td>
<td>2.8</td>
<td>—</td>
</tr>
<tr>
<td>Term, LOS &lt; 96 h</td>
<td>56</td>
<td>2.2</td>
<td>—</td>
</tr>
<tr>
<td>One half of all births &gt; 34 wk born in UK northern region, N = 11406 (Codd et al)</td>
<td>35–37 wk</td>
<td>37</td>
<td>6.3</td>
</tr>
<tr>
<td>&gt;40 wk</td>
<td>57</td>
<td>2.4</td>
<td>—</td>
</tr>
<tr>
<td>38–40 wk</td>
<td>178</td>
<td>3.4</td>
<td>—</td>
</tr>
<tr>
<td>All newborns surviving to discharge at 7 Kaiser Permanente hospitals, N = 33 276 (Escobar et al)</td>
<td>&lt;34 wk (100% in NICU)</td>
<td>26</td>
<td>3.0</td>
</tr>
<tr>
<td>34–36 wk, in NICU ≥ 24 h</td>
<td>34–36 wk, in NICU &lt; 24 h</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>34–36 wk, never in NICU</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>All 34–36 wk infants</td>
<td>94</td>
<td>4.4</td>
<td>—</td>
</tr>
<tr>
<td>≥37 wk, in NICU ≥ 24 h</td>
<td>≥37 wk, in NICU &lt; 24 h</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>≥37 wk, never in NICU</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>All ≥37-wk infants</td>
<td>618</td>
<td>2.0</td>
<td>—</td>
</tr>
<tr>
<td>All Massachusetts newborns discharged early after vaginal delivery, N = 25 324 (Tomashek et al)</td>
<td>34–36 wk</td>
<td>35</td>
<td>3.5</td>
</tr>
<tr>
<td>37–41 wk</td>
<td>489</td>
<td>2.0</td>
<td>—</td>
</tr>
<tr>
<td>34–36 wk</td>
<td>—</td>
<td>—</td>
<td>43</td>
</tr>
<tr>
<td>37–41 wk</td>
<td>—</td>
<td>—</td>
<td>648</td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval; LOS, length of stay; UK, United Kingdom; —, data not reported.
aReadmitted to hospital within 2 weeks after birth hospitalization discharge (Escobar et al46) and within first 28 days of life (Codd et al) and Tomashek et al.
bRequired hospital care includes hospital inpatient readmission and observational stay visits during neonatal period.
cShown are relative risks with confidence limits.

Late-preterm infants is reported to be between 4% and 7%, compared with less than 1% to 2% at term. It is notable that the frequency of apneic events at term was determined by using data from cardiopulmonary monitoring of healthy infants in their homes. Apneic events were inapparent to caregivers and resolved spontaneously. The predisposition to apnea in late-preterm infants is associated with several underlying factors including increased susceptibility to hypoxic respiratory depression, decreased central chemosensitivity to carbon dioxide, immature pulmonary irritant receptors, increased respiratory inhibition sensitivity to laryngeal stimulation, and decreased upper airway dilator muscle tone. It is also suspected that late-preterm infants may be at higher risk of centrally mediated apnea, because their central nervous systems are developmentally immature (ie, fewer sulci and gyri, less myelin) and their brains are approximately two thirds the size of a term infant’s brain.

Little is known about cardiovascular physiology and pathobiology in late-preterm infants; it is generally believed that structural and functional immaturity restricts the amount of cardiovascular reserve that is available during times of stress. Immature cardiovascular function may also complicate recovery of the late-preterm infant with respiratory distress because of delayed ductus arteriosus closure and persistent pulmonary hypertension.

An infant’s response to cold exposure after birth is related to gestational age and is affected by the physical size, the amount of mature brown and white adipose tissue, and maturity of the hypothalamus. Brown-fat accumulation and maturation and concentrations of hormones responsible for brown-fat metabolism (eg, prolactin, leptin, norepinephrine, triiodothyronine, cortisol) peak at term. Thus, late-preterm infants have less white adipose tissue for insulation, and they cannot generate heat from brown adipose tissue as effectively as infants born at term. In addition, late-preterm infants are likely to lose heat more readily than term infants,
because they have a larger ratio of surface area to weight and are smaller in size.

Hypoglycemia may affect fasting newborn infants of all gestational ages because of insufficient metabolic responses to the abrupt loss of the maternal glucose supply after birth.31,59 The incidence of hypoglycemia is inversely proportional to gestational age. Within the first 12 to 24 hours after birth, concentrations of enzymes that are essential for hepatic gluconeogenesis and hepatic ketogenesis rapidly increase. Therefore, hypoglycemia typically resolves. Preterm infants are at increased risk of developing hypoglycemia after birth, because they have immature hepatic glycogenolysis and adipose tissue lipolysis, hormonal dysregulation, and deficient hepatic gluconeogenesis and ketogenesis. Blood glucose concentrations among preterm infants typically decrease to a nadir 1 to 2 hours after birth and remain low until metabolic pathways can compensate or exogenous sources of glucose are provided.31,54 Carbohydrate metabolism among late-preterm infants is not well understood. However, immature glucose regulation likely occurs in late-preterm infants, because hypoglycemia that requires glucose infusion during the initial birth hospitalization occurs more frequently than in term infants.2

Jaundice and hyperbilirubinemia occur more commonly and are more prolonged among late-preterm infants than term infants, because late-preterm infants have delayed maturation and a lower concentration of uridine diphosphoglucuronate glucuronyltransferase.31,54 Late-preterm infants are 2 times more likely than term infants to have significantly elevated bilirubin concentrations and higher concentrations 5 and 7 days after birth.21

Preterm infants also have immature gastrointestinal function27,58 and feeding difficulties that predispose them to an increase in enterohemorrhagic circulation, decreased stool frequency, dehydration, and hyperbilirubinemia.59-68 Feeding during the birth hospitalization may be transiently successful but not sustained after discharge. Feeding difficulties in late-preterm infants that are associated with relatively low oromotor tone, function, and neural maturation also predispose these infants to dehydration and hyperbilirubinemia.30,67-69

MORBIDITY AND MORTALITY AMONG LATE-PRETERM INFANTS

Late-preterm infants are at increased risk of neonatal morbidity compared with term infants. During the initial birth hospitalization, late-preterm infants are 4 times more likely than term infants to have at least 1 medical condition diagnosed and 3.5 times more likely to have 2 or more conditions diagnosed.2 Late-preterm infants are more likely than term infants to be diagnosed during the birth hospitalization with temperature instability, hypoglycemia, respiratory distress,2,24,33,70-71 apnea,38,43 jaundice,7 and feeding difficulties2 (Table 2). During the first month after birth, late-preterm infants are also more likely than term infants to develop hyperbilirubinemia21,60,72,73 and to be readmitted for hyperbilirubinemia3,59,64 and non–jaundice-related diagnoses such as feeding difficulties and "rule-out sepsis."3

Some of the reported increase in morbidity among late-preterm infants may be attributable to observation and detection bias, because a clinician’s threshold to monitor late-preterm infants for medical complications may be lower than their threshold for term infants. For example, a hospital-based study found that late-preterm infants were evaluated for possible sepsis 3 times as often as term infants, and the majority of evaluated late-preterm infants received antibiotic treatment, whereas term infants did not.2 However, studies have also found that late-preterm infants are at increased risk of developing more severe illness than term infants.22,24,70 One study of all California singleton live births who survived to 1 year of age found that infants born at 34 to 36 weeks’ gestation were 3 to 9 times more likely to require mechanical ventilation than infants born at 38 weeks’ gestation.78

Late-preterm infants are also more likely than term infants to have longer initial hospital stays and to be admitted to the NICU.23,33,70 One large cohort study found that 88% of infants born at 34 weeks’ gestation, 54% of infants born at 35 weeks’ gestation, 25% of infants born at 36 weeks’ gestation, 12% of infants born at 37 weeks’ gestation, and 2.6% of infants born at 38 through 40 weeks’ gestation were admitted to a NICU.3

Severity of illness is also reflected in the increased risk of mortality among late-preterm infants compared with term infants in the United States.6,10 In 2002, the neonatal mortality rate (deaths among infants 0–27 days’ chronologic age) for late-preterm infants was 4.6 times higher than the rate for term infants (4.1 vs 0.9 per 1000 live births, respectively). This difference in neonatal mortality has widened slightly since 1995, when there was a fourfold difference in rates between late-preterm and term infants (4.8 vs 1.2 per 1000 live births, respectively). The infant mortality rate was also higher among late-preterm infants than term infants in 2002 (7.7 vs 2.5 per 1000 live births, respectively). This threefold difference has remained relatively constant since 1995, at which time the infant mortality rate was 9.3 per 1000 live births among late-preterm infants and 3.1 per 1000 live births among term infants.

Several case-control studies designed to evaluate risk factors for neonatal hospital readmission after the birth hospitalization have identified late-preterm birth as a significant risk factor.62,63,65,68,74 Studies that compared neonatal hospital readmission rates among late-preterm infants and other groups of infants, including term infants, have found that late-preterm infants are more likely to be readmitted than are term infants (Table 3).4,8,24,59 A large study in the United Kingdom found that infants born at 35 through 37 weeks’ gestation were
1.7 times more likely to be readmitted during the neonatal period than were infants born at 38 through 40 weeks' gestation (adjusted odds ratio: 1.7; 95% confidence interval: 1.2–2.6). A retrospective cohort study of all newborn infants who survived to discharge at 7 hospitals within a large managed care organization found that 4.4% of all late-preterm infants were readmitted within 2 weeks after the birth hospitalization, compared with 3.0% of infants less than 34 weeks' gestation and 2.0% of infants born at or after 37 weeks' gestation. Late-preterm infants who were never admitted to the NICU were at the highest risk of rehospitalization. This study also found that having a home visit or a scheduled outpatient visit within 72 hours after discharge was associated with a decreased risk of rehospitalization. In addition, a population-based study found that late-preterm infants who were not admitted to the NICU after birth were 2 to 3 times more likely than term infants to be rehospitalized for hyperbilirubinemia.

Late-preterm infants with short NICU stays may be at increased risk of hospital readmission after the birth hospitalization compared with all other NICU survivors. A study that assessed outcomes among all newborn infants discharged alive from 6 NICUs within a large managed care organization found that preterm infants of 33 to 36 weeks' gestation with a hospital stay of less than 4 days had higher hospital readmission rates than all other groups, including the most preterm group. The reason for readmission for the majority of these late-preterm infants was jaundice (71%), followed by suspected sepsis (20%) and feeding difficulties (16%).

Late-preterm infants who are discharged early (<2-night hospital stay) from the hospital after a vaginal delivery may be at increased risk of neonatal morbidity compared with term infants who are discharged early. A population-based study that compared rates of postdischarge neonatal morbidity between singleton late-preterm and term infants who were discharged early found that 4.3% and 2.7% of infants, respectively, were either readmitted or had an observational stay; 3.5% and 2.0%, respectively, were readmitted. Jaundice and infection accounted for 77.1% of readmissions among late-preterm infants and 60.3% of readmissions among term infants. In this study, breastfed late-preterm infants were 1.8 times more likely to require hospital-related care and 2.2 times more likely to be readmitted than breastfed term infants. In contrast, there was no difference in need for subsequent hospital-related care or readmission between nonbreastfed late-preterm and term infants.

Several factors have been identified to be associated with an increased risk of hospital readmission, an observational hospital stay, or severe morbidity among late-preterm infants. A population-based cohort study of healthy, singleton late-preterm infants delivered vaginally in Massachusetts hospitals between 1998 and 2002 found that 6.1% received hospital care after the birth hospitalization or died during the neonatal period. Risk factors for requiring hospital care or experiencing morbidity included being the first born, being breastfed at discharge, having a mother who had labor and delivery complications, being a recipient of public insurance at delivery, or being of Asian/Pacific Island descent.

Although it is known that late-preterm infants are at increased risk compared with term infants for infant mortality, morbidity during the initial birth hospitalization, and neonatal morbidity that requires hospital readmission, the long-term health consequences of being born late preterm are not yet known. Small clinical reports that compared late-preterm infants with term infants suggested a higher risk of cerebral palsy, speech disorders, neurodevelopmental handicaps, behavioral abnormalities, and competence (behavioral, scholastic, social, and global). Given that late-preterm infants are born before their nervous systems have fully developed, large population studies that evaluate long-term neurodevelopmental and behavioral outcomes of these children are needed.

The emotional, personal, and financial costs to individuals, family, and society associated with late-preterm births have not been sufficiently described. A conservative estimate for the long-term medical, educational, and productivity costs associated with the birth of all infants before 37 weeks' gestation is approximately $51,600 for each infant or a total cost of $26.2 billion in 2005 dollars. Individual late-preterm infants, on average, require fewer financial and other resources than infants who are born more preterm. However, the total resources and costs associated with late-preterm birth are likely to be a relatively substantial part of the total cost of all preterm births, because the population of late-preterm infants is significantly larger than the population of infants who are born before 34 weeks' gestation.

Collaborative counseling by neonatal and obstetric clinicians about fetal, neonatal, and maternal outcomes is warranted when maternal or fetal conditions indicate the necessity for late-preterm birth. The obstetric clinician can discuss the indications for the delivery and the risks inherent in delaying delivery. The neonatal clinician can provide the family with gestational age-specific outcome information and help prepare the family for the newborn infant's anticipated course in the nursery. Collaborative counseling allows the family to be fully informed and to participate in decision-making. Under emergent conditions, the time to provide such counseling may not exist.

**SUMMARY**

1. Late-preterm infants are immature.

a. Infants born at 34% through 36% weeks' gestation (239–259 days since the first day of the last
menstrual period) should be referred to as "late preterm."

b. Late-preterm infants are physiologically immature and have limited compensatory responses to the extrauterine environment compared with term infants.

2. Late-preterm infants are at a greater risk of morbidity and mortality than are term infants.
   
a. During the birth hospitalization, late-preterm infants are more likely than are term infants to be diagnosed with temperature instability, hypoglycemia, respiratory distress, apnea, jaundice, or feeding difficulties.
   
b. During the first month after birth, late-preterm infants are more likely than term infants to be rehospitalized for jaundice, feeding difficulties, dehydration, and suspected sepsis.

3. Risk factors that have been identified for rehospitalization or neonatal morbidity among late-preterm infants include being the first born, being breastfed at discharge, having a mother who had labor and delivery complications, being a recipient of public insurance at delivery, and being of Asian/Pacific Island descent.

4. Collaborative counseling by both obstetric and neonatal clinicians about the outcomes of late-preterm births is warranted unless precluded by emergent conditions.

Gaps in Knowledge, Clinical Implications, and Research Implications for Late-Preterm Births
The following are areas in which knowledge and research need to be expanded:

1. causes for delivery and short-term fetal, neonatal, and maternal outcomes;
2. developmental immaturity and mechanisms of disease in late-preterm infants;
3. identification tools, educational programs, and screening strategies to identify risk factors and prevent potential medical complications of late-preterm births;
4. recommendations for discharge, early follow-up evaluation, and treatment for jaundice, poor feeding, dehydration, and other complications in late-preterm infants; and
5. long-term medical, neurologic, and developmental outcomes for late-preterm infants.

Recommended Minimum Criteria for Discharge of Late-Preterm Infants
Discharge criteria for late-preterm infants have similarities to criteria developed for both high-risk infants and healthy term infants. Because late-preterm infants are at greater risk of neonatal morbidity and mortality than are term infants, parents of late-preterm infants may need special instruction and guidance before hospital discharge and closer follow-up after discharge. Late-preterm infants who have risk factors for morbidity that requires hospital care (i.e., hospital readmission), such as those who are breastfed or are first born, are most vulnerable. It is extremely important to educate first-time mothers of late-preterm infants how to evaluate feeding success and what signs to look for to detect dehydration and hyperbilirubinemia. In some circumstances, this education may require a longer hospitalization.

Recommended criteria for discharge of late-preterm infants are intended to reflect evidence of physiological maturity; feeding competency; thermoregulation; maternal education; assessment and planned interventions for medical, family, environmental, and social risk factors; and follow-up arrangements.

Minimum discharge criteria for late-preterm infants are as follows:

1. Accurate gestational age has been determined.
2. Timing of discharge is individualized and based on feeding competency, thermoregulation, and absence of medical illness and social risk factors (see below). Late-preterm Infants usually are not expected to meet the necessary competencies for discharge before 48 hours of birth.
3. A physician-directed source for continued medical care (i.e., medical home) has been identified, with a follow-up visit arranged for 24 to 48 hours after hospital discharge. Additional visits may be indicated until an established and maintained pattern of weight gain has been demonstrated.
4. Vital signs should be documented as being within reference ranges and stable for the 12 hours preceding discharge, including a respiratory rate of less than 60 breaths per minute, a heart rate of 100 to 160 beats per minute, and axillary temperature of 36.5 to 37.4°C (97.7–99.3°F) measured in an open crib with appropriate clothing.
5. At least 1 stool has been passed spontaneously.
6. Twenty-four hours of successful feeding, either at the breast or with a bottle, and the ability to coordinate sucking, swallowing, and breathing while feeding has been demonstrated. Any infant with a weight loss of more than 2% to 3% of birth weight per day or a maximum of 7% of birth weight during the birth hospitalization should be assessed for evidence of dehydration before discharge.
7. A formal evaluation of breastfeeding, including observation of position, latch, and milk transfer, has been undertaken and documented in the chart by trained caregivers at least twice daily after birth.
8. A feeding plan has been developed and is understood by the family.46

9. A risk assessment for the development of severe hyperbilirubinemia has been performed and appropriate follow-up has been arranged.48

10. Physical examinations of the infant reveal no abnormalities that require continued hospitalization.45

11. There is no evidence of active bleeding at the circumcision site for at least 2 hours.49

12. Maternal and infant test results are available and have been reviewed, including blood test results for maternal syphilis and hepatitis B surface-antigen status; cord or infant blood type and direct Coombs test results, as clinically indicated; and results of screenings performed in accordance with state regulations, including screening for HIV infection.45,92

13. Initial hepatitis B vaccine has been administered or an appointment has been scheduled for its administration, and the importance of immunizations has been stressed.45

14. Metabolic and genetic screenings have been performed in accordance with state requirements. If a newborn screening is performed before 24 hours of milk feeding, a system for repeating the screening must be in place in accordance with state policy.45

15. A car safety seat study completed by a trained professional to observe for apnea, bradycardia, or oxygen desaturation has been passed.45

16. Hearing assessment has been performed and the results have been documented in the medical chart. Results have been discussed with family or caregivers. If follow-up is needed, follow-up plans have been outlined.45

17. Family, environmental, and social risk factors have been assessed. When risk factors are identified, the discharge should be delayed until they are resolved or a plan to safeguard the infant is in place. Such risk factors may include but are not limited to:

a. untreated parental substance use or positive toxicology test results in the mother or newborn infant;

b. history of child abuse or neglect;

c. mental illness in a parent in the home;

d. lack of social support, particularly for single, first-time mothers;

e. homelessness, particularly during this pregnancy;

f. ongoing or established risk of domestic violence; or

g. adolescent mother, particularly if other risk factors are present.45

18. The mother and caregivers have received information or training or have demonstrated competency in the following:

a. infant’s hospital course and current condition;

b. expected pattern of urine and stool frequency for the breastfeeding or formula-fed neonate (verbal and written instruction is recommended);

c. umbilical cord, skin, and newborn genital care;

d. hand hygiene, especially as a means to reduce the risk of infection;

e. use of a thermometer to assess an infant’s axillary temperature;

f. assessment and provision of appropriate layers of clothing;

g. identification of common signs and symptoms of illness, such as hyperbilirubinemia, sepsis, and dehydration;

h. assessment for jaundice;

i. provision of a safe sleep environment, including positioning the infant on his or her back during sleep46;

j. newborn safety issues including car safety seat use, need for smoke/fire alarms, and hazards of secondhand tobacco smoke and environmental pollutants;

k. appropriate responses to a complication or an emergency; and

l. sibling interactions and appropriate inclusion in care responsibilities.

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Delivery Room Quick Tidbits

How to respond to calls:

NICU Call: “We need a Standard Pediatric Delivery Team to OR C for a routine scheduled C-Section.”

Wait for Hospitalist and Team Leader to respond first, then you should respond.

Intern: (press ASCOM Phone to talk) “Intern responding and going to delivery.”

What to wear:

<table>
<thead>
<tr>
<th>Vaginal Delivery</th>
<th>C-Section Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Yellow Gown (non-sterile)</td>
<td>• Mask and Hat (Put on BEFORE scrubbing in)... Must have before entering any C-section room!</td>
</tr>
<tr>
<td>• Gloves (non-sterile)</td>
<td>• Blue gown (sterile)</td>
</tr>
<tr>
<td></td>
<td>• Gloves (sterile)</td>
</tr>
</tbody>
</table>

Preparing for C-Section Delivery:

1. First put on Hat, Mask
2. Scrub in at OR station (May use air-drying gel if already performed full scrub earlier in day).
3. After scrubbing in, enter into OR room and introduce yourself aloud for everybody to hear, “I’m Dr. Jun, Pediatric intern.”
4. If you used the air-drying gel, NO need to towel off. If you scrubbed with water/soap, dry off with the sterile towel located with your sterile gown.
5. Put on the sterile gown first, then put on the sterile gloves. (Another team member will ask you for your glove size and will open up the glove package for you. However, you put on the gloves by yourself without scrub nurse helping).
6. DON’T touch the scrub nurse’s sterile field! Scrub nurse will hand you the sterile blanket to catch the baby. (Some scrub nurses are quite particular and won’t hand over the blanket until just before the baby is to be delivered.)
7. Stand aside...
8. When uterine incision called, that’s the best time to open the blanket up in preparation to catch the infant.
9. When baby delivered, come close to the OB and receive the baby in blanket, then take baby quickly to the radiant warmer.
10. When baby’s body fully delivered, also announce that baby has been delivered to the NICU RN so that he/she can start the APGAR timer.

Residents are expected to take the lead in the delivery room when appropriate, with supervision and guidance provided as needed.
## Standard vs. Complex Delivery Team

<table>
<thead>
<tr>
<th>Standard Team</th>
<th>Complex Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalist or Neonatal Nurse Practitioner</td>
<td>Fellow</td>
</tr>
<tr>
<td>NICU Team Leader Nurse</td>
<td>Hospitalist or Neonatal Nurse Practitioner</td>
</tr>
<tr>
<td>Residents/Students</td>
<td>NICU Team Leader Nurse</td>
</tr>
<tr>
<td></td>
<td>Residents/Students</td>
</tr>
<tr>
<td></td>
<td>Respiratory Therapist</td>
</tr>
<tr>
<td>&gt;32 weeks</td>
<td>&lt; 32 weeks</td>
</tr>
<tr>
<td>IUGR, chorio, minor anomalies (cleft palate), meconium</td>
<td>Major congenital anomalies</td>
</tr>
<tr>
<td>Delivery of multiples, vacuum/forceps, suspected shoulder dystocia (FHR category I or II)</td>
<td>Emergent cesarean/instrument delivery for abnormal FHR (category “2.9” or III)</td>
</tr>
<tr>
<td>Maternal condition that is not affecting fetus</td>
<td>Infant code/intubation likely</td>
</tr>
<tr>
<td>Infant delivered with one minute Apgar &lt;7 but &gt;4</td>
<td>Infant delivered with one minute Apgar &lt;5</td>
</tr>
</tbody>
</table>

### LABOR AND DELIVERY WHITE BOARD SYMBOL LEGEND

- red square = delivered
- red circle = actively pushing
- blue square = general medical issue
- blue circle = epidural consult
- blue star = Magnesium
- green square = meconium
- black square = premature
- leaf = intrauterine fetal demise
- sunflower = vaginal temperature study
<table>
<thead>
<tr>
<th></th>
<th>40 ml</th>
<th>30 ml</th>
<th>20 ml</th>
<th>10 ml</th>
<th>5 ml</th>
<th>10 ml Saline IV Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-4 ml</td>
<td>0.2-0.4 mg</td>
<td>0.3-0.5 mg</td>
<td>0.1-0.2 mg</td>
<td>0.05-0.1 mg</td>
<td>0.025-0.05 mg</td>
<td>(1:10,000-0.1 mg/ml)</td>
</tr>
<tr>
<td>Volume: 1.5-3 ml</td>
<td>Volume: 1-2 ml</td>
<td>Volume: 0.5-1 ml</td>
<td>Volume: 0.2-0.5 ml</td>
<td>Volume:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.04-0.12 mg</td>
<td>0.03-0.09 mg</td>
<td>0.02-0.06 mg</td>
<td>0.01-0.03 mg</td>
<td>0.005-0.015 mg</td>
<td>(1:10,000-0.1 mg/ml)</td>
<td></td>
</tr>
<tr>
<td>Volume: 0.4-1.2 ml</td>
<td>Volume: 0.3-0.9 ml</td>
<td>Volume: 0.2-0.5 ml</td>
<td>Volume: 0.1-0.3 ml</td>
<td>Volume: 0.06-0.15 ml</td>
<td>0.01-0.03 mg/kg</td>
<td></td>
</tr>
</tbody>
</table>

| 4 kg | 3 kg | 2 kg | 1 kg | 0.5 kg | 0.1-0.3 mg/kg |

**Neonatal NRP Medications**
The Delivery Room

I. Which Deliveries Do We Attend?

A. All high-risk pregnancies (e.g., preterm deliveries, meconium-stained amniotic fluid, or cesarean sections).
B. Instrumented deliveries (e.g., forceps, vacuum).
C. Abnormal presentations (e.g., breech).
D. Polyhydramnios or oligohydramnios.
E. Multiple gestation.
F. Suspected maternal infections (e.g., chorioamnionitis).
G. Prenatal diagnosis of congenital anomalies (e.g., cardiac, gastrointestinal).
H. Mothers receiving sedatives or other types of medication (e.g., anti-epileptics, heroin, methadone, cocaine, amphetamines, magnesium).
I. Fetal distress (e.g., meconium, decelerations, abnormal non-stress test, tachycardia, Category 2 or Category 3 fetal strips).
J. Postmaturity (>42 wks).
K. Intrauterine growth restriction (IUGR).
L. Maternal bleeding (e.g., placenta previa, abruption).

II. Delivery Room Preparation and Resuscitation

A. Delivery Room Team:
   Our “Standard” Delivery Room team is comprised of at least one MD/NNP and at least one RN. Our “Standard” Delivery Room team will attend most of the “high-risk” deliveries (as noted above) for which a Pediatric team is called. However, there may be certain situations where a “Complex” Delivery Room team will be called instead - (including preterm infants <32 weeks, infants with complex congenital anomalies, situations where there is a Category 3 fetal heart tracing, or for deliveries where extensive resuscitation may be required). Our “Complex” Delivery Room team is comprised of at least two MD/NNPs, at least one RN, and at least one Respiratory Therapist.

   If, at any time, you are in the Delivery Room and realize that more support would be helpful, make sure to relay that request to the NICU and ask for a full “Complex” Delivery Room team to be mobilized, and/or specify who else (e.g. Fellow, Attending Neonatologist) or what else (e.g. Tackle Box or other NICU supplies) is needed.

B. Introduction into the Delivery Room.
   When entering the Delivery Room always make sure to introduce yourself. When going to a delivery in the labor rooms, a cover gown can prevent unnecessary soilage. For entry to the C-section suites, one is required to wear scrubs, a hat and mask. Once you have introduced yourself, inquire about the gestational age of the infant (term or preterm), the number of infants being delivered, the presence of meconium, and any other pertinent information. In the surgical suites used for C-sections, you will find a sterile gown, gloves, and blanket waiting on a table next to the radiant warmer. If you will be “catching” the infant, these need to be donned in a timely manner. Attending deliveries in the labor rooms and surgical suites requires knowledge of the location of the resuscitation tray. It is usually on the silver table next to the radiant warmer in the surgical suites or in the bottom drawer underneath the infant resuscitation bed in the labor rooms.

C. Preparing your equipment
   1. Make sure the radiant warmer is on, the heat is turned up to maximum, and warm blankets are available.
   2. Check the suction set-up.
   3. Check the oxygen source and make sure there is adequate flow to the anesthesia bag or T-piece (8-10 lpm).
4. To prepare the T-piece, adjust the gas supply to desired flow rate between 8-10 lpm. Check maximum pressure by occluding the PEEP cap and turning PIP control fully clockwise (the maximum pressure should be 30 cm H2O). Set the PIP by occluding the PEEP cap and simultaneously turning the PIP control knob counter-clockwise until the desired PIP is set (start at 20 cm H2O). Set the PEEP by adjusting the knob on the PEEP cap to the desired PEEP level (start at 5 cm H2O).

5. Check to ensure you have the proper size mask.

6. Check the laryngoscope light and ascertain that proper size blades (#0 or #1 for term infants and #0 or #00 for preemies) are available.

7. Set the correct size endotracheal tube (i.e., 3.5 for term or weight >2 kg, 3.0 for preemies >1 kg, 2.5 for preemies <1 kg, 2.0 for preemies <500 gm) and an end-tidal CO2 detector (pedicap) if available.

8. If attending a meconium delivery, set out the meconium aspirator.

9. If you anticipate that the infant will need resuscitation, PPV, or oxygen supplementation, set out the pulse oximetry probe. Check to ensure you have the proper size probe.

10. If attending the delivery of an infant <35 weeks, take a warming mattress with you. If attending the delivery of an infant <30 wks, take a NeoWrap and thermal cap with you. Prior to the delivery, prepare the warming mattress and place it on the radiant warmer. Next, lay a blanket out on top of the warming mattress and then the NeoWrap flat on top of that.

11. If you anticipate that the infant will be admitted to the NICU, check to see if a battery pack is present on the bottom of the radiant warmer. If one is not present, ask the L&D nurse/tech to see if there is time to bring a radiant warmer with a battery pack to the room.

12. For potential codes, set up an umbilical vein catheter, flush solution, epinephrine, and have the NICU code “tackle box” (which can be brought over from the NICU) and/or crash cart readily accessible. There should be Neonatal Resuscitation Carts available in the main L&D hallway as well as in the C-section suite area. Try to familiarize yourself with the contents and location of the Neonatal Resuscitation Carts prior to the delivery.

13. At the time of delivery, look for nuchal cord, amount of maternal bleeding, degree of placental transfusion, and meconium. Note type of delivery (e.g., NSVD, vacuum-assist, forceps, C-section).

D. Once the infant is born

1. Start the Apgar timer.

2. Place the infant on the radiant warmer with the head towards the end of the bed. If the Infant is <30 wks, immediately place directly in the center of the NeoWrap. Fold the NeoWrap over the infant, covering the entire body except for the infant’s head. It is not necessary to dry the infant prior to using the NeoWrap.

3. It is not necessary to suction all infants, only those who demonstrate respiratory distress or if there is evidence of obstruction.

4. If the infant has meconium prior to or at delivery, see section V-A on “Meconium Staining”.

5. Dry the infant (unless NeoWrap used), especially the head and face, which represent 20% of body surface area. Remove wet blankets as able. Cover the head with a warm cap. (Use the special thermal cap if infant <30 weeks).

6. If resuscitation is anticipated, PPV is required, supplemental oxygen is administered, or persistent cyanosis is present, then place the pulse oximetry probe on the infant as soon as possible. The probe should be attached to the infant before connecting the probe to the monitor. Make sure to place the probe on the right hand in order to obtain a pre-ductal O2 saturation level. When placing the probe, make sure to line up the emitter and detector so that they are directly opposite each other.

7. If the infant has a heart rate <100 and/or has little or no respiratory effort after warming, drying, and stimulation, initiate bag-mask ventilation. In most cases, proper bag-mask ventilation is just as effective as being intubated and will allow you time to stabilize the infant before intubating.

8. The T-piece can be used to give blow-by oxygen, CPAP, and mask or endotracheal tube ventilation.

9. For infants born at term, you may use supplemental oxygen (start at 21%, the concentration can be adjusted between room air and 100% with the oxygen blender) if the infant is cyanotic or when positive-pressure ventilation is required.

10. For preterm infants <35 wks, use an oxygen blender and pulse oximeter during resuscitation. If positive-pressure ventilation is required, you may begin with oxygen concentration at 40% and then
adjust the oxygen concentration (between room air and 100%) as needed to achieve the desired clinical response. If the infant’s heart rate does not respond by increasing rapidly to >100, you may increase the oxygen concentration as necessary up to 100%.

11. If endotracheal (ET) intubation is required for resuscitation (except in the case of suctioning meconium), use an end-tidal CO₂ detector to confirm ET tube placement, if available.

12. If epinephrine is required during the resuscitation, use recommended dosing and concentration for the route available.
   a. IV: 0.1 to 0.3 ml/kg of 1:10,000 solution
      1) Draw up in 1 ml syringe
      2) Recommended route
   b. ET: 0.5 to 1 ml/kg of 1:10,000 solution
      1) Draw up in 3 ml or 6 ml syringe
      2) Consider ET route ONLY while IV access is being obtained

13. Determine the Apgar scores as outlined in Section III.D below “APGAR Scoring System”. Check the heart rate by auscultation or by palpating the umbilical stump. Continue to check the Apgar scores every 5 min until the score is 7 or greater.

14. If you arrive at the delivery room after the infant is greater than 1 min of age, the OB team is responsible for assigning the 1 min Apgar score.

III. Other Resuscitation Information

A. Review your Neonatal Resuscitation Program (NRP) booklet, and attend a Center for Advanced Pediatric and Perinatal Education (CAPE) simulation-based NRP class.

B. Clinical judgement:
   1. When assessing the newborn, do not let the Apgar score dictate disposition or appropriate resuscitative management.
   2. If you have doubt about a baby’s stability, consider admitting the baby to the NICU or PICN for further observation and management.

C. Always explain to the parents what you are doing and allow them to see their baby as soon as possible. Sometimes it is helpful to have the father or significant other follow you back to the unit.

D. APGAR Scoring System: Provides a standard for describing the condition of infants at birth. Five objective signs are evaluated and each given a score of 0, 1, or 2. The sum of the 5 scores is the Apgar score.

<table>
<thead>
<tr>
<th>Sign</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color (Appearance)</strong></td>
<td>Blue or pale</td>
<td>Pink body, blue extremities</td>
<td>All pink</td>
</tr>
<tr>
<td>Heart rate (Pulse)</td>
<td>Absent</td>
<td>&lt;100 bpm</td>
<td>&gt;100 bpm</td>
</tr>
<tr>
<td>Reflex irritability (Grимасе)</td>
<td>No response</td>
<td>Grimace</td>
<td>Cough or sneeze</td>
</tr>
<tr>
<td>Muscle tone (Activity)</td>
<td>Limp</td>
<td>Some flexion of extremities</td>
<td>Active movements</td>
</tr>
<tr>
<td>Respiration</td>
<td>Absent</td>
<td>Slow, irregular</td>
<td>Good, crying</td>
</tr>
</tbody>
</table>

The 1- and 5-minute Apgar scores correlate best with survival. The 10- and 20-minute Apgar scores prognosticate neurologic damage at 1 yr of age.

IV. Admission from the Delivery Room

A. Admissions to the NICU or Packard Intermediate Care Nursery include but are not limited to:
   1. Premature infants born at <35 wks gestation.
   2. Term infants with respiratory distress not responsive to delivery room interventions.
   3. Term infants with hemodynamic instability.
4. Infants at risk for sepsis (e.g., mother diagnosed with chorioamnionitis or preterm premature rupture of membranes/PPROM) will need a full sepsis work-up including antibiotics and will need to be admitted to the NICU or PICN.
5. Infants with significant congenital anomalies.
6. All infants with known congenital heart disease.

B. For all infants admitted to the NICU from the Delivery Room, remember to try to conduct a post-delivery debriefing with the other team members in attendance and make sure to have one of the team members complete and fill out a Delivery Room Checklist.

V. Special Delivery Room Circumstances

A. Meconium Staining
1. It is no longer necessary for the OB team to suction the mouth and nares at delivery.
2. If the infant is vigorous and the heart rate is >100, warm, dry, and stimulate the infant and proceed with routine resuscitation.
3. If the infant is not vigorous at delivery (i.e., heart rate <100 and/or depressed muscle tone and/or depressed respirations) intubate immediately and suction the airway for meconium using a meconium aspirator. If necessary, provide positive pressure ventilation with 100% oxygen in between suction passes. If unable to intubate within 20 sec, stop and ventilate with bag and mask until the heart rate is >100, then intubate.
4. If meconium is found below the cords, continue suctioning until the meconium is cleared from the airway. Please note that NRP guidelines recommend use of a meconium aspirator. However, if the infant is difficult to intubate or is severely depressed it may be beneficial to keep the infant intubated and suctioned with a catheter.
5. If the heart rate slows or becomes irregular, provide CPAP or positive pressure ventilation until the heart rate stabilizes.
6. Always keep the infant warm and dry, changing out the wet blankets frequently; continue to provide free-flow oxygen between suctioning passes.
7. If you have any doubts about the baby's status, take him or her back to the NICU for observation.

B. Congenital Diaphragmatic Hernia
1. Intubate infant as soon as possible after delivery to avoid excessive air entry into GI tract.
2. Place orogastric tube to aid in gastric decompression.

C. Spinal Cord Defects (Myelomeningocele)
1. Keep infant in side-lying or prone position if possible during resuscitation (to keep patient off defect).
2. Place warm saline-soaked gauze/Kerlix™ directly over the defect and then wrap with plastic/Saran™
   Wrap circumferentially around defect and infant's abdomen.

D. Abdominal Wall Defects (Gastrochisis/Omphalocle)
1. Open “turkey bag” in sterile fashion and place on radiant warmer.
2. Upon delivery, place infant in “turkey bag” and cinch bag under infant’s armpits.
3. Resuscitate per NRP protocol. May need to consider intravenous or intraosseous line as route for medication/fluid administration if needed (as umbilical cord will be inaccessible).
## APPENDIX: Summary of Delivery Room Guidelines (posted in each Delivery Room)

<table>
<thead>
<tr>
<th>GA &lt;38 Weeks</th>
<th>GA 38-35 Weeks</th>
<th>GA ≥35 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Delivery Briefing</strong></td>
<td><strong>Pre-Delivery Briefing</strong></td>
<td><strong>Pre-Delivery Briefing (if indicated)</strong></td>
</tr>
<tr>
<td>Warmer on, Heat 100%</td>
<td>Warmer on, Heat 100%</td>
<td>Warmer on, Heat 100%</td>
</tr>
<tr>
<td>FiO₂ 40%</td>
<td>FiO₂ 40%</td>
<td>FiO₂ 21%</td>
</tr>
<tr>
<td>T-piece 20/5</td>
<td>T-piece 20/5</td>
<td>T-piece 20/5</td>
</tr>
<tr>
<td>Flow 8-10</td>
<td>Flow 8-10</td>
<td>Flow 8-10</td>
</tr>
<tr>
<td>Suction 80 mm Hg</td>
<td>Suction 80 mm Hg</td>
<td>Suction 80 mm Hg</td>
</tr>
<tr>
<td>Set Up Intubation</td>
<td>Set Up Intubation (if indicated)</td>
<td>Set Up Intubation (if indicated)</td>
</tr>
<tr>
<td>Neowrap</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Chemical warmer</td>
<td>Chemical warmer</td>
<td>---</td>
</tr>
<tr>
<td>Thermal cap</td>
<td>Normal hat</td>
<td>Normal hat</td>
</tr>
<tr>
<td>Pulse ox by 1 min (Consider &lt;1kg probe)</td>
<td>Pulse ox by 1 min (Standard &lt;3kg probe)</td>
<td>Pulse ox by 1 min (if indicated) (Standard &lt;3kg or 3-20 kg probe)</td>
</tr>
<tr>
<td>Axillary Temp at 5 min</td>
<td>Axillary Temp at 5 min</td>
<td>Axillary Temp at 5 min (if admit)</td>
</tr>
<tr>
<td>Post-Delivery Debriefing</td>
<td>Post-Delivery Debriefing</td>
<td>Post-Delivery Debriefing (if admit)</td>
</tr>
<tr>
<td>Delivery Room Checklist</td>
<td>Delivery Room Checklist</td>
<td>Delivery Room Checklist (if admit)</td>
</tr>
</tbody>
</table>

### Indications for placing pulse oximetry (only 1 criteria needs to be met)

1) Anticipation of advanced resuscitation  
2) Administration of PPV or Supplementary O₂  
3) Persistent cyanosis

### Pulse ox probe placement: Right Hand (preductal)

1) Clean skin well (vernix, etc. can cause interference)  
2) Attach probe on baby before connecting to monitor  
   - Sensor should be placed on lateral side (between 4th/5th digits)  
   - Emitter (with light) on palmar surface / Detector on back of hand  
   - Emitter and detector must be directly opposite each other  
3) May apply posey around probe after probe placement

### Normal SpO₂ saturations

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>SpO₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 min</td>
<td>60-65%</td>
</tr>
<tr>
<td>2 min</td>
<td>65-70%</td>
</tr>
<tr>
<td>3 min</td>
<td>70-75%</td>
</tr>
<tr>
<td>4 min</td>
<td>75-80%</td>
</tr>
<tr>
<td>5 min</td>
<td>80-85%</td>
</tr>
<tr>
<td>10 min</td>
<td>85-95%</td>
</tr>
</tbody>
</table>
Endotracheal Intubation

Purpose: To provide airway and ventilatory support to a compromised newborn.

I. Indications: Endotracheal intubation is performed to provide mechanical respiratory support, to obtain aspirates for culture, to provide pulmonary toilet, to alleviate subglottic stenosis or to clear the trachea of meconium.

II. Equipment
   A. Endotracheal tube
      1. <1000 gm: 2.5
      2. 1000-2000 gm: 3.0
      3. 2000-3000 gm: 3.5
      4. >3000 gm: 4.0
   B. Pediatric laryngoscope handle with blade
      1. #00 Miller blade for infant <1 kg
      2. #0 Miller blade for infants <3 kg
      3. #1 Miller blade for infants >3 kg
   C. Bag-and-mask apparatus
   D. Oxygen source
   E. Suction apparatus
   F. Tape, scissors
   G. Stylet (optional)
   H. Gloves

III. Precautions
   A. Ventilate by bag-mask prior to attempt to avoid hypoxia and bradycardia.
   B. Interrupt an unsuccessful attempt before compromising the patient.
   C. Allow recovery between attempts.
   D. Avoid pushing tube against any obstruction.

IV. Procedure
   A. The endotracheal tube should be precut to eliminate some dead space. Some tubes are marked “oral” or “nasal” and should be cut appropriately.
   B. Be certain that the light source on the laryngoscope is working before beginning the procedure. A bag-and-mask apparatus with 100% oxygen should be available at the bedside. Place the stylet (if used) in the endotracheal tube (flexible stylets are optional but may help guide the tube into position more efficiently.)
   C. Place the infant in the “sniffing position” (with the neck slightly extended). Hyperextension of the neck in infants may cause the trachea to collapse.
   D. Suction the trachea as needed to clear the oropharynx and make the landmarks clearly visible.
   E. Monitor the infant’s heart rate and color.
   F. Hold the laryngoscope with the left hand. Insert the scope into the right side of the mouth, and sweep the tongue to the left side.
   G. Advance the blade a few millimeters, passing it beneath the epiglottis.
   H. Lift the blade vertically to elevate the epiglottis and visualize the glottis. Remember, the purpose of the laryngoscope is to vertically lift the epiglottis, not to pry it open.
   I. To better visualize the vocal cords, gentle external pressure can be placed on the thyroid cartilage by an assistant.
   J. Pass the endotracheal tube along the right side of the mouth and down through the vocal cords during inspiration. It is best to advance the tube only 2-2.5 cm into the trachea to avoid placement in the right
mainstem bronchus. The rule of thumb is 6 + weight in kg (secure 7 cm at the lip in a 1 kg infant, 8 cm in a 2 kg infant or 9 cm in a 3 kg infant). The stylet should be gently removed while the tube is held in position.

K. Confirm the positioning of the tube. The resuscitation bag is attached to the tube, and an assistant provides mechanical breaths while the leader listens for equal breath sounds on both sides of the chest. Auscultate the stomach to be certain that the esophagus was not inadvertently entered.

L. Tape the tube securely in place.

M. Obtain a chest x-ray film to confirm proper placement of the tube.

V. Complications

A. Tracheal perforation is a rare complication requiring surgical intervention. It can be prevented by careful use of the laryngoscope and endotracheal tube.

B. Esophageal perforation is usually caused by traumatic intubation. Treatment depends on the degree of perforation. Most injuries can be managed by use of parenteral nutrition until the leak seals, use of broad-spectrum antibiotics, and observation for signs of infection. A barium swallow contrast study may be necessary after several weeks to evaluate healing or rule out stricture formation.

C. Laryngeal edema is usually seen after extubation and may cause respiratory distress.

D. Palatal grooves are usually seen in cases of long-term intubation and will resolve with time.

E. Subglottic stenosis is most often associated with long-term endotracheal intubation (3-4 wks).
Formula Selection, Description, and Indications

I. Milk Types

A. Mother's milk
   1. Nutrients are readily absorbed.
   2. Anti-infective factors present.
   3. Nutrient composition is unique.
   4. With the addition of human milk fortifier, can meet growth needs of pre-term infants.

B. Banked donor milk
   1. For use with high-risk VLBW infants only when mom is unable or unwilling to provide sufficient breast milk.
   2. Must obtain parental/guardian consent.
   3. Slight nutrient degradation due to the pasteurization and freezing process.
   4. Maintains immune-enhancing properties unable to be duplicated in formula.

II. Formula Types

The AAP recommends all infants who are not breast-fed be given iron-fortified formula.

A. Cow's milk based
   1. Term: (e.g., Enfamil Lipil®, Similac Advance®, Early Shield™, Nestlé Good Start® Supreme) for infants with birthweight >2 kg and gestational age >36 wks.
   2. Pre-term: (e.g., Premature Enfamil®, Similac Special Care®) for infants with birth weight <2 kg and gestational age <34 wks—higher in calcium, phosphorus, and protein.
   3. Transitional: (e.g., Similac Neosure®, Enfamil Enfamil®) for pre-terms once they are >1.8 kg AND adjusted age is 36 wks AND Alk Phos (alkaline phosphatase) is within normal limits. Could use in babies with birthweight of 2 kg and gestational age of 34-35 wks.  

B. Soy protein based: (e.g., Enfamil Prosobee®, Similac Isomil® or Nestlé Good Start® Supreme Soy)
   1. Do NOT use in pre-term infants.
   2. Not always appropriate when infant shows an allergy to milk products.
   3. Likely indicated in infants with galactosemia.

C. Partially hydrolyzed proteins (e.g., Similac Alimentum®, Enfamil Nutramigen®, Enfamil Pregestimil®)
   1. In a setting of compromised GI tract, cow's milk protein allergy or malabsorption.

D. Free amino acid (e.g., Neocate®, Elecare®, Enfamil Nutramigen® AA™)
   1. If infant does not tolerate partially hydrolyzed protein formula, and/or shows multiple protein sensitivities/intolerance.

E. Low-fat formulas (e.g., Portagen, Monogen)
   1. For Chylothorax or Liver failure

<table>
<thead>
<tr>
<th>Formula Type</th>
<th>Product Names</th>
<th>Protein Source</th>
<th>Fat Source</th>
<th>Carbohydrate Source</th>
<th>Other info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow's Milk-based Term</td>
<td>Enfamil Lipil®, Similac Advance® with Early Shield™, Nestlé Good Start® Supreme</td>
<td>Non-fat milk, whey</td>
<td>Vegetable oils</td>
<td>Lactose</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow's Milk-based Pre-term</td>
<td>Enfamil Preemie Lipil®, Similac Special Care Advance®</td>
<td>Whey protein concentrate, non-fat Milk</td>
<td>MCT oil; soy, coconut or sunflower/safflower oils; DHA and ARA</td>
<td>Corn syrup solids, lactose</td>
<td>Similac Special Care® available in high protein 24 cal/oz and in a 30 cal/oz form</td>
</tr>
<tr>
<td>Category</td>
<td>Product</td>
<td>Protein Composition</td>
<td>Fat Source</td>
<td>Carbohydrate Source</td>
<td>Other Components</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Transitional</td>
<td>Similac Neosure® Advance, Enfamil Enfamil Enfamil Lipil®</td>
<td>50:50 whey:casein</td>
<td>Lower vegetable oils, added MCT oil, added DHA, and ARA</td>
<td>50% lactose, 50% glucose polymers</td>
<td>Protein and minerals in greater concentration than standard term formula</td>
</tr>
<tr>
<td>Soy-based</td>
<td>Prosobee®, Similac Isomil®, Nestlé Good Start® Essentials</td>
<td>Soy protein isolate with added methionine</td>
<td>Soy and coconut oils</td>
<td>Glucose polymers, sucrose, lactose free</td>
<td></td>
</tr>
<tr>
<td>Partially hydrolyzed proteins</td>
<td>Enfamil Nutramigen®, Enfamil Pregestimil®, Similac Alimentum®</td>
<td>Hydrolyzed casein with added amino acids</td>
<td>Pregestimil® 55% MCT oil, 45% veg oil Alimentum®: 30% MCT oil Nutramigen®: 5% MCT oil</td>
<td>Glucose polymers; lactose free</td>
<td></td>
</tr>
<tr>
<td>Free amino acid</td>
<td>Neocate®, Elecare®, Enfamil Nutramigen® AA™</td>
<td>L-Amino Acids</td>
<td>Soy, safflower, coconut, and MCT oils (Elecare®: 33% of fat from MCT)</td>
<td>Corn syrup Solids</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Portagen®, Monogen®</td>
<td>Sodium caseinate</td>
<td>MCT oil (Portagen® = 87%; Monogen® = 90%), corn oils</td>
<td>Corn syrup solids, sugar</td>
<td>Standard mix is 30 kcal/oz When ordering for infant, must specify 20 kcal/oz Monogen® contains trace elements and a more complete essential fatty acid profile</td>
</tr>
</tbody>
</table>
Enteral Feeding

I. Introduction
A. Nutritional goals for the premature
   1. Simulate intrauterine growth
      a. Weight 1-2% of body weight/day
      b. OFC 0.5-1.0 cm/wk
      c. Length 1-1.5 cm/wk
   2. Stimulate fetal intestinal function
      a. Fetal gut absorbs 500 ml of amniotic fluid/day near term
      b. Have a direct trophic effect on its development and integrity
   3. Avoid complications of TPN
B. When to start?
   As soon as there are no contra-indications, such as:
   1. Hemodynamic instability:
      a. Volume resuscitation
      b. Dopamine >5 mcg/kg/min
      c. Initiation of hydrocortisone (can feed if stable on weaning doses)
      d. Significant PDA or ≤48 hrs after closure with indomethacin
      e. Surgery within ≤48 hrs
   2. Abnormal abdomen:
      a. Distention, discoloration, “surgical” abdomen
      b. Suspected GI anomaly
      c. Large volume, bloody or bilious gastric residuals
   3. Perinatal depression (e.g., low Apgars, metabolic acidosis, HIE) requires individualized clinical evaluation
   4. Pulmonary instability, e.g.:
      a. Impending ECMO
      b. Significant hypoxemic episodes
      c. Mechanical ventilation and/or UAC are not per se contraindications
   5. Fluid and electrolyte instability needs to be assessed individually:
      a. Hypoglycemia
      b. Hyponatremia
      c. Hypocalcemia

II. What to Feed
A. Maternal milk (MM): Every effort should be made before and after delivery to encourage maternal pumping (unless there is a documented medical contraindication).
   1. The volume of expressed milk at 2 wks post-partum usually is predictive of successful lactation; this should be ≥500 ml/day.
   2. Lactation Services are available to consult and assist our mothers. Early intervention is best.
B. Donor milk
   1. For VLBW infants at risk for NEC, Human Donor Milk (DM) from the Milk Bank is available to supplement the maternal supply. Milk donors are screened like blood donors, but additionally may not smoke nor be on medications. DM is Holder Pasteurized, which destroys bacteria and known viruses such as CMV and HIV.
C. Advantages (immunological)
   1. Lactoferrin limits availability of iron to pathogenic bacteria.
   2. Secretory IgA - mucosal antibodies against specific pathogens.
   3. Lysosome - a nonspecific protective factor in breast milk thought to influence flora of intestinal tract through cell wall lysis.
4. Human milk contains a specific factor encouraging the growth of benign organisms like Lactobacillus bifidus.

5. Presence of numerous hormones and growth factors including epidermal growth factor.

6. Pasteurization does kill the white cells in DM and thus, it is not as good as fresh MM. However, many other factors are preserved (see Table 1 below), and freeze/thawing damages MM, too. Both sources of human milk are superior to formula in preventing NEC and nosocomial infections, and enhancing immunity.

D. Limitations

1. Additional calcium and phosphorus are necessary to meet premature infant’s needs.

2. VLBW infants will also require protein and sodium supplementation.

3. Human milk has a range of caloric content and it is occasionally inadequate to support adequate weight gain by itself. Of note, DM from the Milk Bank is pooled so that the caloric content is fairly constant, and no recipient is at risk of getting low-calorie milk from an “outlier” donor.

4. Maternal milk can be a source of infection if not collected carefully. MM may transmit viruses such as CMV even after freezing.

E. "Fortifying" human milk

Human Milk Fortifiers (HMF) or formula can be added to breast milk to increase caloric density, protein, and electrolyte content. These should not be added until the baby has demonstrated both tolerance of full-volume feeds and the need for fortification, either by slow weight gain, hypoalbuminemia or evidence of inadequate mineral intake (e.g., very high alkaline phosphatase). For stable preemies who can tolerate the volume, increasing the feedings to 180 mL/kg/day or more may be adequate. HMF provides more calcium and phosphorus, but may not be available after discharge, thus we usually switch to powdered formula before discharge when fortification is still needed.

1. Human Milk Fortifier (HMF)
   a. 2 packet per 100 mL human milk = 22 kcal/oz (half strength)
   b. 4 packet per 100 mL human milk = 24 kcal/oz (full strength)
   c. 6 packet per 100 mL human milk = 26 kcal/oz

2. Formula Powder with MM/DM (presumed to be 20 cal/oz), e.g., NeoSure®, Enfamil®, EnfaCare®
   Similac®, Portagen®, Pregestimil®
   a. 1/2 tsp per 100 mL human milk = 22 kcal/oz
   b. 1 tsp per 100 mL human milk = 24 kcal/oz
   c. 1 1/2 tsp per 100 mL human milk = 26 kcal/oz
   d. 2 tsp per 100 mL human milk = 28 kcal/oz
   e. 3 tsp per 100 mL human milk = 30 kcal/oz

3. Liquid Formula with MM/DM -- there are concerns about sterility with powdered formulas. Liquid formulas may be easier for mixing. Mixing human milk with liquid formula decreases the amount of human milk consumed, and can be used to extend supplies if maternal production is limited. Similac Special Care® (SSC®) is designed for this purpose. This provides additional Ca and Phos as well as calories.
   a. Human Milk: SSC®@ 2:1 = 23 kcal/oz
   b. Human Milk: SSC®@ 1:1 = 25 kcal/oz

4. Protein – BeneProtein® [protein powder] 1.5 gm (6 kcal) per 1 teaspoon.

5. Fat – very concentrated caloric source, though not optimum nutrition and large doses can cause loose stools.
   a. MCT oil (medium-chain triglycerides) – 7.6 kcal/mL readily absorbed
   b. MicroLipid – 4.5 kcal/mL includes essential long-chain fatty acids

F. Formula feedings

On (hopefully) rare occasions, mothers may not provide their own milk and refuse donor milk. In this situation, premature infants should be started on a 20 kcal/oz premature formula (e.g., Premature Enfamil® or PE®; Similac Special Care® or SSC®). There is no need to dilute these formulas. Once full-feeds are tolerated, these can be advanced to the 24 kcal/oz version. For infants with increased protein needs or low serum albumins, there is now a SSC® “HiProtein” which provides 10% more protein at the same osmolality and caloric density.
III. Fluid Volume

A. Most pre-term infants <2 kg and <35 wks gestation will require IV fluid initially because of suck/swallow discoordination and the risk of hypoglycemia. However, they do not require sodium and water initially. Fluids initially are held to 60-80 mL/kg/day of D10W to provide adequate glucose, and then slowly advanced as indicated.

1. Term and near-term babies can start on ad lib feeds with IV fluids reserved for those with specific risk factors for hypoglycemia (e.g., IDM, SGA) or who can't feed.
2. Late pre-term babies (35-36 wks; 2000-2500 gm) are at increased risk for hypoglycemia if mother attempts to breast feed only (inadequate supply immediately after birth and decreased ability to suck vigorously) and may often avoid IV fluids if started on gavage or bottle feeds (discontinued as soon as breast feeding is well established).

B. Our main goals for enteral feeds are to provide calories for growth and to meet all of the other nutritional needs of the patients.

1. Usually your target is 100-120 kcal/kg/day. This will require 150 mL/kg/day of 24-calorie formula/fortified human milk as the feeding target for most preemies, although many without heart or lung problems will tolerate 175-180 mL/kg/day or more.
2. III preemies with chronic lung disease or heart disease may require 120-150 kcal/kg/day with decreased tolerance for fluid, dictating >24-calorie formula or additional nutrient supplements.

C. Parenteral Nutrition (PN) usually will be needed for VLBW infants until feedings can be advanced to a significant volume (see NICU Guide Section II.A.2. “Management of IV Fluids and TPN”). This is necessary to prevent a protein and calorie deficit from accruing during the initial period of restricted enteral intake. However, once the preemie can tolerate a substantial amount of enteral nutrition, fluid supplementation can be with just D10W and electrolytes. Generally, PN is stopped when approximately 75% of target intake is enteral.

IV. Feeding Guidelines

A. Route

1. Asymptomatic infants who can suck/swallow (usually >32 wks EGA) can be allowed to try nipple feeds.
2. Most preemies <34 wks are fed via gavage. Gavage feeding provides an easy way of checking tolerance by aspirating back and determining residual feeding material prior to introduction of additional feeds.
3. Preemies who don't tolerate NG feeding due to poor gastric emptying or small preemies <1 kg who require nasal CPAP are often managed with transpyloric nasojugal (NJ) feeding. With small infants on CPAP, swallowed air can collect in the stomach leading to distention and feeding intolerance. By feeding transpylorically and using standard oro gastric (OG) tube left open to air for venting, gastric distention is minimized and feeding can be accomplished safely.
   a. NJ tubes require an x-ray to verify placement.
   b. Transpyloric feeds must be “continuous drip” using a pump.

B. Trophic feeds

Early enteral nutrition has been demonstrated to have a beneficial effect on maturing the intestinal tract of the VLBW and sick infant. The prolonged withholding of enteral feeds delays the capability of the intestines to adapt to the extra-uterine environment and may actually enhance the potential of pathogenic organisms to translocate from the intestine, causing generalized infection. Several investigators have demonstrated that the early initiation of minimal enteral feedings has improved pre-term sick neonates' ability to tolerate enteral feedings, thus decreasing the need for PN, the incidence and severity of cholestasis and hepatic dysfunction, and the incidence of nosocomial infections. Small volume trophic feeds can be given with UAC in place.

C. Colostrum

Colostrum, the initial milk produced in the first several days of lactation, has very important immunologic and trophic effects. Even if the volume is small, it provides great benefit to our preemies, and every effort should be made to collect and utilize it.

1. If the infant is ready to begin feeds, colostrum should be used according to the appropriate pathway described below.
2. If feeds are still contraindicated as above, colostrum should be delivered to the buccal pouch in small volumes (≤1 mL each side) via syringe or cotton swab until the patient is ready to begin following the appropriate pathway.

D. Feeding pathways

Use for all VLBW infants meeting criteria for initiation of feeds above:

1. See the 2 Pathways below for details of feeding for babies either ≤1000 gm or 1001–1500 gm birthweight.

2. Feedings should be rounded to nearest mL (i.e., 2 mL not 2.2 mL).

3. Feeding days are NOT the same as day of life, but count from day feeds initiated.

4. For infants ≤14 days old, use birthweight. Thereafter, you may need to individualize for small weight changes during the protocol.

E. Monitoring

Tolerance to feeds must be monitored continuously. Babies must be evaluated with chart documentation and feedings reduced or withheld for:

1. Abdominal distention, visible loops or abdominal discoloration

2. Worsening clinical status, e.g.:
   - a. Hemodynamic/respiratory instability
   - b. Hypo- or hyperglycemia

3. Bloody stools NOT related to anal fissure

4. Bloody or bilious gastric residual or emesis

5. Large volume residual, defined as >1/2 the volume fed.

F. Constipation

Many preemies may go more than 24 hrs without a stool, but constipation may result in feeding intolerance. If otherwise benign, an order for occasional glycerin suppository PR may be needed to prevent feeding problems.

G. Vitamins

Multivitamins are an important dietary adjunct for VLBW infants. Once the infant is on full enteral feeds, a multivitamin preparation such as Poly-Vi-Sol® should be started. For infants weighing <1500 gm, the dose is 0.5 mL PO BID. For infants ≥1500 gm, the dose is 1 mL PO daily. Although the formulas for pre-term infants contain supplemental vitamins, as do the human milk fortifiers, the premature infant may benefit from the multivitamin preparations. If, however, the infant’s serum phosphorus level is found to be increasing (≥8 mg/dL) the vitamins may need to be decreased or discontinued as the infant may be receiving too much vitamin D. One should first be sure that the elevation is not due to a low Ca:Phos ratio in the diet or renal abnormalities.

H. Iron

After the infant has been on full feeds and has tolerated the enteral multivitamin preparation, Fer-In-Sol® (elemental Fe 25 mg/mL) can be started at 0.1 mL/day and increased slowly to 0.2, 0.3, and even 0.6 mL/day for infants >2.5 kg. The goal is 2-3 mg/kg (0.1 mL/kg) daily-maintenance, 5-6 mg/kg (~0.2 mL/kg) daily if there is evidence of iron deficiency or if on Erythropoietin®. To convert elemental Fe to ferrous sulfate multiple by 5 (thus Fer-In-Sol is 125 mg FeSO4/mL).

I. Minerals

Usually, other supplements such as HMF, powdered or liquid formula, etc., provide sufficient minerals. Indeed, 180-200 mL/kg/day of MM can be adequate for bone growth. Occasionally, supplementation with calcium and/or phosphorus are needed to prevent or treat nutritional rickets. The doses will be calculated with the help of the Dietitian to provide about a 1:7:1 Ca:Phos ratio for the entire intake including the milk or formula. The commonly used supplements include:

1. Calcium gluconate (Neo-CaGlucon) = 23 mg elemental calcium/mL.

2. Calcium carbonate (Tums®) = 100 mg elemental calcium/mL.

3. Na/K phosphate (Neutra-Phos) = 0.32 mM or 10 mg elemental phosphorus/mL.

J. Routine laboratories

We routinely check labs weekly on “feeding and growing preemies” for signs of vitamin/mineral, iron, or protein deficiency.

1. HCT q week, if low, then twice a wk and check a reticulocyte count.
2. Electrolytes for patients on chronic diuretics once or twice a wk.
3. Preemie Nutritional Panel (PNP) every wk. This contains:
   a. BUN: assesses protein utilization and renal function. A high BUN in the presence of normal renal function implies protein overload. Conversely, one can "push" protein intake as long as the BUN stays low.
   b. Ca/Phos: assesses bone mineralization and vitamin D status.
   c. Alk P: normally increased with bone formation in preemies, but if significantly elevated (>800 IU) it may be due to sub-optimal calcium/phosphorous or vitamin D intake. Alk P is elevated in patients with hepatocellular damage and/or cholestasis, and it may be difficult to ascertain which factor is causing the elevation. Furthermore, Alk P increases during bone healing with resolving nutritional rickets. Radiograph of the bones are not often helpful and we do not perform densitometry.
   d. Albumin/Pre-albumin: assesses protein intake.

K. Growth monitoring

Growth parameters over the preceding 1-2 wks are the best judge of nutritional adequacy. In general, for preemies we expect:
1. Gain weight by about 10% per wk
2. The OFC should increase about 1 cm/wk
3. Preemie growth charts are created automatically by
   a. Open "Pt Info" tab
   b. Go to "Growth Charts"
   c. Click on desired chart "FENTON"
   d. You can print these out or follow percentiles

### Selected Components of Human Milk After Freezing and Pasteurization

<table>
<thead>
<tr>
<th>Function</th>
<th>Percentage per day</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgA and IgM</td>
<td>Raised in the baby's digestive system to prevent their passage into mammary tissue.</td>
<td>15-40%</td>
</tr>
<tr>
<td>IgG</td>
<td>Antibodies specifically targeted against pathogens in which the mother has been exposed.</td>
<td>8</td>
</tr>
<tr>
<td>Feeding capacity</td>
<td>Antibodies specifically targeted against pathogens in which the mother has been exposed.</td>
<td>15-40%</td>
</tr>
<tr>
<td>Iron</td>
<td>Raised in vitro, may become iron bound by ascorbic acid.</td>
<td>15</td>
</tr>
<tr>
<td>Methylxanthines</td>
<td>Produced by liver; associated with high levels of newborn calories.</td>
<td>30-35</td>
</tr>
<tr>
<td>Neuraminic acid</td>
<td>Produced by liver; associated with high levels of newborn calories.</td>
<td>30-35</td>
</tr>
<tr>
<td>Lipids and cellular</td>
<td>Essential fatty acids, and other cellular components.</td>
<td>30-35</td>
</tr>
<tr>
<td>Carbohydrates and amino acids</td>
<td>Essential fatty acids, and other cellular components.</td>
<td>30-35</td>
</tr>
</tbody>
</table>

*These biochemicals in infant formula do not exist in commercial formula.
**Some manufacturer are not adding desmacholization acids and other supplementary formulas in infant formula preparations.


Pathway: Birth Weight ≤1000 gm (≤27+0 wks):

<table>
<thead>
<tr>
<th>Feeding day</th>
<th>Feeding</th>
<th>ml/kg-day</th>
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<tbody>
<tr>
<td>Day 1</td>
<td>2-3 mL/kg q 6h</td>
<td>10</td>
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<tr>
<td>Day 2</td>
<td>2-3 mL/kg q 6h</td>
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<tr>
<td>Day 3</td>
<td>2-3 mL/kg q 6h</td>
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<tr>
<td>Day 4</td>
<td>2-3 mL/kg q 6h</td>
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</tr>
<tr>
<td>Day 5</td>
<td>2-3 mL/kg q 3h</td>
<td>20</td>
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<tr>
<td>Day</td>
<td>Feeding</td>
<td>mL/kg-day</td>
</tr>
<tr>
<td>-------</td>
<td>------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>6</td>
<td>2-3 mL/kg q 3h</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>2-3 mL/kg q 3h</td>
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<td>8</td>
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<td>9</td>
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</tr>
<tr>
<td>12</td>
<td>11-13 mL/kg q 3h</td>
<td>100</td>
</tr>
<tr>
<td>13</td>
<td>14-16 mL/kg q 3h</td>
<td>120 [may stop HAL]</td>
</tr>
<tr>
<td>14</td>
<td>17-19 mL/kg q 3h</td>
<td>140</td>
</tr>
<tr>
<td>15</td>
<td>20 mL/kg q 3h</td>
<td>160</td>
</tr>
</tbody>
</table>

Pathway: Birth Weight 1001-1500 gm (<31+0/7 wks):

<table>
<thead>
<tr>
<th>Feeding day</th>
<th>Feeding</th>
<th>mL/kg-day</th>
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</thead>
<tbody>
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<td>2-3 mL/kg q 3h</td>
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<tr>
<td>6</td>
<td>6-8 mL/kg q 3h</td>
<td>60</td>
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<td>9-10 mL/kg q 3h</td>
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</tr>
<tr>
<td>9</td>
<td>14-16 mL/kg q 3h</td>
<td>120 [may stop HAL]</td>
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<td>10</td>
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<td>11</td>
<td>20 mL/kg q 3h</td>
<td>160</td>
</tr>
</tbody>
</table>

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Parenteral Fluids, Electrolytes and Nutrition

I. Introduction

Newborn infants typically lose up to 10% of their body weight over the first 7-14 days of life. Premature babies have higher total body water content and an excess of extracellular water resulting in more weight loss than term infants. While a healthy term infant should demonstrate a real gain (not just edema) over birth weight by 2 wks of age, many premature infants will still be below birth weight at that time.

Extra-uterine growth restriction is an ongoing issue in the NICU. Neonates, particularly premature ones, whose nutritional needs are not met for any significant length of time, rapidly fall off their optimal growth curve. Even a short period without appropriate nutrition can result in protein, calcium, or phosphorus deficiencies that can be difficult to correct.

At birth, neonates are fluid overloaded, and will need to diurese and lose weight. Though they don’t need water initially, they need some fluid as a vehicle to provide the rest of their maintenance requirements (e.g., glucose, amino acids, calcium). Too much fluid and sodium initially delays diuresis, resulting in increased residual lung fluid, worse lung disease, and a greater risk of ductal patency.

II. Rationale for Fluid Management

A. Very Low Birth Weight (VLBW) Infants (<1500 gm) have increased fluid needs due to a variety of factors:

1. Skin integrity results in increased transcutaneous water losses.
2. Kidneys have decreased ability concentrate and dilute urine.
3. Capillaries are more prone to leak fluid resulting in extravascular edema.
4. Both skin integrity and renal concentrating ability improve significantly over first wk of life.

B. Both term and pre-term infants with capillary leak problems (e.g., associated with asphyxia and septic shock) are best managed by providing a relatively restricted baseline crystalloid infusion and supplementing with “bolus” infusions of crystalloid, FFP or blood.

C. The goal of IV fluid therapy during the first few days of life is to:

1. Prevent excessive weight loss and dehydration, which can result in hypotension, cell damage, hyperkalemia, and IVH.
2. Allow the premature infant to lose 1-2% body weight per day, not to exceed a total of 15% over the first 7-10 days of life.
3. Provide adequate glucose and amino acid delivery.
4. Meet electrolyte needs.
5. Keep indwelling catheters patent.
6. Avoid fluid overload, which can lead to pulmonary edema, PDA, and an increased incidence of Chronic Lung Disease.

D. Typical volume (ml/kg•day) varies with the gestational age and diagnosis of the infant. Some guidelines are as follows:
1. >1500 gm: 60-80 mL/kg•day 
2. 1000-1500 gm: 80 mL/kg•day 
3. <1000 gm: 100 mL/kg•day 
4. Advance over next 5 days depending upon labs, weights, urine output, etc., by 10-20 mL/kg/d to reach 150-160 mL/kg•day.

E. Micro-preemies (< 25 wks or 800 gm) may need 200 mL/kg•day or more of IVF in first wk because of increased transdermal losses or very immature renal function. Indication for increasing fluids include weight loss >15% of birth weight, urine output >6 mL/kg•hr, serum sodium >150 mg/dL, and BUN >40.

F. Adjustments are needed as follows-

1. Increase maintenance fluids for:
   Excessive weight loss
   Gastrochisis/omphalocele
   Immature, sticky, translucent skin
   Polyuria, hypernatremia, hyperkalemia

2. Decrease maintenance fluids for:
   Asphyxia/cerebral edema
   Generalized body edema
   Oliguria (e.g., renal failure, SIADH, Indomethacin)
   Heart failure or Patent Ductus Arteriosus (PDA)
   Pulmonary edema
   Excessive weight gain

III. Additional Guidelines for the <1500 gm Premature Infant

A. Include volume boluses (saline, blood products) in total fluids and lower IVF accordingly.
B. Do not treat metabolic acidosis unless pH <7.20 and base deficit over -8. Consider Lactated ringer’s instead of normal saline as bolus (it is buffered) as long as hyperkalemia not a concern.
C. Do not treat hypotension unless mean BP is less than gestational age or diastolic BP is less than 20 mm Hg. Try to limit volume boluses for hypotension to 2 per day. Use dopamine or consider hydrocortisone (see also NICU Guide section II.H.3 “Management of Hypotension with Suspected Adrenal Insufficiency Among Pre-Term Infants”)
D. Babies <1000 gm should be in Giraffe® incubator or double-walled incubator within 24 hrs of age.
E. Consider humidification of incubator. Start at 60-70% humidity. (see also NICU Guide section II.A.1 “Humidification in the VLBW Infant”)
F. Initiate hyperalimentation immediately upon admission, usually with min potassium and sodium.

IV. Electrolyte Requirements

A. Hemodynamically stable term infants usually need no sodium or potassium during the first day of life. Total serum calcium levels are usually low due to hypoalbuminemia and rise with improved nutrition. Ionized calcium values (reported with ABGs) are more accurate, although alkalosis and heparin can result in false low measurements.
B. Patients with hypotension or cardiac disease, frequent blood product transfusion (calcium is bound by anticoagulants used by the blood bank) or documented hypocalcemia (ionized calcium values <1.0) need to have IV calcium supplied. Central infusion is required since calcium burns can result in permanent scarring.
A. Initial levels are checked by a glucometer. Levels <40 need to be verified by a serum glucose determination (sent to lab). Glucose concentration in whole blood (glucometer) is approximately 10-15% lower than in serum (lab).

B. Blood for glucose levels needs to be checked via heel-stick, venipuncture or drawn through an indwelling catheter that is NOT being used to infuse glucose (it’s impossible to “clear” a line infusing glucose).

C. IV glucose concentration and delivery rate needs to be adjusted to keep the glucose level >40 and <150.

D. Repeat glucose determinations need to be done every 30 min until stable levels are confirmed after an intervention for hypoglycemia.

E. IV glucose is the appropriate therapy for levels <25 mg/dL regardless of gestational age or symptoms.

F. Know the glucose delivery being supplied to any patient. For example, a patient on D12.5W at 80 mL/kg•day receives 6.3 mg/kg•min. of glucose. (See section XIII below “Basic Calculations”).

G. Hypoglycemia is treated with IV pushes of dextrose (2 mL/kg of D10W). All IV boluses must be accompanied by increases in the maintenance glucose delivery rate and a glucose level should be rechecked within 30 min following an intervention.

H. For persistent hypoglycemia, please see NICU Guide Section II.H.2 “Hypoglycemia”.

VII. Parenteral Nutrition

A. Goals

The goals of PN are to meet the patient’s fluid, calorie, fat, protein, electrolyte, vitamin, and trace element maintenance needs, initially to prevent deficits, then to advance to levels needed for appropriate growth and development.

B. Calories

Most of the calories to support growth, generally around 70%, should come from dextrose monohydrate (3.4 kcal/gm), with the remainder from lipids. Protein hopefully will be incorporated in new tissue and not be burned as energy.

1. Maintenance: 60-80 kcal/kg•day
2. Growth: 70-100 kcal/kg•day
3. Pulmonary/heart disease: 100-120 kcal/kg•day
4. Target: 70% calories from dextrose, remainder from lipids.

C. Protein

Babies need protein initially to prevent tissue break-down [catabolism], and then for new tissue growth. TrophAmine® is the preferred Amino Acid (AA) solution in LPCH NICU secondary to improved nitrogen retention, plasma amino acid patterns comparable to breast fed infants, and decreased cholestasis compared to standard amino acid solutions. Special situations [e.g., renal failure, metabolic disease] may require a different solution.
1. Maintenance requirements are provided by calcium gluconate, 200-400 mg/kg•day, when Ca needed.
2. When boluses are required for severe hypocalcemia (ionized levels <0.8) and poor cardiac function, calcium chloride 20 mg/kg is given thru a central line over 10-30 min (IV push in a "code" situation) since, unlike calcium gluconate, it does not have to be metabolized by the liver for free calcium delivery. If no central access is available, it is okay to “bolus” with calcium gluconate. [See section XII below "Basic Calculations" for calculating calcium in maintenance fluids.]

NOTE: 20 mg/kg calcium chloride delivers the same amount of free calcium as 50 mg/kg calcium gluconate, and does it much faster. Calcium is incompatible with many meds, especially bicarbonate; don’t add calcium to any line unless you are sure it is compatible. Adding extra calcium to Parenteral Nutrition (PN) solutions (after pharmacy already prepared it) is dangerous and precipitation may occur based on the phosphorus concentration.

C. When the patient demonstrates a need for sodium, either by falling sodium levels or to support tissue growth, add sodium chloride 2-3 mEq/kg•day. When treating hyponatremia, it is important to remember volume expanders like FFP and 5% albumin contain nearly the same amount of sodium as normal saline and may contain as much as 175-180 mEq/liter. It seldom is necessary to give hypertonic IV boluses of sodium in the NICU. Hyponatremia during early life can be an indication of volume overload, and reduction in fluid delivery is the treatment of choice.

D. Potassium requirement is usually 2 mEq/kg•day initially, and is added when the patient demonstrates a need and normal renal function. We do not give boluses of potassium for mild hypokalemia (K+ level 2.9-3.5) unless patient is on digoxin. Adding more potassium chloride to the maintenance infusion should take care of the problem. If K+ level is <3, use the “IV Potassium Replacement” order set available in LINKS.

V. Glucose Requirements

A. Newborn infants have a basal requirement of about 4-6 mg/kg•min of glucose.

B. Healthy term infants can meet this need through glycolysis and gluconeogenesis and do not necessarily need IV infusions.

C. Pre-term infants and IUGR term infants have decreased supply of substrate and decreased ability to utilize their stores.

D. Infants of Diabetic Mothers (IDMs) are exposed to higher than normal glucose levels in utero which results in islet-cell hyperplasia. They therefore may be relatively hyperinsulinemic at birth, resulting in above normal glucose requirements.

E. Septic Newborns Hypoglycemia can be a sign of sepsis in the newborn infant.

F. Typical IV infusion is dextrose 10% in water (D10W) which contains 10 gm of dextrose monohydrate, the equivalent of 9.1 gm of glucose, per 100 ml. This was chosen because at 60 ml/kg•day minimum rate, this provides about 3.8 mg/kg•min of glucose. We may infuse concentrations between D3W and D12.5W through a peripheral IV. Higher concentrations, up to D20W, require central access.

VI. Notes on Hypoglycemia
1. Initial

Recent data demonstrate that the neonate loses about 1.2 gm of protein/kg•day if unsupplemented. All infants should be started on at least 2.0 gm of protein/kg•day (or maximum achievable per fluid restriction) in the form of amino acids beginning as soon as possible after birth even if adequate calorie intake is not able to be infused.

2. Growth

Amino acids can gradually be increased until 3.5 gm/kg•day is reached. This may be increased to 4 gm/kg•day, if indicated. Serum albumin levels should be followed to confirm adequate protein levels. BUN levels are not very helpful in assessing protein status in the first few days of life due to changes in renal function and fluid status. Once these are stable, elevations in BUN may indicate a need to decrease amino acids.

D. Lipid

Fats are needed to meet essential fatty acid requirements (~0.5 gm/kg•day of intravenous fat) for cell membrane, myelination, skin formation, and hormone production. Additional lipids are supplied to achieve overall caloric delivery necessary for growth. Rapid infusion of lipids may induce increased pulmonary vascular resistance, so this is infused over 24 hrs, and the advance may be slowed in babies with severe respiratory failure. Additional, free fatty acids can interfere with bilirubin-albumin binding. As long as the fatty acid/albumin ratio is low, this is not a problem. Thus, triglyceride [TG] levels must be monitored while on IV lipids, particularly in jaundiced babies.

1. Initial

Most neonates will tolerate 1 gm/kg•day of fat initially.

2. Growth

Lipids can be advanced by 0.5-1.0 gm/kg daily up to 3 gm/kg•day. For ELBW infants, lipids are usually held at 1.0-1.5 gm/kg•day for the first wk until greater metabolic stability and after the peak of hyperbilirubinemia. TG levels are monitored daily while advancing the dose, 1-2 per wk once on full lipids. The lipid infusion should be held briefly for levels > 250-300 mg/dl (or > 200 mg/dl in babies with significant bilirubin levels), then restarted at a lower level. Patients with persistent TG levels > 250 mg/dl may receive 0.5-1.0 gm/kg of lipids 2 times per wk to prevent essential fatty acid deficiency. L-Carnitine (10 mg/kg•day) added to PN may enhance fat clearance in patients with persistent high TG levels.

VIII. Ordering Parenteral Nutrition

A. PN must be ordered daily and custom-formulated for each patient receiving it. This is accessible from the desktop and mobile computers ("COWS") in the NICU via "TPN-Link". You will have to specify all of the details described here. This program allows you to see the previous day's order, which you can modify and up-date. For patients tolerating stable maintenance parenteral nutrition, you can review the previous order and re-order it without change if appropriate. The paragraphs below are summarized succinctly in the table that follows.
B. Central vs. Peripheral. Catheters ending in a large vessel (inferior/superior vena cava) are considered central regardless of type (Broviac, Cook, UAC, UVC, mini silastic "PICC" line). Please check catheter placement and verify with your attending that the line can be considered "central". The differentiation is important, since the concentrations of various key elements of parenteral nutrition (e.g., Dextrose, Calcium) that can be infused safely are greater in Central vs. Peripheral vessels. By indicating the catheter site, the Pharmacy can help assure that safe concentration limits are NOT exceeded.

C. Fluid Volume. By indicating what other IV fluids are running, the Pharmacy can adjust the Parenteral Nutrition accordingly to avoid fluid overload. List all other drips (e.g., fentanyl, dopamine, Versed®) as well as other fluid infusions used to keep lines open (e.g., peripheral A-line, CVP line). NaCl (i.e., 1/2 NS or NS) should be listed, especially with small preemies, as the NaCl delivery from a peripheral arterial line can be significant: 1/2 NS @ 1 mL/hr in a 500 gm baby gives 3.7 mEq/kg•day NaCl.

D. Enteral Feeds. If the infant on PN is feeding and the feeding volume is included in the total fluid intake, the Pharmacy subtracts the feeding volume, then prepares the PN, concentrating additive into the reduced PN volume. If the feeding volume is NOT included on the PN order, PN will be created assuming patient is NPO. You must be careful to watch electrolytes when feeds are included in total fluids as the sodium and potassium supplements the baby is receiving may impact the serum values once the baby comes off PN (i.e., become hyponatremic or hypokalemic). Thus, for patients whose feedings are changing, it may be better not to include the feeds in the daily PN order.

E. Dextrose. The goal is to provide about 70% of total calories as glucose, which provides 3.8 kcal/gm of Dextrose monohydrate. Initial dextrose concentration is usually D10 used in standard IV fluid; this provides about 3.8 mg/kg•min of glucose at 60 mL/kg•day, and 5.1 mg/kg•min at 80 mL/kg•day. Increase 10-20% a day to keep serum glucose levels 50-150 until the carbohydrate goal of 70% total calories is met. Typical maximum concentration via Central line is D20. Although most patients will not need this high a concentration, those with fluid restriction or high caloric needs may need more (up to D30). Maximum dextrose concentration through a peripheral IV is D12.5 which is adequate for the vast majority of our patients. Keep in mind that too much Dextrose is a bad thing – it leads to increased CO2 production, may worsen respiratory acidosis, and contributes to fatty liver. Most texts recommend a target range of 13-18 gm/kg•day. We recommend not exceeding a total of 18 gm/kg•day of parenteral carbohydrate intake because of these concerns.

F. Lipids. Intralipid® 20% (IL-20) is used in the LPCH NICU. It is ordered in gm/kg daily. IL-20 provides 0.2 gm/mL of lipid, and 2 kcal/mL (9 kcal/gm of lipid, and an additional 0.2 kcal/mL from glycerol). Thus, 0.1 mL/kg/hr delivers about 0.5 gm/kg•day; 15 mL/kg•day delivers 3 gm/kg•day, and 30 kcal/kg•day.

G. Protein. Patients should be started on Trophamine® 2.0 gm/kg•day (or as close as achievable, if restricted) as soon as possible, with increases of 0.5-1.0 gm/kg•day to 3.0-3.5 gm/kg•day. Occasionally, a greater concentration of amino acids is required, up to 4 gm/kg•day. Adjustments may need to be made for liver or renal dysfunction.

H. Trace Elements. 0.2 mL/kg of Pediatric Trace Element Solution (PTES) is the usual dose. For patients with a direct bilirubin greater than 2 mg/dL, we discontinue this additive because of impaired hepatic excretion. (See section VII. V below “PN Cholestasis”)

I. Zinc. Preemies typically need 400 mcg/kg•day of Zinc in PN. PTES only provides 200 mcg/kg•day so we need to order an additional 200 mcg/kg•day on the PN form. Term infants need an extra 50 mcg/kg•day zinc for a total of 250 mcg/kg•day. If not receiving PTES due to direct hyperbilirubinemia, preemies need 400 instead of 200 mcg/kg•day, and term infants 250 mcg/kg•day total ordered (Below “PN Cholestasis” VIII. V)

J. Vitamins: For our preemie population (weight <2.5 kg) 2 mL/kg•day (maximum 5 mL/day) of Pediatric MVI is given to supply vitamins (i.e., A, E, D, K) plus Folate. Larger infants receive 5 mL/day.

K. Sodium: Usual maintenance is 3 mEq/kg•day. VLBW infants do not usually require sodium during the first few days of life as their total body sodium (and water) levels are usually high, and they need to diurese. Growing preemies commonly require more. Patients on diuretics will have lower sodium values. Do not push to have "normal" Na levels in patients on diuretics [that is how diuretics work]. A value in the low 130’s is probably optimal for a patient on diuretics.

L. Potassium: Usual maintenance is 2 mEq/kg•day. Potassium is difficult to measure in patients without central lines. Heel-stick K+ values are almost always falsely evaluated. Reported K+ values >7 always need
to be rechecked, and values >6 need to be rechecked in patients receiving IV KCl. We will preferentially increase KCl infusions in hypochloremic patients as it is better tolerated than increased NaCl or arginine chloride infusions. Increased amounts of potassium are required in patients receiving diuretics, especially if evidence of metabolic alkalosis is present.

M. Acetate/chloride. Cations (Na, K) are balanced with either acetate or Cl anions. Acetate is a good source of base for infants with low serum bicarbonate, as we cannot give bicarbonate in PN (it would precipitate out with calcium). Most of the time we include relatively balanced acetate/chloride numbers. For example, a patient receiving 4 mEq of Na and 4 mEq of K will need about 8 mEq of anion. Typically, one can write “balanced” in the acetate blank. However, with the new PN computer program one must write in the amount of acetate desired. Pharmacy will do the appropriate additions and determine if what we write is appropriate. In patients with hypochloremia from chronic diuretic use we must put “minimum” acetate in the PN. The computer program will prompt you as to what the minimum for that patient is. In patients with chronic metabolic acidosis (i.e., Renal Tubular Acidosis of Prematurity), and low serum bicarbonate values (<17) we may give “max” acetate. Be careful not to let the serum bicarbonate values get too high (>30) as alkalotic patients may not respond to hypercapnia well and will be difficult to extubate! In a patient with normal serum bicarbonate (19-24), an initial dose of 3 mEq/kg•day is typical. Also, remember that almost 1 mEq of acetate is provided by each gm of Trophamine, thus this “typical” case may not need additional acetate.

N. Magnesium. Maintenance magnesium (Mg) of 0.25 mEq/kg•day is ordered usually unless a patient has an abnormal level. Neonates that are hypermagnesemic initially secondary to maternal Mg tocolysis usually need no magnesium for the first several days.

O. Calcium/Phosphorus. Both elements are vital to bone deposition. The body will compensate for hypocalcemia by reabsorbing new deposited bone so it is important to give sufficient calcium and phosphorus in the correct ratio (1.3–1.7:1 mg Ca:mg P) to have net bone production. We aim for calcium gluconate of about 400 mg/kg•day and phosphorus of 1 mMol/kg•day. VLBW infants may need 500 mg/kg•day of calcium gluconate. Growing preemies will rarely be hypophosphatemic or hypocalcemic even while developing osteopenia, since bone serves as a great reservoir.

P. Heparin. Total heparin delivery not to exceed 5 units/kg•hr.

1. PIV (Peripheral IV): no heparin.
2. Arterial Lines (i.e., UAC, pAL): 1 unit heparin/mL
3. Central Venous Lines (i.e., UVC, PICC, Hickman/Broviac): 1/2 unit heparin/mL

Q. Ranitidine: Ranitidine should NOT be ordered routinely for stress ulcer prophylaxis for patients on PN, as the preemie stomach is a poor acid producer. Ranitidine use has been associated with NEC, and acidification of feedings has been suggested as a means of preventing NEC. Its use should be reserved for patients with coagulopathy, gastritis, documented GE reflux, and those on steroids. Ranitidine can be added to PN at a dose of 2 mg/kg•day.

R. Selenium: After an infant has been on PN for 1 mo, selenium should be added to the daily PN solution in the amount of 2 micrograms/kg•day. Levels should be checked monthly while on selenium.

S. Copper: Should be added when a deficiency is noted and at 1 mo. Check levels every 2-3 wks after 1 mo.

T. PN Labs: Order the “Clinical Pathway for TPN” in LINKS. After 1 mo of PN, zinc, copper, and selenium levels should be followed.

U. Carnitine: Should be added in cases of very high serum triglyceride levels, as it helps process lipids as a transport mechanism inside cells. The dose is 10-20 mg/kg•day.

V. PN Cholestasis: in patients with PN Cholestasis (conjugated bilirubin >2), we remove the trace elements because copper and manganese are excreted through the bile and will build up in tissue, especially the liver, causing hepatic toxicity (see section VIII.1 “Zinc” above). Infants with PN cholestasis are started on Ursodiol (10 mg/kg q8hr) if direct bilirubin levels are >2 and infant is on feedings. Also see NICU Guide Section II.F.4. “Neonatal Cholestasis” for more detail.

IX. Important Notes Regarding PN
A. **Initiation of PN** is recommended on admission unless significant fluid shifts or metabolic derangements are present.

B. **PN rate** should never be increased to make-up additional fluid requirements unless PN has specifically been written for this purpose.

C. **Central PN** should never be run in a peripheral line (even if Ca and dextrose concentration look okay) unless specifically cleared by pharmacy, due to possible osmolality differences.

D. **The UAC catheter** is used as a non-contaminated site for lab sampling. Standard solution is 1/2 NS with 1 unit heparin/mL at 1 mL/hr. If no other central access is available, PN or other IVFs may be run through the UAC.

X. **Peripheral vs. Central Line Concentration Limits**

There are both solubility and osmolality limits to what can be placed in parenteral solutions. The “TPN-Link” program will alert you if you go over these. Sometimes you may be paged by the PN Pharmacy if there are problems.

A. **Amino Acids**

1. **Peripheral IV**: 2% of PN volume
2. **Central IV**: 3% of PN volume

B. **Dextrose**

1. **Peripheral IV**: 12.5%
2. **Central IV**: 30%

C. **Potassium**

1. **Peripheral IV**: 60 mEq/L
2. **Central IV**: 120 mEq/L

D. **Calcium gluconate**

1. **Peripheral IV**: 3 gm/L in PN, otherwise no calcium in peripheral line
2. **Central IV**: 8 gm/L or as per calcium/phosphate solubility curves

XI. **Monitoring**

A. **NPO infants**: Check serum electrolytes and calcium at 12 hrs of age, and every morning afterwards until electrolytes have stabilized.

B. **Healthy, rule-out-sepsis babies** do not need electrolytes and calcium checked if they are predominantly orally fed.

C. **Weights and urine outputs** need to be assessed quite frequently in the micro-preemies, and adjustment in the fluid rate and composition made as indicated.

D. **Chemstrip glucometers** need to be assessed daily for patients on IVF.

E. **Hematocrit and serum sodium and BUN values** (in patients not receiving excessive amounts of sodium) are useful indicators of intravascular volume. Increasing Na/HCT/BUN indicates dehydration.

F. **Micro-preemies (<25 kg and <800 gm)** need much more vigilant fluid assessment. Electrolytes, calcium, and HCTs should be checked every 12 hrs if the patient demonstrates instability. Urine output must be
followed; >5 mL/kg•hr is a clue that the patient has unstable kidney function. At least twice a day, the micro-preemie’s total IVF needs to be assessed against laboratory data, weight changes, and total urine output. If the total IVF is less than the urine output, this is a problem, especially if supported by weight drop and increasing sodium values. Patients can lose 25-100 ml/kg•day just through the skin.

XII. Basic Calculations

A. Glucose delivery: Calculating glucose delivery or Glucose Infusion Rate (GIR) requires converting grams of dextrose monohydrate to the equivalent in anhydrous glucose with the correction factor (180/198), based upon their molecular weights, which is reduced to (10/11).

1. GIR mg/kg•min = (D%)(10/11)(# mL/kg•day)(1/144). Example -

D12.5% @ 80 mL/kg•day = (12.5)(10/11)(80)(1/144) = 6.3 mg/kg•min

a. Most neonates require 4-8 mg/kg•min initially.
b. Advance by ~1-2.5 mg/kg•min daily as tolerated.
c. Max is 10-12 mg/kg•min.

2. GIR gm/kg•day = (D%)(10/11)(# mL/kg•day)(1/100). Example -

D12.5% @ 120 mL/kg•day = (12.5)(10/11)(120)(1/100) = 13.6 gm/kg•day

a. Most neonates need 13.18 gm/kg•day; avoid >18 gm/kg•day.

3. To convert mg/kg•min to gm/kg•day, multiply by 1.44.

B. Calories Provided: Calories from PN can be calculated from the amounts of fats and carbohydrates given. (NOTE: Patients should not be using supplied protein for caloric needs unless malnourished. Protein contains roughly 16% nitrogen by weight).

1. Carbohydrate – calculate either from dextrose monohydrate concentration (3.4 kcal/gm), or from GIR (3.8 kcal/gm):

a. Dextrose: (D%)(# mL/kg•day)(3.4 kcal/gm)(1/100) = kcal/kg•day, or,
b. GIR: (Glucose gm/kg•day)(3.8 kcal/gm) = kcal/kg•day, or,
c. GIR: (Glucose mg/kg•min)(1.44)(3.8 kcal/gm) = kcal/kg•day.

2. Lipids – calculate either from:

a. gm/kg•day = (gm/kg•day)(10 kcal/gm), e.g., 3 gm/kg•day = (3)(10) = 30 kcal/kg•day, or
b. mL/kg•day = (mL/kg•day)(2 kcal/ml), e.g., 15 mL/kg•day = (15)(2) = 30 kcal/kg•day.
3. **Protein** – Kcal/kg = \( \text{gm amino acid/kg}\cdot\text{day}\)/(4 kcal/gm), e.g., 3 gm/kg\cdot\text{day}, thus \((3)(4) = 12\ \text{kcal/kg}\cdot\text{day}\).

**C. Sample Initial Fluid Orders**

1. Term pre-ECMO with septic shock via UVC:
   D10W + 1.25 gm Ca Gluc/250 mL IVF + 1/2 unit heparin/mL @ 60 mL/kg\cdot\text{day}

2. 32-wk healthy preemie via PIV:
   D10W @ 80 mL/kg\cdot\text{day}

3. 28-wk preemie with RDS via UAC:
   D10W + 400 mg Ca Gluc/250 mL IVF + 1 unit heparin/mL @ 100 mL/kg\cdot\text{day}

4. 24-wk micro-preemie with RDS via PICC:
   D5W + 250 mg Ca Gluc/250 mL IVF + 1/2 unit heparin/mL @ 120 mL/kg\cdot\text{day}

**B. Calcium calculations:** calcium gluconate mg per 250 mL bottle = \((\text{mg calcium/kg}\cdot\text{day})/(\text{mL/kg}\cdot\text{day IV}) \times 250\).

1. **Remember maximum safe concentrations** – calcium IV infiltrates can cause severe injury resulting in skin grafts, even tendon damage.
   a. **Central:** 400 mg/100 mL
   b. **Peripheral:** 100 mg/100 mL

**C. Sample orders for patients >12 hrs of life with serum electrolytes reported:**

1. **Term pneumonia patient:** Na 134, K 3.0, Ionized Ca 1.0, good urine output:
   a. **Via UVC:** D10W + 9 meq NaCl/250 mL IVF + 7 meq KCl/250 mL IVF + 800 mg Ca Gluc/250 mL IVF + 1/2 unit heparin/mL @ 80 mL/kg\cdot\text{day}

2. **8-wk preemie with RDS:** Na 130, K 3.0, Ionized Ca 1.1, no urine output yet, edematous:
   a. **Via UVC:** D10W + 7 meq KCl/250 mL IVF + 400 mg Ca Gluconate/250 mL IVF + 1/2 unit heparin/mL @ 70 mL/kg\cdot\text{day} (down from 100 mL/kg\cdot\text{day})

3. **4-wk micro-preemie with RDS:** Na 150, K 5.1, Ionized Ca 1.2, urine output >5 mL/kg\cdot\text{hr}:
   a. **Via PICC:** D5W + 250 mg Ca Gluc/250 mL IVF + 1/2 unit heparin/mL @ 160 (increased from 140) mL/kg\cdot\text{day}

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Initial</th>
<th>Advance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextrose</td>
<td>&lt;1500 gm: 4-6 mg/kg/min</td>
<td>&lt;1500 gm: 1-2 mg/kg/min/day</td>
<td>Min = 4 mg/kg/min</td>
</tr>
<tr>
<td>All others: 6-8 mg/kg/min</td>
<td>All others: 2.5% daily</td>
<td></td>
<td>Max = 20% due to high osmolarity</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Goal GIR: 10-12 mg/kg/min</td>
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<tr>
<td><strong>Fat/IL 20%</strong></td>
<td>&lt;1000 gm: none on 1st day, otherwise 0.5 g/kg/day</td>
<td></td>
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<td>---------------</td>
<td>--------------------------------------------------</td>
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<tr>
<td></td>
<td>1001-1500 gm: 0.5 g/kg/day</td>
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<tr>
<td></td>
<td>All others, minimal lung disease: 1-2 g/kg/day</td>
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<tr>
<td><strong>Protein/AA</strong></td>
<td><strong>&lt;1500 gm: max allowed, up to 3 gm/kg/d</strong></td>
<td></td>
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<tr>
<td><em>(Trophamine)</em></td>
<td>All others: 2-3 gm/kg/d</td>
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<td></td>
<td>1 gm/kg/day, up to max 4 gm/kg/day</td>
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<tr>
<td><strong>Trace</strong></td>
<td>Pre-mixed additive solution</td>
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<tr>
<td><strong>elements</strong></td>
<td>(contains Cu, Zn, Cr, Mn)</td>
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<tr>
<td></td>
<td>Add additional Zn: 200 mcg/kg/d for &lt;1500 gm</td>
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<tr>
<td></td>
<td>50 mcg/kg/d for all others</td>
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<tr>
<td><strong>Ca/Phos</strong></td>
<td>Calcium gluconate: max allowed, up to 400 mg/kg/day</td>
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<tr>
<td></td>
<td>Phosphorus: &lt;1000 gm: none on 1st day, otherwise 0.5 mM/kg/day</td>
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<tr>
<td></td>
<td>All others: 0.5 mM/kg/day</td>
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<tr>
<td><strong>Na</strong></td>
<td>1st DOL: no additional needed (i.e., min allowed)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>DOL 2-3: 0-2 mEq/kg/day</td>
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<tr>
<td></td>
<td>Older: maintenance per labs</td>
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<tr>
<td><strong>K+</strong></td>
<td>1st DOL: no additional needed (i.e., min allowed)</td>
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<td></td>
<td>DOL 2-3: 0-2 mEq/kg/day</td>
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<tr>
<td></td>
<td>Older: Maintenance per labs</td>
<td></td>
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<tr>
<td><strong>Acetate</strong></td>
<td>0-1 mEq/kg/day</td>
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<tr>
<td></td>
<td>(&lt;1500 gm may need max allowed)</td>
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<tr>
<td><strong>Mg</strong></td>
<td>Do not give if mom on Mag</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Otherwise: 0.25 mEq/kg/d</td>
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<tr>
<td></td>
<td>Usual dose: 0.25 mEq/kg/d, once Mg level returns to normal</td>
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</table>

**Hold lipids if TG >200, then check next day and start at lower level if TG <200 0.5 g/kg/day min to prevent essential fatty acid deficiency**

**Advance daily unless true renal disease or severe azotemia (BUN >60) exists**

**Add 2 mcg/kg/d Se after PN ≥1 month**

If D Bilir >2, hold trace elements, but add 250 mcg/kg/d Zn for term, 400 mcg/kg/d Zn for preemies

If severe renal disease, hold trace elements and Se

If trace elements are held, check baseline Cu at beginning and monthly; if Cu level is low, restart Cu at 20 mcg/kg/d until level is normal, then decrease to 10 mcg/kg/d

**Calcium gluconate goals:**

<1500 gm: 400-600 mg/kg/d

All others: 300-400 mg/kg/d

**Optimal Ca:Phos ratio is:**

1.3-1.7:1 by weight (displayed on "TPN Links")

Watch labs closely

Maintenance: 3-5 mEq/kg/d

Watch labs closely

Maintenance: 2-4 mEq/kg/d

Watch labs closely

As needed per labs

Watch labs closely
Hypoglycemia

I. Definition
A serum glucose level <45 mg/dl.

II. Etiology
A. Transient hypoglycemia (a few days):
   1. Hyperinsulinism:
      a. Infant of a mother with gestational diabetes or diabetes mellitus (IDM) are usually LGA infants (>4 kg or >90%), but can be SGA if maternal DM is poorly controlled
      b. Congenital hyperinsulinism (focal or diffuse beta cell hypertrophy)
      c. SGA
      d. Iatrogenic (from excess insulin administration)
   2. Perinatal stress
   3. Sepsis (especially Gram Negative bacteremia)
   4. Asphyxia or hypoxic-ischemic encephalopathy
   5. Hypothermia
   6. Polycythemia
   7. Insufficient delivery of glucose
   8. Maternal drugs (e.g., terbutaline, ritodrine or chlorpropamide)
   9. Erythroblastosis fetalis
   10. Exchange transfusion
   11. Poor umbilical artery line placement
B. Decreased glycogen stores
   1. IUGR or SGA (infants <5 lb or 2608 gm)
   2. Premature or post mature infants (<37 wks or >41 wks)
C. Persistent hypoglycemia
   1. Hormone excess hyperinsulinism:
      a. Beckwith-Wiedemann syndrome
      b. Diffuse or focal b cell hyperplasia
      c. SGA
      d. Stress-related hyperinsulinism
   2. Hormone deficiencies:
      a. Growth hormone deficiency
      b. Adrenal insufficiency:
         1) ACTH deficiency
         2) ACTH non-responsiveness
         3) Congenital Adrenal Hyperplasia
         4) Adrenal Hypoplasia
         5) Bilateral adrenal hemorrhage (rare)
      c. Epinephrine deficiency (rare)
      d. Glucagon deficiency (rare)
   3. Hereditary defects in carbohydrate metabolism
   4. Hereditary defects in amino acid metabolism
   5. Hereditary defects in fatty acid metabolism

III. Diagnosis
A. Laboratory studies
   1. Routine labs
      a. Check serum glucose level to confirm if <45 mg/dl on heel stick. Sample must be run STAT.
      b. CBC with diff to screen for sepsis.
   2. Persistent hypoglycemia
      a. Critical sample:
1) Insulin*
2) Cortisol*
3) Growth hormone
4) Glucose to lab*
5) Urine ketones*
6) Lactic acid
7) Ammonia
8) Beta hydroxybutyrate*

* Test must be performed while hypoglycemic. Others can be done at other times. If serum sample is not sufficient to run all tests, order of priority is glucose, insulin, cortisol, lactic acid, growth hormone, beta hydroxybutyrate.

b. Free fatty acids
c. Thyroid tests (T4 and TSH)
d. Glucagon stimulation test
e. Metabolic:
   1) Lactic acid
   2) Ammonia
   3) Plasma amino acids
   4) Urine organic acids
   5) Uric acid
f. Consider continuous glucose monitoring
g. Consider MRI and ophthalmology consult if septo-optic dysplasia or other midline abnormality suspected

IV. Treatment
A. For infants ≥35 wks gestation with hypoglycemia
   1. Feed infant within 30-60 min of life if no respiratory distress.
   2. Check glucose 30-60 min after feeding. Target for glucose should be >60 mg/dl.
      a. If glucose >45 mg/dl repeat glucose 2-4 hrs after feeding and resume feeds every 2-3 hrs.
      b. If glucose <45 mg/dl by heel stick then send STAT serum glucose to lab and attempt another feed.
      c. If glucose < 45 mg/dl after second feed, start IV treatment per “C” below.
B. For infants <35 wks gestation
   1. Start IV treatment as below
   2. Determine further treatment based on clinical findings
C. IV Treatment
   1. Start IV of 5-8 mg/kg/min (highest glucose in a peripheral IV is 12.5%).
   2. Give 2 ml/kg of D10W slow push.
   3. Follow-up glucose 15 min following bolus to document resolution of hypoglycemia or need for further intervention.
D. Persistent hypoglycemia
   1. Increase dextrose delivery in IV incrementally.
   2. Send lab work:
      a. Metabolic.
      b. Critical sample.
      c. Complete hypopituitarism work-up (free T4, cortisol post Cortrosyn®/GL, IGFBP-3, sodium)
3. Medications to consider:
   a. Diazoxide (7-15 mg/kg/day divided every 8 hrs, orally).
   b. Octreotide.
   c. Human growth hormone (if GH deficient).
   d. Hydrocortisone (if cortisol deficient).
   e. Glucagon.
   f. Consider continuous glucose monitoring.

V. Consultation
Endocrine consultation is recommended for persistent hypoglycemia and those cases with unclear etiology.
Gastroesophageal Reflux vs. Gastroesophageal Reflux Disease

I. Definition of Gastrointestinal Reflux (GER)
   A. Spontaneous retrograde movement of gastric contents into the esophagus due to low pressure in the lower esophageal sphincter (LES) combined with prolonged relaxation of the LES and poor coordination of esophageal motility.
   B. GER is common and physiologic in babies during the first 6 mos of life. The amount of GER usually decreases over the 1st year of life with developmental maturation, upright posture, and an increased intake of solids.
   C. It is controversial when to consider GER pathologic, which is referred to as GERD, gastroesophageal reflux disease. However, there is consensus that it is pathologic when it leads to insufficient caloric intake and poor growth/failure to thrive (FTT), esophagitis (uncommon during infancy for the pre-term and full-term infant) and its sequelae (bleeding, anemia, stricture) or tracheal aspiration.
   D. GERD may be associated with feeding problems, such as frequent emesis or nasal-oral regurgitation, feeding aversion, poor weight gain, aspiration, and exacerbation of chronic lung disease.
   E. In term infants, GERD may be associated with apnea and airway problems, such as hoarse cry and stridor, due to edema and inflammation from the effects of high reflux and gastric acidity. Some infants may present with “apparent life threatening event” (ALTE). Some diagnoses/clinical problems that have a greater incidence of GERD are infants following tracheoesophageal repair, post-gastrostomy repair, and infants with Trisomy 21.
   F. GERD classically presents with regurgitation and vomiting, but also can present with FTT, disturbed sleep, respiratory symptoms, and feeding aversion. Although apnea, bradycardia, and oxygen desaturations may be seen in the full-term infant this association is uncommon in the pre-term infant.

II. Diagnosis of GERD
   A. pH Probe/apnea study: This study consists of a direct continuous measurement of intraesophageal pH (single or multiple level), ideally over a 24-hr period. Current computerized ambulatory system available for clinical bedside studies allows video monitoring along with apnea, bradycardia, oxygen saturation, and intraesophageal pH collected by a digital recorder. The pH probe is placed through a nostril into the distal 3rd of the esophagus (infant should be NPO 2 hrs prior to placement), verified by CXR as needed. The infant must be on bolus feeds (continuous feeds will mask pH changes) and not on H2 blockers (such as ranitidine) for 48 hrs or other medications, which can increase the gastric pH. To arrange the study, contact the Pulmonary Laboratory. Multi-level pH recording is available and may be helpful in detecting high very low GER events. The routine for the NICU is the single level pH recording. Scoring of the recording is based on percentage of reflux time with pH <4, and the frequency and duration of reflux episodes. Baseline data for full-term and pre-term infants are available/published. See Pulmonary Function laboratory report for baseline data to which your patient will be compared.
   B. Barium swallow/UGI, upper gastrointestinal study: Can demonstrate gross reflux, but not as sensitive as pH probe in determining reflux activity over 18-24 hrs. The UGI can be helpful in identifying delayed gastric emptying associated with partial upper GI obstruction.
   C. Gastric emptying study (Nuclear Medicine): This is used to identify prolonged emptying time. Esophageal and gastric outlet anatomy are not well-evaluated.
   D. Manometry: This is used to assess LES tone and function and is not generally available for clinical testing and cannot dynamically assess reflux activity over 18-24 hrs.
   E. GER Impedance: Can record reflux events at multiple levels and may accompany pH (as in above). There are no standards for this measurement and it has not been determined if this measurement is more clinically helpful than pH measurement alone. This methodology is not currently available at the LPCH Pulmonary Laboratory.

III. Non-pharmacologic Treatment for GERD
A. Antireflux positioning: Elevate head at bed 30°, position with left side down (this affects the position of the LES so that it is in a higher position. Prone position is also effective but is counter to the "back to sleep" recommendation to reduce the risk for sudden infant death syndrome (SIDS).  
B. Thickened feeds: There is no evidence to support or refute efficacy of feedthickener in newborn infants with GER, but it may be effective and is worth trying since it is a low risk. Rice cereal or Enfamil® AR can be used.

IV. Pharmacologic Treatment for GERD  
A. Metoclopramide (Reglan®)  
1. Mechanism of action: Increases LES tone, esophageal peristalsis tone, and amplitude of gastric contraction Also accelerates gastric emptying probably by sensitizing the tissues to acetylcholine.  
2. Dose: 0.1 mg/kg/dose oral PO 3-4 times/day (max 0.5 mg/kg/day); give before feeds. Can give up to 0.2 mg/kg/dose per GI for severe GER. Hepatic conjugation and renal excretion.  
3. Side effects: Extrapyramidal symptoms (e.g., dystonia, stiffness of face, back, neck, opisthotonus, oculogyric crisis, trismus, involuntary movements). Treat with Benadryl® and discontinue Reglan®. We have had term infants present with presumed "seizures" who have had this side effect.

B. Ranitidine (Zantac®)  
1. Mechanism of action: H2 blocker used to decrease gastric acidity.  
2. Dose: 2 mg/kg/day twice daily PO and may increase to 2 mg/kg/dose every 8 hrs. Max dose 6 mg/kg/d.  
3. Side effects: Constipation, diarrhea, nausea, vomiting, and abdominal pain.  
   It is important to check the gastric pH for effect (pH 5-6).

C. Omeprazole (Prilosec®)  
1. Mechanism of action: proton-pump inhibitor (PPI). Used for severe cases of GER in which an H2 blocker has not maintained a decrease in gastric acidity. This medication has gained acceptance in our NICU; however, pharmacokinetics and pharmacodynamic data are lacking.  
2. Dose: Start at 0.7 mg/kg PO once every day, then may give a 2nd dose 12 hrs later if necessary. Dose range 0.2-3.5mg/kg/d. It is important to check the gastric pH for effect (pH 5-6).  

D. Pantoprazole (Protonix®)  
1. Mechanism of action: PPI. Used for severe cases of GER in which H2 blockers have not maintained an effective decrease in gastric acidity.  
2. Dose: 1 mg/kg PO every 12-24 hrs. Even less is known about pharmacokinetics and Pharmacodynamics.  
3. Side effects: same as omeprazole.  
   Note: It is important to check the gastric pH for effect (pH 5-6)

V. Surgical Treatment  
A. After failure of medical therapy with the following indications:  
1. Failure to thrive  
2. Recurrent aspiration pneumonia  
3. Persistent vomiting  
4. Anemia caused by esophageal bleeding  
5. Large hiatal hernia or paraesophageal hernia  
6. Esophageal stricture or ulceration  
B. Surgical techniques  
1. Nissen fundoplication This involves placing the esophagogastric junction within the abdomen and wrapping the fundus 360° around the esophagus for a distance of 3-4 cm. The fundus is sutured to itself and the underlying esophageal wall. This reliably relieves reflux in 85% of cases. LPCH Surgeons prefer not to do fundoplication in young infants since it seems to have poorer results in that age group.  
2. Thal repair This also mobilizes the esophagogastric junction into the abdomen and closes the esophageal hiatus, but forms an anterior wrap of the fundus, encircling only 180° of the esophagus.  
3. Side effects of surgery
Infant will have limited ability to "burp" relieve gastric distension via the esophagus.

VI. Summary
GER/GERD has become a common diagnosis/presumed mechanism for early and late apnea, bradycardia and apnea/bradycardia and oxygen desaturation in the pre-term infant. There is no evidence that this is a clinical phenomenon in pre-term infants. Although it is hypothesized that this association should be present due to the recognized “recurrent laryngeal reflex” in immature infants, which can cause respiratory pause and apnea when irritant receptors in laryngeal and perilaryngeal area are stimulated, retrospective and prospective studies in preterm infants have not documented this relationship.

The most common intervention used in the NICU is an H2 blocker or proton pump inhibitors to decrease gastric acidity and increase gastric pH >4. It is important to document that gastric pH is >4 after treatment to verify adequate intervention and to make a concerted effort to document that there is clinical improvement which may be associated with this intervention. If symptoms are due to regurgitation of gastric contents (acid or alkaline) changing gastric acidity may not lead to resolution of clinical symptoms (e.g., with chronic recurrent tracheal aspiration). Data on efficacy of prokinetics is lacking in pre-term infants. If this intervention is used, careful clinical monitoring is again essential. As with all "therapies" there is a risk: benefit ratio and good “intentions” do not ensure that a medical benefit will result for the infant. In general the diagnosis of GER/GERD as the cause of apnea, bradycardia, and oxygen desaturation is over-used in many NICUs and is not substantiated by the evidence.
## Apnea, Brady, Desaturation Response Matrix

What is the purpose of the ABD response matrix?
- To decrease variation in response to ABD's.
- To improve RN comments in charting ABD's so provider can determine significance.
- To decrease length of separation from family.

Which babies are ready for ABD Matrix?
- When considered a level II.
- No cyanotic heart disease.
- No CLD or other pulmonary process.
- No pre-threshold ROP identified.
- When off oxygen
- When off caffeine.
- When being prepared for discharge.

When **ALL** conditions above are met, MD/NNP **change** Cardiorespiratory alarm parameters:
- HR 80-200 beats/min
- Apnea Alarms 20 second delay
- SpO₂ Alarms 80-100%, Target Range 95-100% in Room Air

What is a "Significant Cardiopulmonary Event" [SCE]?
- ABD that occur while asleep or lying down and **DO NOT** self-resolve:
  - Apnea > 20 seconds.
  - Apnea 10-20 seconds with a HR < 80 bpm for > 5 seconds.
  - Bradycardia < 60 bpm for > 5 seconds.
  - Oxygen desaturation < 80% for > 10 seconds.
- Events associated with feedings **are not** apnea of prematurity, but **may be** SCE if above true.
- Events preceded by procedures such as ROP exams, suctioning, and feeds **may not** be SCE.

### How does the nurse respond and chart events?

<table>
<thead>
<tr>
<th>Episode</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>RN Charting</td>
<td>Chart all events per policy. Add &quot;additional&quot; comments so that providers can decide if CSCPE and determine length of stay.</td>
</tr>
<tr>
<td>Apnea</td>
<td>Stimulate after 20 seconds, then room air breaths</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>Stimulate only if HR &lt; 60, or other alarm, e.g. -</td>
</tr>
<tr>
<td>Desaturation</td>
<td>Stimulate first, then room air breaths, then slow O₂ increase</td>
</tr>
</tbody>
</table>
How does the nurse respond and chart events?

<table>
<thead>
<tr>
<th>Event</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>RN Charting</td>
<td>Chart all events per policy.</td>
</tr>
<tr>
<td></td>
<td>• Give details about response to help decide if SCE</td>
</tr>
<tr>
<td>Apnea</td>
<td>Alarms after 20-sec; watch for 5-10 sec unless</td>
</tr>
<tr>
<td></td>
<td>• Bradycardia &lt; 80, or</td>
</tr>
<tr>
<td></td>
<td>• Desat &lt; 80%</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>Stimulate only if HR &lt; 60, or other alarm, e.g. -</td>
</tr>
<tr>
<td></td>
<td>• Apnea 10-20 seconds, or</td>
</tr>
<tr>
<td></td>
<td>• Desat &lt; 80%</td>
</tr>
<tr>
<td>Desaturation</td>
<td>Watch for 10-20 sec unless</td>
</tr>
<tr>
<td></td>
<td>• Apnea 10-20 seconds, or</td>
</tr>
<tr>
<td></td>
<td>• Bradycardia &lt; 80</td>
</tr>
</tbody>
</table>
Provider Info: Screening for Critical Congenital Heart Disease in Newborns

Screening for Critical Congenital Heart Disease in Newborns (CCHD) is being done in compliance with California State Law, AB-1731. This state law requires oxygen saturation screening to identify pre-symptomatic newborns with critical congenital heart disease in order to provide life-saving treatment before it is emergently necessary.

Who gets the screen? Every infant admitted to the NICU/PICU/SEQ/WASH who has not undergone a post-natal echocardiogram should receive the screening prior to discharge.

Procedure:

What: The order is pre-checked in both the Neonatal Critical and Intermediate admit powerplans. You may also enter the order individually by typing in "Pre/Post PDA," selecting the order, and specifying a date and time for the screen to be performed.

When: With the pre-checked admit order, the order will show up on the nurses’ task list when the infant is 24 hours old. However, the CCHD screen should actually be performed when you are ready to perform an ALGO on the infant (i.e. prior to discharge).

How: One probe will be placed on the right hand (pre-ductal) and the other will be placed on either foot (post-ductal). The probes will be left in place until the waveform and reading have stabilized. Measurement can be done one extremity at a time.

Results:
- Passed screen: O2 saturation is ≥ 95% on either probe AND there is ≤ 3% difference between the two probe readings
- Failed screen: O2 saturation is 90-94% on both probes OR there is > 3% difference between the two probe readings
- Critically failed screen: O2 saturation is < 90% in either probe

If there is a failed screen:
- Critical Fail: If the O2 saturation is <90% in either probe, the infant’s provider will be notified immediately.
- Fail: If the O2 saturation is ≥ 90% but there is a > 3% difference between the two probe readings, the screen will be repeated in 4 hours. If the repeat screen is a fail or a critical fail, the infant’s provider will be notified immediately.
- If you are notified of a fail or critical fail screen, the next step is to order an echocardiogram.

10/14/2103
Documentation:
- Nurse will complete Care Form found in Ad Hoc Charting section called “O2 Saturation Screening”
- When the results are documented, they will pull to both the Problems and Systems Progress Notes (either may be used), and to the Discharge Summary. In all cases, they will appear under the label “CCHD Screening.”

O2 Saturation Screen:
- **O2 Saturation Screening - Initial Result:** Pass (07/25/13 07:01)
- **SpO2 Pre/Upper - Initial Result:** 100 (07/25/13 07:01)
- **SpO2 Pre/Upper Probe Site - Initial Result:** left hand (07/25/13 07:01)
- **SpO2 Post/Lower - Initial Result:** 100 (07/25/13 07:01)
- **SpO2 Post/Lower Probe Site - Initial Result:** right foot (07/25/13 07:01)

- On the two Progress Notes, a “Comments” box is available if you wish to remark on why the screening has not been completed, such as an echocardiogram has been performed instead.
Car Seat Monitoring of High Risk Infants

I. Purpose
To evaluate premature and all high-risk infants for respiratory compromise while in the infant car seat, prior to discharge.

II. Policy
A. The American Academy of Pediatrics (AAP) has recommended that all premature infants (<37 wks) be monitored in a car seat prior to discharge to evaluate for presence of apnea, bradycardia or desaturation.
B. Other high-risk infants will be evaluated based on their physician-ordered oxygen saturation range. In addition, some infants are unable to tolerate a sitting position because of physical or developmental limitations and must be placed in an alternative restraint device. Placing an infant in a car bed will not guarantee that these conditions will not occur while traveling in the car bed.

III. Considerations
A. Infants <37 wks gestation at birth or who meet 1 of the following criteria:
   1. Weight at discharge less than 5 lbs (2.27 kg)
   2. With lung disease requiring supplemental oxygen
   3. With reflux requiring medication or thickened feedings
   4. All infants meeting any of the above criteria are eligible for infant car seat monitoring
B. Infants with known physical or developmental limitations who are not able to tolerate sitting positions may or may not require infant car seat monitoring, based on Physical Therapy/Occupational Therapy assessment data.

IV. Equipment
A. Pulse oximeter
B. Cardiorespiratory monitor
C. Car seat that will be used to transport the infant home

V. Process
A. Upon identification of an Infant requiring monitoring, arrangements should be made for the parents to bring in the car seat that will be used to transport the infant home. This should occur for babies in the SCN, NICU, and NICU 2 days prior to discharge; for babies in the WBN, the day before discharge.
B. Testing should be done at least 30-60 min after a feeding.
C. Place infant on cardiorespiratory and oxygen saturation monitors. Get baseline measures for 10 min before placing infant in car seat. If the infant is already on cardiorespiratory and oxygen saturation monitor, note baseline measurements from flow sheet.
D. If infant is going home on a monitor, hook the baby up to the home monitor.
E. Place infant in car seat. Bolster with blankets to keep baby in optimal position while maintaining manufacturer’s and AAP recommendations. There should not be anything between the baby and the car seat that did not originally come with the car seat.
F. Monitor infant for ≥30 min to evaluate for apnea, bradycardia or desaturation episodes.
G. The infant has failed if the saturation is less than 88% for 20 sec or as identified by the physician or the heart rate is <80 bpm. If the infant fails, do not test again with that car seat. The infant can be tested in a different type of car seat at the parent’s request.
H. Results are documented in LNKs under “Car Seat Study” by the RN. This is found under “Ad Hoc Charting”. Once documented, the results can be found in the “Care Forms” tab and under “Car Seat Test”.
I. Report results to the physician.
J. If infant fails, the infant must go home in a car bed which can be obtained from Distribution Supply.
K. Instruct the parents to follow the manufacturer’s instructions for proper placement of the car bed in the vehicle and proper positioning of the infant in the car bed.
L. Instruct the parents that the infant's Pediatrician will order a re-test of car seat monitoring at a later date. The car bed should be used until the infant passes the re-test.
M. Provide the parents with the "Receipt of Information and Release, and Child Safety Seat Program" form and obtain their signature. Place form in medical record.
N. Parents may choose to forego car seat monitoring or take the infant home in a seat other than the one in which the infant was observed. This should be documented in the patient's medical record.
Neonatal Hyperbilirubinemia

I. Introduction

Jaundice, a frequent clinical diagnosis, is characterized by yellowness of the skin. When the bilirubin level is sufficiently elevated, it extends to the mucous membranes, sclera, and body fluids. Elevated unconjugated (indirect) and/or conjugated (direct) bilirubin levels account for total plasma bilirubin (TB), and the transcutaneous bilirubin (TcB). Biologically, bilirubin is a known anti-oxidant at low levels (in vitro) and a potent neurotoxin at high levels (in vivo). Bilirubin and carbon monoxide are the major degradation products of heme. Non-water-soluble unconjugated bilirubin (bound to albumin) is processed in the hepatocyte to excretable, water-soluble conjugated bilirubin by the enzyme uridine-di-phospho-glucuronosyl-transferase (UGT). In the presence of decreased gastrointestinal activity and/or starvation in the immediate postnatal period, some of this conjugated bilirubin is reconverted to unconjugated bilirubin in the gut, and reabsorbed in the circulation (enterohepatic recirculation). Unconjugated bilirubin (mg/dL) binds with albumin (grams/dL) in a ratio of about 8:1. Acidosis, hypoalbuminemia, lower gestational age, post-natal age (age <3 days) and drugs (especially sulfa and some cephalosporins) are associated with impaired albumin-bilirubin binding. If unmonitored or untreated in a timely manner, irreversible post-icteric sequelae known as kernicterus spectrum disorders may occur. These can include movement disorders of dystonia, athetosis, and choreoathetosis, sensorineural hearing loss, oculomotor abnormalities of strabismus, and gaze palsy (especially, upgaze).

II. Incidence of severe hyperbilirubinemia

A. Healthy term and near-term infants (>35 wks gestation)

Table 1. Current incidence of severe hyperbilirubinemia

<table>
<thead>
<tr>
<th>TB levels at age &gt;72 hrs</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;17 mg/dL (&gt;95th percentile)</td>
<td>8.1 to 10%</td>
</tr>
<tr>
<td>&gt;20 mg/dL (&gt;98th percentile)</td>
<td>1 to 2%</td>
</tr>
<tr>
<td>&gt;25 mg/dL (&gt;99.9th percentile)</td>
<td>0.16%</td>
</tr>
<tr>
<td>&gt;30 mg/dL (&gt;99.99th percentile)</td>
<td>0 to 0.032%</td>
</tr>
<tr>
<td></td>
<td>1 in 10</td>
</tr>
<tr>
<td></td>
<td>1 in 70</td>
</tr>
<tr>
<td></td>
<td>1 in 700</td>
</tr>
<tr>
<td></td>
<td>1 in 10,000</td>
</tr>
</tbody>
</table>

B. Sick neonates and preterm infants (<35 wks gestation)

Preterm and sick infants are at increased risk for hyperbilirubinemia and its sequelae. Factors that negatively affect these populations for an almost universal risk of hyperbilirubinemia include decreased enteral intake and decreased gastrointestinal activity resulting in increased enterohepatic circulation. As a result of biological conditions such as: vulnerability of the blood-brain barrier, asphyxia, acidosis, hypoalbuminemia and impaired bilirubin binding to albumin, neurotoxicity may occur at lower bilirubin levels than for term and healthy infants.

III. Causes of Hyperbilirubinemia

A. Causes of neonatal jaundice
Table 2. Common causes of neonatal jaundice

<table>
<thead>
<tr>
<th>Biological basis</th>
<th>Clinical conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑ Bilirubin production</td>
<td>Isoimmunization – Rh, ABO, and minor group incompatibilities</td>
</tr>
<tr>
<td></td>
<td>RBC enzyme defects – G6PD deficiency, pyruvate kinase deficiency, hexokinase deficiency, congenital erythropoietic porphyria, etc.</td>
</tr>
<tr>
<td></td>
<td>RBC structural defects – hereditary spherocytosis (autosomal dominant; especially if 1 parent has splenomegaly or had splenectomy), hereditary elliptocytosis, infantile pyknocytosis</td>
</tr>
<tr>
<td></td>
<td>Sepsis – bacterial, viral (e.g., CMV), protozoal</td>
</tr>
<tr>
<td></td>
<td>Extravasted blood – bruising, cephalohematoma, subgaleal bleed, subdural hematoma, hemangiomas</td>
</tr>
<tr>
<td></td>
<td>Polycythemia</td>
</tr>
<tr>
<td>↑ Enterohepatic circulation</td>
<td>Prematurity</td>
</tr>
<tr>
<td></td>
<td>Starvation</td>
</tr>
<tr>
<td></td>
<td>Decreased gastrointestinal activity</td>
</tr>
<tr>
<td></td>
<td>Delayed bacterial colonization of the gut</td>
</tr>
<tr>
<td></td>
<td>Pyloric stenosis, GI immotility or obstruction</td>
</tr>
<tr>
<td>↓ Elimination</td>
<td>Crigler-Najjar Syndrome (Type 1 UGT) – autosomal recessive, diagnosed by liver biopsy</td>
</tr>
<tr>
<td></td>
<td>Gilbert Syndrome – neonatal variant often confused as “breast milk jaundice” sometimes co-inherited with G6PD deficiency</td>
</tr>
<tr>
<td></td>
<td>Arias Syndrome (Type II UGT) – autosomal dominant with variable penetrance</td>
</tr>
<tr>
<td></td>
<td>Transient familial neonatal hyperbilirubinemia (Lucey-Driscoll Syndrome) – rare, caused by inhibitor of UGT from mother</td>
</tr>
<tr>
<td></td>
<td>Drugs – e.g., novobiocin, excessive sedation/paralysis</td>
</tr>
</tbody>
</table>

IV. Screening Tests

A. Visual assessment of jaundice

All infants should be routinely monitored for the development of jaundice, and nurseries should have established protocols for the assessment of jaundice. Jaundice should be assessed whenever the infant’s vital signs are measured, but no less than every 8 to 12 hrs. Jaundice can be detected by blanching the skin with digital pressure to reveal the underlying skin and subcutaneous tissue color at the forehead, sternum, iliac crest, patella and malleolus. Jaundice is usually seen first in the face and progresses caudally to the trunk and extremities but can sometimes appear and fades similar to a tan (Figure 1). The assessment of jaundice must be done in a well-lit room or, preferably, in daylight at a window. It is usually a cephalo-caudal progression and sometimes, it can fade in and out like a tan. Color varies from lemon yellow to bright orange and sienna. Assessment may be limited by skin pigmentation, plethora, decreased ambient light, and exposure to sun or
phototherapy. Absence of jaundice is not an indication of the absence of hyperbilirubinemia, estimating the degree of hyperbilirubinemia can lead to errors; and, the absence or severity of jaundice are not predictive of subsequent severe hyperbilirubinemia. However, the complete absence of jaundice (when reliably recognized at age 36 to <72 hrs) may predict term infants will not develop significant hyperbilirubinemia.

Figure 1. Cephalo-caudal progression of jaundice

<table>
<thead>
<tr>
<th>Jaundice Progression</th>
<th>Zone</th>
<th>Bilirubin (mg/dL) mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Face and neck</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Umbilicus</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Knees</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Ankles</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Toes</td>
<td>5</td>
<td>&gt;20</td>
</tr>
</tbody>
</table>

1Kramer LL. Am J Dis Child, 1969; 118:454-8

B. Bilirubin measurement

1. Total bilirubin assay

TB is measured in plasma to objectively assess the severity of jaundice. In term and late preterm infants, this level is plotted on an hour-specific nomogram that identifies risk zones and/or assessment of clinical risk factors. The nomogram (Figure 2) provides a more appropriate understanding of the magnitude of hyperbilirubinemia in the contexts of postnatal age in hrs and the percentile level as defined for healthy infants.

Figure 2. Risk assessment for significant hyperbilirubinemia using the hour-specific bilirubin nomogram
2. Predictive ability of pre-discharge bilirubin in infants ≥35 weeks GA

TB is the only currently available clinical test that can be used to predict the risk of subsequent significant hyperbilirubinemia when these values are plotted on the hour-specific nomogram. When measured concurrent to the routine pre-discharge metabolic screening, it is a powerful screening tool (Table 3). It defines the high risk and low risk for post discharge excessive hyperbilirubinemia. The predictive accuracy and the significance of its role as useful as a practical screening are shown below. The clinical significance of these data is not only the identification of a high-risk population but also that of the low-risk population. The predictive ability of TB has now been validated by several other prospective studies.

Table 3. Predictive ability of pre-discharge bilirubin level (age 18 to 72 hrs)*

<table>
<thead>
<tr>
<th>Risk-zone</th>
<th>Probability</th>
<th>Likelihood Ratio</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-risk zone, &gt;95th percentile</td>
<td>2/5</td>
<td>14.08</td>
<td>97.8</td>
<td>39.5</td>
<td>54.0</td>
<td>96.2</td>
</tr>
<tr>
<td>Hi-Intermediate, 75-94th percentile</td>
<td>1/8</td>
<td>3.20</td>
<td>99.5</td>
<td>21.6</td>
<td>90.5</td>
<td>84.7</td>
</tr>
<tr>
<td>Low-Intermediate, &gt;40-74th percentile</td>
<td>1/46</td>
<td>0.48</td>
<td>100</td>
<td>11.6</td>
<td>100</td>
<td>64.7</td>
</tr>
<tr>
<td>Low-risk zone, ≤60th percentile</td>
<td>0</td>
<td>0</td>
<td>28 Bhutani VT, et al. Pediatrics 1999; 103:6-14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Defined as when a subsequent TB value reaches into the high-risk zone (>95th percentile track).

3. Transcutaneous bilirubin (TcB) testing

TcB testing is a potential and non-invasive alternative to TB measurement. TcB devices are useful screening tools and provide a valid estimate of the TB level, although data are limited. TcB levels can be unreliable during phototherapy or with exposure to sunlight because of the bleaching effect of light on the skin. Confounding effects of skin melanin content among different races and manufacturing consistency among devices are additional limitations. Measurements in newborns using the new TcB devices are within 2-3 mg/dL of the TB and useful to screen for TB levels <12 mg/dL. The use of TcB measurements in sick and preterm infants as well as those undergoing phototherapy has not yet been validated.

C. Clinical risk factors

Assessment of risk for severe neonatal hyperbilirubinemia include exclusive and insufficient breast milk transfer, family history of neonatal jaundice, bruising, cephalhematoma, ethnicity (Asian), maternal age (>25 yrs), male gender, and gestational age <38 wks (summarized in Table 4).

Table 4. Major risk factors and assessment

<table>
<thead>
<tr>
<th>Major risk factors</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-discharge TB/TcB &gt;95th percentile</td>
<td>Laboratory test</td>
</tr>
<tr>
<td>Jaundice at age &lt;24 hrs</td>
<td>Clinical observation</td>
</tr>
<tr>
<td>Blood group incompatibility</td>
<td>Laboratory test</td>
</tr>
<tr>
<td>Gestational age 35 to &lt;38 wks</td>
<td>Clinical exam</td>
</tr>
</tbody>
</table>
Sibling received phototherapy
Cephalhematoma or significant bruising
Exclusive but sub-optimal breastfeeding
East Asian race
Male gender

Ethnicity (such as, risk of G6PD deficiency)

History
Clinical exam
History and observation
History
Clinical exam
History

The predischarge bilirubin level, expressed as a risk zone on the bilirubin nomogram, when combined with multiple clinical risk factors (Table 5) have a similar accuracy for predicting significant hyperbilirubinemia. Of these, an infant’s GA (late preterm infant and those <38 wks GA) appears to be the most significant clinical risk factor and adds to the risk of subsequent severe hyperbilirubinemia for those with TB values <75th percentile.

Table 5. Postnatal characteristics that predict TB >95th percentile

<table>
<thead>
<tr>
<th>Maternal Race: OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Hispanic</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maternal Health: OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Parity</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Smoked</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pregnancy and Delivery: OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal bleeding</td>
</tr>
<tr>
<td>Caesarean section</td>
</tr>
<tr>
<td>Forceps</td>
</tr>
<tr>
<td>Vacuum</td>
</tr>
<tr>
<td>PROM</td>
</tr>
<tr>
<td>Oxytocin (induction)</td>
</tr>
<tr>
<td>Epidural</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infant Health: OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
</tr>
<tr>
<td>Breast</td>
</tr>
<tr>
<td>Both</td>
</tr>
<tr>
<td>% weight loss/day</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infant Clinical Signs: OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Cephalhematoma</td>
</tr>
<tr>
<td>Deasuring</td>
</tr>
<tr>
<td>&lt;38 wk</td>
</tr>
<tr>
<td>&gt;40 wk</td>
</tr>
<tr>
<td>SGA</td>
</tr>
<tr>
<td>LGA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infant: Pre-discharge TB: OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40th 75th percentile</td>
</tr>
<tr>
<td>76th 95th percentile</td>
</tr>
<tr>
<td>&gt;95th percentile</td>
</tr>
</tbody>
</table>


V. Management of Term and Late Preterm Infants

A. Laboratory evaluation

Table 6. Laboratory evaluation of the jaundiced infant ≥35 weeks' gestation*

<table>
<thead>
<tr>
<th>Indication</th>
<th>Laboratory assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*
- Jaundice at age <24 hrs
  - Measure TcB and/or TB

- Jaundice excessive for infant's age
  - Measure TcB and/or TB

- Infant receiving phototherapy
  - TB rising rapidly (such as crossing percentiles)
  - Unexplained by history and physical examination
  - Blood type and Coombs' test, if not obtained with cord blood
  - Complete blood count and peripheral smear
  - Measure direct or conjugated bilirubin
  - It is an option to assay reticulocyte count, G6PD, carboxyhemoglobin or ETCOc, (if available)
  - Repeat TB in 4-24 hrs depending on infant's age and TB level

- TB approaching exchange levels
  - Failure of response to phototherapy
  - Reticulocyte count, G6PD, albumin, ETCOc, (if available)

- Elevated direct (or conjugated) bilirubin level
  - Urinalysis and urine culture
  - Evaluate for sepsis indicated by history and physical examination

- Jaundice at age >2 wks or a sick infant with jaundice
  - Total and direct (or conjugated) bilirubin level
  - If direct bilirubin is elevated, evaluate for causes of cholestasis
  - Check results for newborn thyroid and galactosemia screen

*TB=total serum bilirubin; ETCOc=end tidal carbon monoxide, corrected for ambient carbon monoxide; G6PD=glucose-6-phosphate dehydrogenase

**B. Strategies for bilirubin reduction**

Strategies to rapidly reduce the bilirubin load are described in the 2004 American Academy of Pediatrics Practice Parameters4 and a recent review article by Dennery et al5 and summarized in Table 7, below. Be alert to nonspecific signs of Acute Bilirubin Encephalopathy (ABE). Severely jaundiced babies and symptomatic babies should be admitted directly to the NICU.

**Table 7. Interventions for bilirubin reduction**

<table>
<thead>
<tr>
<th>Interventions for bilirubin reduction</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteral feeds to promote breastfeeding</td>
<td>Preventive strategy</td>
</tr>
<tr>
<td>Phototherapy</td>
<td>Requires hospitalization</td>
</tr>
<tr>
<td>Exchange transfusion</td>
<td>Assess individualized risk-benefit ratio; indicated for clinical signs of ABE</td>
</tr>
<tr>
<td>Chemoprevention</td>
<td>Use Intravenous Immunoglobulin</td>
</tr>
</tbody>
</table>

**VI. Phototherapy**

**A. Background information**
The absorption of light by the normal form of bilirubin (4Z,15Z bilirubin), at a peak wavelength of 460 nm, generates transient excited-state bilirubin molecules. These fleeting intermediates can react with oxygen to produce colorless lower molecular weight products, or they can undergo rearrangement to become structural isomers (lumirubins) or isomers in which the configuration of at least 1 of the 2 Z-configuration double bonds has changed to an E configuration. The plasma from an infant undergoing phototherapy contains several photoisomers, including the predominant 4Z,15E isomer. The photoisomers are less lipophilic than the natural 4Z,15Z form of bilirubin and can be excreted unchanged in the bile without undergoing glucuronidation. Once in bile, the configurational isomers revert spontaneously to the natural bilirubin. Most lumirubins and some photooxidation products are excreted in the urine. Bilirubin photoisomer by-products may confound the total bilirubin assay and impact bilirubin’s ability to bind to albumin. Blue lights in the 425-475 nm range (Phillips F-20 T12/BB or NeoBlueTM) should be easily and rapidly accessible, and periodically inspected and maintained to ensure proper functioning. These may be complemented with white halogen lights to cover a wider surface area. Avoid shadows with multiple lights.

Table 8. Practice considerations for optimal administration of phototherapy

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specific interventions</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light source (nm)</td>
<td>Blue light spectrum: such as &lt;500 nm</td>
<td>Use narrow wavelength spectral range</td>
</tr>
<tr>
<td>Light irradiance (dose)</td>
<td>Optimal irradiance: such as, &gt;30 μW/cm²/nm</td>
<td>Uniformity over the light footprint</td>
</tr>
<tr>
<td>Body surface area (cm²)</td>
<td>Close to the skin surface</td>
<td>Expose entire body surface (exclude eye patches and diaper area) maximal skin area</td>
</tr>
<tr>
<td>Response</td>
<td>Assure efficacy of Intervention</td>
<td>Degree of bilirubin decline</td>
</tr>
<tr>
<td>Interruption of therapy</td>
<td>May use intermittent phototherapy</td>
<td>After confirmation of adequate response</td>
</tr>
<tr>
<td>Duration</td>
<td>Discontinue at desired bilirubin threshold</td>
<td>Serial bilirubin measurements defined by rate of decline</td>
</tr>
</tbody>
</table>

Figure 3. Guidelines for intensive phototherapy in infants >35 wks
B. Intensive approach for an infant readmitted for severe hyperbilirubinemia
1. Assess for ABE regardless of the TB level.
2. Check TB/TcB and send labs.
3. Conduct procedures while infant is under phototherapy lights.
4. Prepare for an exchange transfusion (look for line placement sites.)
5. Evaluate for concurrent dehydration: IV infusions will not lower TB levels.
6. Continue enteral feeds to decrease entero-hepatic circulation of bilirubin. Breastfeeding can occur with infant (and mother) under phototherapy lights. If baby is unwrapped for skin exposure, heat lamps may be needed to maintain temperature.

C. Management of hyperbilirubinemia in sick and preterm infants

The primary strategy of clinical management for sick and preterm infants is prevention. Jaundice should be monitored along with other vital signs. Bilirubin testing should be conducted every 8-12 hrs; testing can be decreased to every 12-24 hrs during phototherapy, when bilirubin levels are decreasing or when the infant is beyond 1 wk of age. Sick and preterm infants may be at increased risk for an acute rise of bilirubin with concurrent infection or illness, when NPO or as a result of a transfusion or acute hemolysis.

Table 9. Suggested operational thresholds to manage hyperbilirubinemia in preterm infants (<35 wks GA)
[pending availability of evidence-based data]

<table>
<thead>
<tr>
<th>Stratification by birth weight</th>
<th>Operational TB levels to initiate phototherapy</th>
<th>Double Blood Volume Exchange Transfusion (190 ml/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm Infants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;28 wks GA</td>
<td>5-7 mg/dL</td>
<td>A preventive approach is essential in order to minimize the need for exchange transfusion. In the presence of suspicious neurological signs or when TB levels &gt;5 mg/dL above the values listed in the column, prepare to perform an exchange transfusion.</td>
</tr>
<tr>
<td>28-29 wks GA</td>
<td>6-8 mg/dL</td>
<td></td>
</tr>
<tr>
<td>30-31 wks GA</td>
<td>8-10 mg/dL</td>
<td></td>
</tr>
<tr>
<td>32-33 wks GA</td>
<td>10-12 mg/dL</td>
<td></td>
</tr>
<tr>
<td>≥34 wks GA</td>
<td>12-14 mg/dL</td>
<td></td>
</tr>
</tbody>
</table>

In view of diminished bilirubin-binding ability of albumin at age <72 hrs, a lower threshold for of intensive phototherapy initiation is suggested for infants <72 hrs of age.

D. Crash-cart management for acute bilirubin encephalopathy (ABE)
Once ABE is recognized (Table 10), the goal of therapy is to reduce the bilirubin load through a safe, efficacious, and prompt approach (Table 11).

### Table 10. Progression of clinical signs of ABE

<table>
<thead>
<tr>
<th>Severity of Clinical Signs</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Status</td>
<td>Sleepy</td>
<td>Lethargic</td>
<td>Stupor</td>
</tr>
<tr>
<td></td>
<td>Poor feeding</td>
<td>Irritable</td>
<td>Seizures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coma</td>
</tr>
<tr>
<td>Muscle Tone</td>
<td>Neck stiffness</td>
<td>Arching neck</td>
<td>Bowing of trunk</td>
</tr>
<tr>
<td></td>
<td>Mild hyper-/</td>
<td>Retrocolis</td>
<td>Opisthotonus</td>
</tr>
<tr>
<td></td>
<td>hypotonia</td>
<td>Arching trunk</td>
<td></td>
</tr>
<tr>
<td>Cry Pattern</td>
<td>High pitched</td>
<td>Shrill</td>
<td>Inconsolable</td>
</tr>
</tbody>
</table>

### Table 11. Considerations for a ‘crash-cart’ approach

<table>
<thead>
<tr>
<th>Options</th>
<th>Identify the most effective means to minimize brain damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk</td>
<td>Weigh against the potential risk of ABE’s intervention</td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>· Start intensive phototherapy (while procedures are being done)</td>
</tr>
<tr>
<td></td>
<td>· Consider immune globulin (IVIG) for isoimmunization</td>
</tr>
<tr>
<td></td>
<td>· Consider albumin infusion (1 g/kg) for hypoalbuminemia (&lt;3.4 g/dL)</td>
</tr>
<tr>
<td>Procedure</td>
<td>Iso-volume double volume exchange (170 mL/kg in term, 190 mL/kg in preterm infants)</td>
</tr>
<tr>
<td>Duration</td>
<td>May be accomplished within 3-4 hrs (consent, labs, lines, and procedures)</td>
</tr>
<tr>
<td>Technical problems</td>
<td>A single volume exchange transfusion may be inadequate</td>
</tr>
</tbody>
</table>

### E. Exchange Transfusion

**Figure 4: Guidelines for exchange transfusion in infants >35 wks**
VII. Follow-up

Infants with TB levels >25 mg/dL and those who receive an exchange transfusion, should be followed through infancy until school age for awkwardness, gait abnormality, failure of fine stereognosis, gaze abnormalities, poorly coordination, and exaggerated extra-pyramidal reflexes. Follow-up should include:

- Neurologic and neuro-developmental evaluation
- Neuro-imaging with MRI
- Auditory evoked brainstem responses (ABR)

VII. References


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Figure 1. Management and Follow-Up Guidelines for Repeat Bilirubin Testing Based on Predischarge Bilirubin Screening for Full-Term and Late-Preterm Infants

Note. LPT = late-preterm; TcB = transcutaneous bilirubin; TSB = total serum or plasma bilirubin. Original monogram courtesy of Vined K. Shastani, MD, FAAP, professor of pediatrics—neonatology, Stanford University School of Medicine, Lucile Packard Children’s Hospital, Stanford, CA.
# Management of Hyperbilirubinemia in sick term and preterm infants

<table>
<thead>
<tr>
<th>Stratification by Bwt</th>
<th>Initiate Phototherapy</th>
<th>Double Blood Volume Exchange Transfusion (190 ml/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1000 gms</td>
<td>4 to 6 mg/dL (bedside decision)</td>
<td>A preventive approach is essential in order to minimize the need for exchange transfusion. In the presence of suspicious neurological signs, or when TSB levels are &gt;5 mg/dL above the values listed in this table, prepare to perform an exchange transfusion. Consider infusion with albumin (1 g/kg) prior to exchange transfusion.</td>
</tr>
<tr>
<td>1001-1500 g</td>
<td>6 to 8 mg/dL</td>
<td></td>
</tr>
<tr>
<td>1501-2000 g</td>
<td>8 to 10 mg/dL</td>
<td></td>
</tr>
<tr>
<td>2001-2500 g</td>
<td>10 to 12 mg/dL</td>
<td></td>
</tr>
<tr>
<td>&gt;2500 g</td>
<td>12 to 14 mg/dL</td>
<td></td>
</tr>
</tbody>
</table>

**Term Infants and those not “healthy”**

| >2500 g              | 12 to 15 mg/dL        | 18 to 20 mg/dL                                    |

In view of diminished bilirubin-binding ability of albumin at age <72 hrs, the lower thresholds for initiation of intensive phototherapy are suggested for infants age <72 hrs of age.

<table>
<thead>
<tr>
<th>Stratification by Gestational Age</th>
<th>Initiate phototherapy</th>
<th>Double Blood Volume Exchange Transfusion (190 ml/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;28 weeks GA</td>
<td>5-6 mg/dL</td>
<td>11-14 mg/dL</td>
</tr>
<tr>
<td>28-29 wks GA</td>
<td>6-8 mg/dL</td>
<td>12-14 mg/dL</td>
</tr>
<tr>
<td>30-31 wks GA</td>
<td>8-10 mg/dL</td>
<td>13-16 mg/dL</td>
</tr>
<tr>
<td>32-33 wks GA</td>
<td>10-12 mg/dL</td>
<td>15-18 mg/dL</td>
</tr>
<tr>
<td>≥ 34 wks GA</td>
<td>12-14 mg/dL</td>
<td>17-19 mg/dL</td>
</tr>
</tbody>
</table>
Suspected Sepsis in Newborn Infants

William Benitz, M.D. and Arun Gupta, M.D.

Suspected sepsis may be the most common working diagnosis in neonatal medicine. Bacterial infection is confirmed by positive blood cultures in only about 1 in 1000 newborn infants, but this strict criterion probably underestimates the true burden of disease. Signs of neonatal bacterial infection are nonspecific and sometimes subtle. Delays in antibiotic therapy may permit progression to respiratory failure, septic shock or meningitis. These concerns have prompted an aggressive approach to identifying, evaluating, and treating infants at risk. This conservative approach necessarily results in treatment of many babies who turn out not to have been infected.

I. Management Principles

Our approach to management of infants is based on three core principles:

A. Prevent infection whenever possible

B. Identify and treat bacterial infection early and consistently

C. Focus or stop antibiotic therapy as soon as possible

Strategies for pursuit of these goals are outlined below.

II. Classification of Neonatal Sepsis

A. Early-Onset Sepsis

Early-onset sepsis is defined as invasive bacterial infection occurring in the first 3 days after birth. Early-onset sepsis is strongly associated with perinatal risk factors (Table 1) and almost always results in clinical signs of illness within the first 24 hours after birth. The bacteriology of early-onset sepsis is summarized in Figure 1.

![Image of bacteriology chart]

**Figure 1.** Bacteriology of early-onset neonatal sepsis. A. Culture-proven cases < 72 hrs of age. B. Relationship to birth weight. Data from Stoll 2011.
B. Hospital Acquired Late-Onset Sepsis

Hospital acquired infections (HAI), including late-onset sepsis, is defined as invasive bacterial infection occurring on or after day 4 after birth through discharge from the hospital. HAI are associated with indwelling vascular catheters, prolonged parenteral nutrition, postnatal steroid exposure (including hydrocortisone), suppression of gastric acid secretion (H1 blockers and PPIs), prematurity, prolonged antibiotic use, and surgical conditions. The risk of HAI can be mitigated by adoption of the CLABSI prevention “bundle”, minimizing exposure to antibiotics, steroids, and antacid medications, and facilitating the transition from parenteral to enteral nutrition. The bacteriology of hospital acquired late-onset sepsis is summarized in Figure 2.

![Figure 2](image)

**Figure 2.** The bacteriology of hospital acquired late-onset sepsis. Data from Perlman 2007.

C. Community Acquired Late-Onset Sepsis

Community acquired late-onset sepsis is defined as invasive bacterial infection occurring on days 4 through 28 after birth in previously well infants after discharge from the hospital. Community acquired sepsis is not strongly associated with perinatal risk factors. Late-onset GBS sepsis is associated with prematurity, lack of maternal opsonizing antibodies, and maternal GBS colonization, but late-onset GBS sepsis is not prevented by intrapartum or perinatal prophylaxis. The bacteriology of community acquired late-onset sepsis is summarized in Figure 3.

![Figure 3](image)

**Figure 3.** The bacteriology of community acquired late-onset sepsis. A. Culture-proven cases 3-28 days of age. B. Relationship to postnatal age. Data from Greenhow 2012.
III. Prevention of Neonatal Infections

Prevention is the mainstay of management. We have been very successful in prevention of early-onset GBS sepsis (Figure 4). Guidelines for GBS prevention are summarized in Figure 5.

Figure 4. Impact of intrapartum prophylaxis on early-onset group B streptococcal sepsis. Data from Schrag 2005 and annual CDC Active Bacterial Core Surveillance Reports (1999-2010).

Figure 5. An integrated approach to prevention and management of early-onset neonatal sepsis. Adapted from Verani 2010 and Polin 2012. Annotations are provided in the Appendix (below).
Adoption of the CLABSI prevention “bundle” and assiduous attention to minimizing antibiotic days in our nurseries have substantially reduced the number of hospital-acquired infections in our patient population, with reduced rates of coagulase-negative *Staphylococcus* bacteremia and *Candida* fungemia, respectively, in particular.

No strategies are known to be effective for prevention of community acquired late-onset neonatal infections.

### IV. Diagnosis of Neonatal Sepsis

Sepsis should be suspected in babies with the risk indicators or clinical findings listed in Table 1. Essentially any sign of illness in a newborn infant may be an indication of bacterial infection.

Some perinatal factors, including PPROM and chorioamnionitis, are associated with sufficient risk to merit automatic complete diagnostic evaluation and empiric treatment. Management of infants with perinatal risk factors for early-onset sepsis is mapped in Figure 5. Postnatal risk factors are not sufficiently predictive of disease to merit automatic intervention.

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Clinical Signs</th>
<th>Cutaneous</th>
<th>Metabolic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early-Onset Sepsis</strong></td>
<td>Behavioral</td>
<td>Thermoregulatory</td>
<td>Jaundice</td>
</tr>
<tr>
<td>PPROM</td>
<td>Lethargy</td>
<td>Fever</td>
<td>Petechiae</td>
</tr>
<tr>
<td>Preterm labor</td>
<td>Irritability</td>
<td>Hypothermia</td>
<td>Purpura</td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>Poor feeding</td>
<td></td>
<td>Pustules</td>
</tr>
<tr>
<td>Prior infant with GBS</td>
<td></td>
<td>Gastrointestinal</td>
<td>Cellulitis</td>
</tr>
<tr>
<td>Maternal GBS bacteriuria</td>
<td><strong>Respiratory</strong></td>
<td>Vomiting (bilious!)</td>
<td>Exfoliation</td>
</tr>
<tr>
<td>Maternal GBS colonization</td>
<td>Apnea</td>
<td>Feeding intolerance</td>
<td></td>
</tr>
<tr>
<td>PROM &gt; 18 hours</td>
<td>Grunting, flaring</td>
<td>Distended abdomen</td>
<td></td>
</tr>
<tr>
<td>Intrapartum fever &gt; 38°C</td>
<td>Tachypnea</td>
<td>Diarrhea</td>
<td>Hypoglycemia</td>
</tr>
<tr>
<td>Lack of GBS-specific Ab</td>
<td>Retractions</td>
<td>Hematochezia</td>
<td>Hyperglycemia</td>
</tr>
<tr>
<td><strong>Hospital Acquired Sepsis</strong></td>
<td>Cyanosis</td>
<td>Hepatomegaly</td>
<td>Hyperlipidemia</td>
</tr>
<tr>
<td>Extreme prematurity</td>
<td></td>
<td>Splenomegaly</td>
<td>Hyponatremia</td>
</tr>
<tr>
<td>Prolonged antibiotic use</td>
<td><strong>Circulatory</strong></td>
<td></td>
<td>Acidosis</td>
</tr>
<tr>
<td>Prolonged TPN</td>
<td>Poor perfusion</td>
<td>Neurologic</td>
<td></td>
</tr>
<tr>
<td>Indwelling catheters</td>
<td>Congestive failure</td>
<td>Jitteriness</td>
<td></td>
</tr>
<tr>
<td>Postnatal steroid exposure</td>
<td>Shock</td>
<td>Seizures</td>
<td></td>
</tr>
<tr>
<td>Gastric antisecretory drugs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Community Acquired Sepsis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prematurity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal GBS colonization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of GBS-specific Ab</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The diagnostic evaluation of infants with suspected sepsis includes both indirect and definitive indicators of infection. The former consist of measurements of the inflammatory response, such as blood counts and measurement of serum acute phase reactant levels (CRP, procalcitonin, IL-6, etc). These tests are notoriously unreliable for early diagnosis of sepsis. The performance of standard hematological measurements (note low sensitivity and PPV) is shown in Table 2. Acute phase reactants, such as C-reactive protein (CRP) are similarly insensitive early in an infection, as shown in Table 9 (see below).

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>I:T &gt; 0.15*</td>
<td>96%</td>
<td>71%</td>
<td>25%</td>
<td>99%</td>
</tr>
<tr>
<td>↑ or ↓ PMNs*</td>
<td>96%</td>
<td>61%</td>
<td>20%</td>
<td>99%</td>
</tr>
<tr>
<td>I:M ≥ 0.3</td>
<td>93%</td>
<td>81%</td>
<td>32%</td>
<td>99%</td>
</tr>
<tr>
<td>Bands &gt; 1500*</td>
<td>63%</td>
<td>69%</td>
<td>17%</td>
<td>95%</td>
</tr>
<tr>
<td>↑ or ↓ WBC †</td>
<td>44%</td>
<td>92%</td>
<td>36%</td>
<td>94%</td>
</tr>
<tr>
<td>WBC degenerative changes**</td>
<td>33%</td>
<td>95%</td>
<td>39%</td>
<td>93%</td>
</tr>
<tr>
<td>Platelets ≤ 150,000</td>
<td>22%</td>
<td>99%</td>
<td>60%</td>
<td>93%</td>
</tr>
</tbody>
</table>

* based on data of Manroe, 1979, as shown in Figure 6
† WBC ≤ 5K or ≥ 25K, 30K, or 21K at birth, 12-24h, or after 24 h, respectively
** ≥ 3+ per Zipursky, 1976

Figure 6. Normal white blood cell counts for newborn infants. From Manroe 1979. The performance of blood counts can be improved by combining observations into a hematological score, as shown in Table 3.
Table 3. Performance of Hematological Scoring System for Early-Onset Sepsis

<table>
<thead>
<tr>
<th>Score*</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 1</td>
<td>100%</td>
<td>41%</td>
<td>14%</td>
<td>100%</td>
</tr>
<tr>
<td>≥ 2</td>
<td>100%</td>
<td>63%</td>
<td>21%</td>
<td>100%</td>
</tr>
<tr>
<td>≥ 3</td>
<td>96%</td>
<td>78%</td>
<td>31%</td>
<td>99%</td>
</tr>
<tr>
<td>≥ 4</td>
<td>89%</td>
<td>89%</td>
<td>45%</td>
<td>99%</td>
</tr>
<tr>
<td>≥ 5</td>
<td>41%</td>
<td>96%</td>
<td>52%</td>
<td>94%</td>
</tr>
<tr>
<td>≥ 6</td>
<td>22%</td>
<td>100%</td>
<td>86%</td>
<td>93%</td>
</tr>
</tbody>
</table>

* 1 point each for I:T > 0.15, ↑ or ↓ neutrophils, I:M ≥ 0.3, bands > 1500/mm³, ↑ or ↓ WBC, degenerative WBC Δ, or platelets ≤ 150,000; 2 points for no circulating neutrophils (see Table 2)

The more reliable performance of hematological testing at 12-24 hours of age (Table 4) has prompted recommendation of delayed testing to screen for early-onset sepsis (Figure 5).

Table 4. Performance of Delayed Blood Counts in Early-Onset Sepsis

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manroe¹²</td>
<td>68%</td>
<td>45%</td>
<td>43%</td>
<td>70%</td>
</tr>
<tr>
<td>Rodwell¹⁰</td>
<td>63%</td>
<td>55%</td>
<td>46%</td>
<td>71%</td>
</tr>
<tr>
<td>At 12-24 hours:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manroe¹²</td>
<td>100%</td>
<td>50%</td>
<td>56%</td>
<td>100%</td>
</tr>
<tr>
<td>Rodwell¹⁰</td>
<td>100%</td>
<td>73%</td>
<td>73%</td>
<td>100%</td>
</tr>
</tbody>
</table>

There is little evidence that screening tests add to serial examinations every 2 to 4 hours over the first 24 hours after birth, however, so that approach (which should now be our practice at LPCH) is now an accepted alternative.

Definitive diagnosis of neonatal sepsis requires cultures, which should be obtained from one of the following nonpermissive sites:
- blood, whenever antibiotics are initiated or changed to broaden antibacterial coverage
- endotracheal aspirates, from babies with respiratory distress and a pulmonary infiltrate
- urine, in neonates > 72 hours of age
- cerebrospinal fluid, in neonates with clinical signs of illness or a positive blood culture

True-positive blood cultures are very likely to be positive after incubation for 36 hours (Figure 7A); those reported as positive after 48 hours of incubation are likely spurious, so 36 hours is sufficient for detection of 95% of true-positive results¹³. However, up to 40% of bacteremic infants may have negative blood cultures, so continuation of treatment despite negative cultures may be appropriate if there are other clinical or laboratory signs of serious bacterial infection.
Figure 7. Utility of bacterial cultures in suspected neonatal sepsis. A. Time to detection of positive blood cultures\textsuperscript{13}. B. Utility of tracheal aspirate cultures\textsuperscript{14}. C. Yield of urine cultures by postnatal age\textsuperscript{15}. D. Yield of blood cultures in culture-proven bacterial meningitis\textsuperscript{16}.

Cultures of tracheal aspirates are valuable adjuncts to blood cultures in infants with respiratory distress and pulmonary infiltrates\textsuperscript{14}. In 3 to 4% of these patients, tracheal aspirates will yield the only bacteriological diagnosis (a positive tracheal culture with a negative blood culture; Figure 7B). Tracheal aspirate cultures therefore should be sent upon intubation of such infants, but intubation solely for the purpose of obtaining cultures is probably not justified. Tracheal aspirate cultures are not useful in infants who have been intubated for more than a day or two (even if the endotracheal tube has been just replaced), as those cultures reflect only bacterial colonization of the chronically instrumented airway. (The one exception to this is that tracheal colonization with Candida is strongly associated with development of disseminated disease within the following week, and should be treated.)

Urine cultures obtained in the first 72 hours after birth are unlikely to produce additional diagnostic information; fewer than 1% of infants evaluated will have an isolated positive urine culture\textsuperscript{15}. Specimens obtained in older infants are likely to be informative, however, as urine will be the sole source of bacteria in about 5% of them (Figure 7C). Collection technique for urine cultures is critical. Bacterial culture of “bag” specimens is useless in neonates; false-positive cultures are extremely frequent and they cannot be distinguished on the basis of low colony counts or isolation of a single bacterial strain (since heavy colonization with a single or strongly dominant strain is very common as infants acquire normal superficial microflora). Specimens obtained by urethral catheterization are better but are also often spuriously positive. The best and very strongly preferred method for urine collection for culture in neonates is suprapubic aspiration; results of these cultures are rarely ambiguous, as the presence of any organisms is abnormal.
CSF should be obtained in any infant with clinical signs of illness. CSF culture provides the only bacteriological diagnosis in 15-50% of infants with meningitis\(^{16}\), so the specimen should be obtained before or very soon after initiation of antibiotic treatment. It is unlikely that truly asymptomatic infants undergoing evaluation only for perinatal risk factors will have meningitis, so lumbar puncture can be deferred until there is a positive blood culture. In the latter instances, CSF cell counts and chemistries must be relied upon to diagnosis meningitis and determine the required length of therapy (see below). Normal ranges for CSF findings in neonates are summarized in Table 5. Bacterial meningitis is characterized by elevated WBC counts (predominantly granulocytic), low glucose levels, and high protein levels.

**Table 5. 95% Confidence Intervals for Cerebrospinal Fluid Analytes in Neonates\(^{17}\)**

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Preterm Infants</th>
<th>Term Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 7 days old</td>
<td>&gt; 7 days old</td>
</tr>
<tr>
<td>White blood cell count ((\mu)L)</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Protein (mg/dL)</td>
<td>213</td>
<td>203</td>
</tr>
</tbody>
</table>

**V. Treatment of Neonatal Sepsis**

**A. Empiric Initial Treatment**

Initial antibiotic coverage should be based on the bacteriology of each category of neonatal sepsis as delineated above, in accordance with the recommendations provided in Table 6.

**Table 6. Empiric Initial Treatment for Suspected Neonatal Sepsis**

<table>
<thead>
<tr>
<th>Patient Category</th>
<th>Initial Empiric Antibiotic Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early-onset sepsis</td>
<td>Ampicillin and gentamicin</td>
</tr>
<tr>
<td>Hospital acquired late-onset sepsis</td>
<td>Vancomycin and cefotaxime</td>
</tr>
<tr>
<td>Community acquired late-onset sepsis</td>
<td>Ampicillin and gentamicin or cefotaxime</td>
</tr>
</tbody>
</table>

Use of cefotaxime rather than gentamicin for early-onset neonatal sepsis is associated with higher mortality rates (Figure 8), so gentamicin is the preferred agent (along with ampicillin).

**Figure 8.** Empiric treatment with cefotaxime is associated with higher mortality rates in infants with suspected sepsis\(^{18}\) or meconium aspiration syndrome\(^{19}\).
**Figure 9.** Early-onset neonatal sepsis caused by ampicillin-resistant *E. coli* is more likely to occur in preterm infants\(^\text{20}\) (A) exposed to numerous doses of ampicillin before birth\(^\text{31}\) (B).

Cefotaxime should be considered (either instead of or in addition to gentamicin) in sick preterm infants whose mothers have received multiple antepartum antibiotic doses (because of the increased risk of resistance in *E. coli* isolates; Figure 9) and for infants with meningitis (because of superior penetration into the CNS and CSF).

Signs of skin or soft tissue infection, endocarditis, or osteomyelitis should raise concern for possible *Staphylococcus aureus* infection and receive antibiotics tailored to treat this pathogen. Until methicillin resistance is ruled out, vancomycin is the preferred drug.

**B. Adjustment of Treatment**

If changes are made to antibiotic coverage because of an unsatisfactory response to empiric therapy, the new antibiotics should be chosen to ensure coverage of resistant Gram-negative enteric bacilli (consider meropenem, piperacillin/tazobactam, ceftazidime, cefipime, or aztreonam) and *Staphylococcus aureus* (consider vancomycin). Remember that third-generation cephalosporins and carbapenems do not provide good coverage for *Listeria* or *Enterococcus*, and aztreonam does not cover *Listeria*, *Streptococcus* or *Enterococcus*.

Isolation of the causative organism from a nonpermissive site (see above) should prompt immediate narrowing of antibiotic coverage focused on the recovered bacterial isolate. Recommended responses to selected isolates are outlined in Table 7.

Coverage for anaerobic organisms is rarely necessary in neonates, because newborn infants (preterm infants < 7-14 days and term infants < 3-4 days of age) are rarely colonized with anaerobes, anaerobic infections are rare, and they appear to be well tolerated. Coverage for anaerobic organisms may be appropriate for older infants with bowel perforation and peritoneal soiling; clindamycin or metronidazole are appropriate agents.

When results of antimicrobial sensitivity become available, antibiotic coverage should be adjusted to use the most selective, least expensive, and (usually) oldest effective drug.

Certain isolates, including coagulase-negative *Staphylococcus* (in the first few days after birth), diphtheroids, *Corynebacterium*, and *Propionobacterium*, are likely spurious and can be ignored.
Table 7. Responses to Selected Positive Nonpermissive Culture Results

<table>
<thead>
<tr>
<th>Bacterial Isolate Reported</th>
<th>Response to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram-negative bacilli</td>
<td>Stop ampicillin or vancomycin</td>
</tr>
<tr>
<td>Gram-positive bacilli</td>
<td>Stop gentamicin or cefotaxime</td>
</tr>
<tr>
<td>Gram-negative cocci in pairs</td>
<td></td>
</tr>
<tr>
<td>Gram-positive cocci in pairs or chains</td>
<td>Stop gentamicin or cefotaxime</td>
</tr>
<tr>
<td>Gram-positive cocci in clusters</td>
<td>Stop gentamicin or cefotaxime, add vancomycin</td>
</tr>
<tr>
<td>Group B streptococci</td>
<td>Gentamicin (X 3 d), penicillin or ampicillin course</td>
</tr>
<tr>
<td><em>Staph. aureus</em>, methicillin-sensitive (MSSA)</td>
<td>Change to cefazolin or nafcillin</td>
</tr>
<tr>
<td><em>Staph. aureus</em>, methicillin-resistant (MRSA)</td>
<td>Change or narrow coverage to vancomycin</td>
</tr>
<tr>
<td>Coagulase-negative <em>Staph.</em></td>
<td>Change or narrow coverage to vancomycin</td>
</tr>
<tr>
<td><em>Enterococcus</em>, pencillin-sensitive</td>
<td>Change to penicillin+ gentamicin</td>
</tr>
<tr>
<td><em>Enterococcus</em>, vancomycin-sensitive</td>
<td>Change to vacomycin</td>
</tr>
<tr>
<td><em>Enterococcus</em>, vancomycin-resistant (VRE)</td>
<td>Change to linezolid</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>Stop vancomycin; use ampicillin+gentamicin</td>
</tr>
<tr>
<td><em>Escherichia coli</em>, ampicillin-resistant</td>
<td>Change to meropenem or piperacillin/tazobactam</td>
</tr>
<tr>
<td><em>Klebsiella</em></td>
<td>Change to ceftazidime + gentamicin</td>
</tr>
<tr>
<td><em>Serratia, Pseudomonas, Proteus, Acinetobacter, Citrobacter, Enterobacter</em></td>
<td>Change to Meropenem or Cefipime + Amikacin/Tobramycin</td>
</tr>
</tbody>
</table>

C. Duration of Treatment

Treatment can be discontinued when:
- it has been determined that the infant was not infected, or
- an effective course of therapy has been completed

Exclusion of sepsis depends upon absence of ongoing clinical signs of sepsis, negative culture results, and reassuring ancillary laboratory test results (Figure 5). A framework for deciding is provided in Table 8.

Table 8. Framework for Decision to Stop or Continue Antibiotic Treatment

<table>
<thead>
<tr>
<th>Infant Condition</th>
<th>Cultures</th>
<th>CRP</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well</td>
<td>Positive</td>
<td>Normal</td>
<td>Complete treatment*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elevated</td>
<td>Complete treatment</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>Normal</td>
<td>Stop treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elevated</td>
<td>Stop treatment</td>
</tr>
<tr>
<td>Sick</td>
<td>Positive</td>
<td>Normal</td>
<td>Complete treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elevated</td>
<td>Complete treatment*</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>Normal</td>
<td>Stop treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elevated</td>
<td>Continue treatment?</td>
</tr>
</tbody>
</table>

* consider spuriously positive culture, stopping antibiotics
Infants who remain well and have negative laboratory tests (including cultures) and those with positive cultures are the easy cases (no treatment and a full course of treatment, respectively). Well infants with negative culture results, in general, should also have antibiotic treatment stopped. Sick infants with negative cultures and normal CRP levels should have antibiotics discontinued, based on the excellent negative predictive of serial normal serum CRP levels (obtained 8-24 hours after the initial evaluation and again 24 hours later); those results reduce the probability that the baby was infected by 85% or more (Table 9). Sick infants with negative cultures and elevated CRP levels represent the most difficult case; blood cultures may be negative in up to 40% of infants who are bacteremic, so negative cultures alone may not be reassuring. These cases will require careful thought and clinical judgment.

Table 9. Diagnostic Utility of C-Reactive Protein Measurements

<table>
<thead>
<tr>
<th></th>
<th>Early-Onset Sepsis</th>
<th>Late-Onset Sepsis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRP #1*</td>
<td>CRP #2+3</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>35.0%</td>
<td>88.9%</td>
</tr>
<tr>
<td>Specificity</td>
<td>90.0%</td>
<td>73.8%</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>6.7%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>98.6%</td>
<td>99.7%</td>
</tr>
<tr>
<td>Posterior:prior likelihood ratio for normal results</td>
<td>0.72</td>
<td>0.15</td>
</tr>
<tr>
<td>Posterior:prior likelihood ratio for abnormal results</td>
<td>3.51</td>
<td>3.40</td>
</tr>
</tbody>
</table>

* CRP #1 = CRP at initial evaluation, CRP #2+3 = delayed CRP level 24 hours apart

The data provided in Table 9 support the utility of CRP levels for retrospective exclusion of sepsis, they do not support use of CRP levels for screening early in the course of illness (note the low sensitivity of CRP #1 for both early- and late-onset sepsis). Similarly, the positive predictive value for early-onset culture-proven sepsis of elevated CRP levels is modest (Figure 10A). Elevated CRP levels therefore should not compel prolonged treatment of suspected early-onset sepsis; they merit more concern in late-onset cases (Figure 10B). An elevated CRP level with negative blood cultures, especially in an asymptomatic baby should prompt a search for nonbacterial causes of CRP elevation (Table 10)

Table 10. Some Nonbacterial Causes of CRP Elevation

| Chorioamnionitis (without fetal infection) | Renal artery or vein thrombosis | Severe viral infections (CMV, enteroviruses) |
| Isoimmune hemolysis                        | Necrotizing enterocolitis        | Cephalohematoma                                |
| Myelodysplastic syndrome                    | Gastrochisis                     | Subgaleal hematoma                              |
| Meconium aspiration                        | Clavicular or humeral fracture   | Cerebral infarction                             |
| Surgical procedures                        | Epidermolysis bullosa            | Prostaglandin infusion                         |
Figure 10. Positive predictive values of CRP levels for early- (A) and late-onset (B) proven (open bars) or proven/suspected sepsis (solid bars). Confirmed cases of serious bacterial infection require treatment of sufficient duration to ensure complete cure. There is very little empirical evidence to establish minimum durations of effective treatment, so we must rely upon prior experience with standard treatment intervals. These are summarized in Table 11.

Table 11. Traditional Treatment Intervals for Neonatal Infections

<table>
<thead>
<tr>
<th>Condition</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis, pneumonia, cellulitis</td>
<td></td>
</tr>
<tr>
<td>Gram-positive: 10 days</td>
<td></td>
</tr>
<tr>
<td>Gram-negative: 14 days</td>
<td></td>
</tr>
<tr>
<td>Meningitis</td>
<td></td>
</tr>
<tr>
<td>Gram-positive: 14 days</td>
<td></td>
</tr>
<tr>
<td>Gram-negative: 21 days</td>
<td></td>
</tr>
<tr>
<td>Osteomyelitis or septic arthritis</td>
<td>4-6 weeks</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>4-8 weeks</td>
</tr>
</tbody>
</table>

Some recent publications have suggested treatment until CRP levels return to normal. This approach has not been adequately evaluated and should not be adopted.

References:


Appendix: Annotations to Figure 5

1. PPROM: Preterm (< 37 weeks) premature (before onset of labor) rupture of membranes.

2. Chorioamnionitis: A clinical diagnosis based upon intrapartum fever and additional findings (uterine tenderness, foul-smelling vaginal discharge, fetal or maternal tachycardia, maternal leukocytosis). The diagnosis made by the obstetrician should be considered definitive.

3. PROM: Prolonged rupture of membranes (> 18 hours).

4. NAAT: Nucleic acid amplification test, also known as rapid PCR, for GBS colonization.

5. IAP: Intrapartum antibiotic prophylaxis, which should consist of Penicillin G, 5 million units IV initial dose, then 2.5–3.0 million units† every 4 hrs until delivery or Ampicillin, 2 g IV initial dose, then 1 g IV every 4 hrs until delivery; Patients with a history of allergy to penicillin should receive Cefazolin, 2g IV initial dose, then 1 g IV every 8 hrs until delivery unless there is an allergy history of anaphylaxis, angioedema, respiratory distress, or urticaria after receiving penicillin or a cephalosporin? The latter patients should receive vancomycin unless sensitivity testing of the maternal GBS isolate demonstrates sensitivity to erythromycin and clindamycin, in which case clindamycin should be used.

6. Limited evaluation for sepsis includes blood culture at birth and a complete blood count with differential either at birth or at 6-12 hours of age. Full diagnostic evaluation includes a blood culture, a complete blood count (CBC) including white blood cell differential and platelet counts, chest radiograph (if respiratory abnormalities are present), and lumbar puncture (if the patient is stable enough to tolerate the procedure and sepsis is suspected).

7. If ≥ 37 weeks gestational age, observation may occur at home after 24 hours if other discharge criteria have been met, access to medical care is readily available, and a person who is able to comply fully with instructions for home observation will be present. If any of these conditions is not met, the infant should be observed in the hospital for at least 48 hours and until discharge criteria are achieved.

8. A complete course of antibiotics requires treatment for 7 to 21 days (or longer), depending on the nature of the infection and the causative organism (see Table 11).
POLICY STATEMENT

Recommendations for the Prevention of Perinatal Group B Streptococcal (GBS) Disease

COMMITTEE ON INFECTIOUS DISEASES AND COMMITTEE ON FETUS AND NEWBORN

KEY WORDS
- group B Streptococcus, early onset, diagnosis, prophylaxis, penicillin allergy, treatment

ABBREVIATIONS
- GBS — group B streptococcal/Streptococcus
- IAP — intrapartum antibiotic prophylaxis
- CDC — Centers for Disease Control and Prevention
- CBC — complete blood cell

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abstract

The Centers for Disease Control and Prevention (CDC) guidelines for the prevention of perinatal group B streptococcal (GBS) disease were initially published in 1996. The American Academy of Pediatrics (AAP) also published a policy statement on this topic in 1997. In 2002, the CDC published revised guidelines that recommended universal antenatal GBS screening; the AAP endorsed these guidelines and published recommendations based on them in the 2003 Red Book. Since then, the incidence of early-onset GBS disease in neonates has decreased by an estimated 80%. However, in 2010, GBS disease remained the leading cause of early-onset neonatal sepsis. The CDC issued revised guidelines in 2010 based on evaluation of data generated after 2002. These revised and comprehensive guidelines, which have been endorsed by the AAP, reaffirm the major prevention strategy — universal antenatal GBS screening and intrapartum antibiotic prophylaxis for culture-positive and high-risk women — and include new recommendations for laboratory methods for identification of GBS colonization during pregnancy, algorithms for screening and intrapartum prophylaxis for women with preterm labor and premature rupture of membranes, updated prophylaxis recommendations for women with a penicillin allergy, and a revised algorithm for the care of newborn infants. The purpose of this policy statement is to review and discuss the differences between the 2002 and 2010 CDC guidelines that are most relevant for the practice of pediatrics. Pediatrics 2011;128:000

INTRODUCTION

Group B streptococcal (GBS) disease has been a leading cause of neonatal morbidity and mortality since the 1970s. Maternal colonization with GBS in the genitourinary or gastrointestinal tract and transmission to the infant during the labor and delivery process is the principal risk factor for early-onset invasive GBS disease. Women who are identified as being GBS-colonized through culture-based screening are more than 25 times more likely to deliver an infant with early-onset infection than are women with negative prenatal cultures. Identification of maternal colonization through universal, culture-based screening with intrapartum antibiotic prophylaxis (IAP) for women with positive screening results has been recommended since 2002. This strategy, endorsed by the American Academy of Pediatrics, has been widely adopted in the United States and has resulted in an estimated 80% decrease in early-onset GBS infection.
TABLE 1 Evidence-Based Rating System Used to Determine Strength of Recommendations

<table>
<thead>
<tr>
<th>Strength of recommendation</th>
<th>Definition</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Strong evidence for efficacy and substantial clinical benefit</td>
<td>Strongly recommended</td>
</tr>
<tr>
<td>B</td>
<td>Strong or moderate evidence for efficacy, but only limited clinical benefit</td>
<td>Generally recommended</td>
</tr>
<tr>
<td>C</td>
<td>Insufficient evidence for efficacy, or efficacy does not outweigh possible adverse consequences</td>
<td>Optional</td>
</tr>
<tr>
<td>D</td>
<td>Moderate evidence against efficacy or for adverse outcome</td>
<td>Generally not recommended</td>
</tr>
<tr>
<td>E</td>
<td>Strong evidence against efficacy or for adverse outcome</td>
<td>Never recommended</td>
</tr>
<tr>
<td>Quality of evidence supporting recommendation</td>
<td>Evidence from at least 1 well-executed randomized, controlled trial or 1 rigorously designed laboratory-based experimental study that has been replicated by an independent investigator</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Evidence from at least 1 well-designed clinical trial without randomization, cohort or case-controlled analytical studies (preferably from more than 1 center), multiple time-series studies; dramatic results from uncontrolled studies; or some evidence from laboratory experiments</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Evidence from opinions of respected authorities based on clinical or laboratory experience, descriptive studies, or reports of expert committees</td>
<td></td>
</tr>
</tbody>
</table>


However, even in the era of universal screening, cases of GBS disease continue to occur. To evaluate data published after the Centers for Disease Control and Prevention (CDC) issued guidelines for the prevention of GBS perinatal disease in 2002, the CDC called a meeting of clinical and public health representatives in June 2009. The goal of the meeting was to identify potentially modifiable reasons for continued GBS disease and to address these issues. The American Academy of Pediatrics was represented by members of its Committee on Infectious Diseases and Committee on Fetus and Newborn. The purpose of this policy statement is to review and discuss the differences between the 2002 and 2010 CDC guidelines that are most relevant for the practice of pediatrics. Table 1 outlines the evidence-based rating system that supports each recommendation; strength (indicated by a letter) and quality (indicated by a roman numeral) of evidence are shown in parentheses. The 2010 CDC guidelines can be accessed online (www.cdc.gov/groupbstrep/guidelines/guidelines.html).

LABORATORY DIAGNOSIS OF GBS COLONIZATION

The 2002 guidelines from the CDC recommended universal culture-based screening for GBS at 35 to 37 weeks of gestation. In the intervening years, new diagnostic technologies have been developed, including pigmented enrichment broths, chromogenic agars, DNA probes, and nucleic acid amplification tests (NAATs). These methods have been validated for antenatal testing for GBS colonization and are used in many clinical laboratories, which enables more rapid identification of GBS. A positive test result for GBS by culture, DNA probe, or NAAT performed during antenatal screening indicates colonization, and the woman should receive IAP. However, infants with early-onset GBS can be born to women with negative antenatal screening results, because all laboratory-screening methods are imperfect. Culture-based screening, especially if processing in the laboratory does not always follow the CDC guidelines, may not identify all colonized women. Infants with signs and symptoms of sepsis should be managed according to the neonatal algorithm (Fig 1) and receive an initial antibiotic regimen that includes ampicillin regardless of maternal screening results.

Recommendations

- Options for GBS identification from culture of maternal vaginal/rectal swabs have been expanded to include a positive identification from chromogenic agar media. Identification of GBS directly by nucleic acid amplification tests (NAATs), such as commercially available polymerase chain reaction assays, can also be used after broth enrichment if laboratories have validated their NAAT performance and instituted appropriate quality controls (CII).

INTRAPARTUM ANTIBIOTIC PROPHYLAXIS

Penicillin and ampicillin have each been demonstrated in controlled clinical trials to be effective in preventing early-onset GBS disease when administered during labor. Penicillin and ampicillin at the recommended dosages for IAP rapidly achieve therapeutic concentrations in the fetal circulation and then amniotic fluid. Cefazolin has similar pharmacokinetics when compared with penicillin, and IAP dos-
FIGURE 1
Algorithm for the prevention of early-onset GBS infection in the newborn. (Adapted with permission from Centers for Disease Control and Prevention. Prevention of perinatal group B streptococcal disease: prevention of perinatal group B streptococcal disease from CDC, 2010. MMWR Recomm Rep. 2010;59(RR-10):1–32.) a Full diagnostic evaluation includes a blood culture, CBC count, including white blood cell differential and platelet counts, chest radiograph (if respiratory abnormalities are present); and lumbar puncture (if the patient is stable enough to tolerate procedure and sepsis is suspected). b Antibiotic therapy should be directed toward the most common causes of neonatal sepsis, including intravenous ampicillin for GBS and coverage for other organisms (including Escherichia coli and other Gram-negative pathogens) and should take into account local antibiotic-resistance patterns. c Consultation with obstetric providers is important in determining the level of clinical suspicion for chorioamnionitis. Chorioamnionitis is diagnosed clinically, and some of the signs are nonspecific. d Limited evaluation includes blood culture (at birth) and CBC count with differential and platelets at birth and/or at 6–12 hours of life. e GBS prophylaxis is indicated if 1 or more of the following is true: (1) mother is GBS-positive within the preceding 5 weeks; (2) GBS status is unknown and there are 1 or more intrapartum risk factors, including <27 weeks’ gestation, rupture of membranes for ≥18 hours, or temperature of ≥100.4°F (38.0°C); (3) GBS bacteriuria during current pregnancy; or (4) history of a previous infant with GBS disease. f If signs of sepsis develop, a full diagnostic evaluation should be performed, and antibiotic therapy should be initiated. g If at ≥37 weeks’ gestation, observation may occur at home after 24 hours if other discharge criteria have been met, and there is ready access to medical care, and a person who is able to comply fully with instructions for home observation will be present. If any of these conditions is not met, the infant should be observed in the hospital for at least 48 hours and until discharge criteria have been achieved. h Some experts recommend a CBC count with differential and platelets at 6 to 12 hours of age. i IV indicates intravenously.

ing achieves high intra-amniotic concentrations. Cefazolin has been the preferred alternative for IAP for penicillin-allergic women at low risk of anaphylaxis since 2002, although it has been used uncommonly for this indication. At least 4 hours of IAP with one of these β-lactam antibiotics is effective in preventing early-onset GBS disease in neonates. The definition of adequate IAP has been clarified to include penicillin, ampicillin, or cefazolin for at least 4 hours before delivery. Duration of IAP shorter than 4 hours and all other regimens, including clindamycin and vancomycin, are considered to be inadequate prophylaxis for infants because of lack of data regarding efficacy and limited data regarding favorable pharmacokinetics. No clinical trials have evaluated the efficacy of non-β-lactam regimens for IAP in women with serious penicillin allergy. Although clindamycin is the most commonly chosen IAP regimen in the United States for penicillin-allergic women at low risk of anaphylaxis, current data indicate that approximately 20% of GBS isolates are resistant to clindamycin. Clindamycin should never be used for IAP if susceptibility testing of the mother’s GBS isolate has not been performed. Several recent studies have revealed that susceptibility testing is rarely performed on GBS isolates, and early-onset GBS disease has been reported in infants born to mothers who have received clindamycin IAP.

Recommendations
- Penicillin remains the agent of choice for IAP, and ampicillin is an acceptable alternative (AI).
- Penicillin-allergic women who do not have a history of anaphylaxis, angioedema, respiratory distress, or urticaria after administration of penicillin or a cephalosporin should receive cefazolin (III).
- Penicillin-allergic women at high risk of anaphylaxis should receive clindamycin if their GBS isolate is susceptible or vancomycin if their GBS isolate is intrinsically resistant to clindamycin (CIII).
- The definition of adequate IAP has been clarified to be at least 4 hours of penicillin, ampicillin, or cefazolin. The initial intravenous dose of penicillin is 5 million units; for ampicillin and cefazolin, the initial dose is 2 g (AIII).
- All other antibiotics, doses, or durations are considered inadequate for the purposes of neonatal management (AIII).

PREVENTION OF EARLY-ONSET GBS DISEASE
The revised 2010 GBS American Academy of Pediatrics guidelines for neonatal management were designed to broaden the scope to include all neonates, to increase the clarity of the recommendations, and to decrease un-
necessary laboratory evaluations and empirical antibiotics for infants at low risk. Although this strategy will never prevent all infections, the revised guidelines should result in a further decrease in cases of perinatal GBS disease. The management of neonates continues to be based on clinical signs, the presence of maternal risk factors for GBS neonatal disease, and the likely efficacy of IAP (or maternal antimicrobial treatment in the case of clinical or occult chorioamnionitis) in preventing early-onset disease. The revised infant management algorithm (Fig 1) is derived from recent data summarized in the published COC document regarding the epidemiology of GBS disease and the usefulness of a “limited evaluation” of well-appearing neonates.

All newborn infants with signs suggestive of sepsis should have a full diagnostic evaluation, including a lumbar puncture if the infant is stable enough to undergo the procedure; 15% to 35% of infants with early-onset meningitis have sterile blood cultures, so evaluating the cerebrospinal fluid is required for optimal diagnostic sensitivity.16-21 If the care provider believes that a noninfectious condition is responsible for the infant’s signs (eg, transient tachypnea of the newborn) and there are no maternal risk factors for sepsis in an otherwise well-appearing infant, the lumbar puncture can be deferred or eliminated. Empirical antimicrobial therapy, typically intravenous ampicillin and gentamicin (unless local antibiotic-resistance patterns suggest the need for another combination), then should be initiated promptly. Chorioamnionitis continues to be a significant risk factor for early-onset GBS sepsis in infants born to GBS colonized women. All well-appearing newborn infants born to women who have a clinical diagnosis of chorioamnionitis from their obstetric provider should undergo a “limited evaluation,” which includes a complete blood cell (CBC) count and differential and a blood culture before initiation of empirical antimicrobial therapy. The sensitivity of the CBC count is improved if delayed for 6 to 12 hours after birth. Empirical therapy should be discontinued as soon as the clinical course and laboratory evaluation exclude sepsis.

The indications for maternal IAP remain unchanged and include 1 of more of the following: (1) GBS culture-positive within preceding 5 weeks; (2) GBS status unknown with 1 or more intrapartum risk factors including less than 37 weeks’ gestation, prolonged rupture of membranes for ≥18 hours, or temperature of ≥100.4°F (38.0°C); (3) GBS bacteruria during current pregnancy; and (4) history of a previous infant with GBS disease. When a cesarean delivery is performed before onset of labor with intact amniotic membranes, the risk of early-onset GBS disease among infants is extremely low.22,23 Therefore, IAP is not recommended as a routine practice for cesarean deliveries performed under these circumstances, regardless of the GBS colonization status of the woman or the gestational age of the infant.

In well-appearing newborn infants born to women without an indication for IAP, routine clinical care is indicated unless signs of sepsis develop. For well-appearing term newborn infants born to mothers with an indication for IAP to prevent GBS disease and receipt of 4 or more hours of penicillin, ampicillin or cefazolin at the appropriate doses before delivery, routine care, and 48 hours of observation continue to be recommended. However, if these infants meet other discharge criteria, including term birth and ready access to medical care, discharge can occur as early as 24 hours after birth. In this latter circumstance, follow-up care by a care provider within 48 to 72 hours is recommended.

In well-appearing term newborn infants whose mothers had an indication for GBS prophylaxis and rupture of membranes for <18 hours but who received inadequate IAP—either by duration before delivery or by inappropriate agent or dose—observation in the hospital for at least 48 hours is recommended. These infants would include infants born to women with a serious penicillin allergy who received either clindamycin or vancomycin. This revised recommendation is based on the poor sensitivity of the “limited-evaluation” assessments in this circumstance and also data indicating that signs of early-onset GBS sepsis appear in more than 98% of neonates within this interval of hospitalization.

The authors of several studies have reported the sensitivity of an abnormal CBC count in predicting GBS sepsis to range from 41% to 68%, whereas the presence of clinical signs has a sensitivity of 92%.24-27 The yield of blood culture can be low among newborn infants exposed to intrapartum antibiotics.28 Finally, for all preterm neonates (<37 weeks of gestation) or for term newborn infants born in the setting of rupture of membranes 18 hours or more before delivery without adequate maternal IAP, a limited evaluation and observation for at least 48 hours is recommended.

Recommendations for Management of Newborn Infants

- All newborn infants with signs of sepsis should undergo a full diagnostic evaluation (including a lumbar puncture) and receive empirical antimicrobial therapy (All).

- All well-appearing newborn infants born to women given a diagnosis of chorioamnionitis by their obstetric provider should undergo a...
limited diagnostic evaluation (no lumbar puncture) and receive empirical antimicrobial therapy (AII).

- For all women who received adequate IAP defined as penicillin (preferred), ampicillin, or cefazolin (penicillin-allergic women at low risk of anaphylaxis) for 4 or more hours before delivery, their newborn infants require only routine care and observation in the hospital for 48 hours (BII). If these infants meet other discharge criteria, including term birth and ready access to medical care, discharge can occur as early as 24 hours after birth with follow-up care by a care provider within 48 to 72 hours (CII).

- Well-appearing term newborn infants whose mothers received no or inadequate IAP (including clindamycin or vancomycin) and had rupture of membranes for less than 18 hours require only observation for 48 hours (BII).

- Well-appearing term infants born to women with no or inadequate IAP and rupture of membranes for 18 or more hours before delivery should undergo a "limited evaluation" (ie, blood culture and CBC count with differential and platelets at birth) and observation for at least 48 hours (BII).

**REFERENCES**


Lumbar Puncture (Spinal Tap)

**Purpose:** To remove cerebrospinal fluid for diagnostic or therapeutic purposes.

I. Indications
   A. To obtain cerebrospinal fluid (CSF) for the diagnosis of central nervous system disorders such as meningitis or subarachnoid hemorrhage.
   B. To drain cerebrospinal fluid in communicating hydrocephalus.

II. Materials
   A. (3-4) specimen tubes
   B. Sterile drapes
   C. Sterile gauze
   D. Sterile gloves
   E. 22-gauge 1-1/2 inch spinal needle or 25 gauge 3/4 inch spinal needle with stylet
   F. Povidone-iodine solution with applicators (3)
   G. Alcohol wipes
   H. Bottle 70% alcohol

III. Procedure
   A. Clean the top of the procedure cart (or whatever surface is used to rest neonate on) with alcohol using a paper towel. Cover surface with a sterile drape.
   B. An assistant restrains the infant in a sitting or lateral decubitus position. The position to use depends on personal preference. Generally an intubated, critically ill infant must be treated in the lateral decubitus position. Some clinicians feel that if CSF cannot be obtained in the lateral decubitus position, the sitting position should be used. In the lateral decubitus position, the head and legs must be flexed (knee-chest position). Make sure airway patency is maintained.
   C. Once the infant is in position, check for landmarks. Palpate the iliac crest and slide your finger down to the interspace that falls immediately above or below a line drawn between the iliac crests (L3-L4 or L4-L5 interspace). It is sometimes easier to make a nail imprint at the exact location to mark the site.
   D. Prepare the materials.
   E. Put sterile gloves on.
   F. Clean the lumbar area with antiseptic solution, starting at the interspace selected. Prep in the following way:
      1. Clean the skin with povidone-iodine solution with an applicator starting in the center and working outward, wiping in a spiral pattern outward.
      2. Allow the povidone-iodine to dry on the patient’s skin. Antisepsis takes time to occur so it is important to allow the povidone-iodine to dry.
      3. Repeat steps 1 and 2 two more times.
      4. Remove the iodine solution by wiping the area with a sterile alcohol wipe starting in the center and working outward, wiping in a spiral pattern outward.
      5. The lumbar puncture site may be wiped with sterile gauze after the cleaning procedure.
   G. Drape the area with 1 towel under the infant and 1 towel covering everything but the selected interspace.
   H. Palpate again to find the selected interspace.
   I. Insert the needle in the interspace with steady force aimed toward the umbilicus.
   J. Advance the needle slowly 1-1.5 cm and then remove the stylet to check for appearance of fluid. One usually does not feel a “pop” as the ligamentum flavum and dura are penetrated, as is the case with older children and adults. Therefore, it is necessary to remove the stylet frequently to keep from going too far and getting a bloody specimen.
   K. Collect about 1 mL (10 drops) of CSF in each of the three sterile specimen tubes by allowing the fluid to drip into the tubes.
   L. Replace the stylet and withdraw the needle.
M. Maintain pressure on the area, and clean off the antiseptic solution.
N. For routine CSF examination, send 4 tubes of CSF to the laboratory.
1. Tube 1: For Gram stain, culture, and sensitivity.
2. Tube 2: For glucose and protein levels.
3. Tube 3: For cell count and differential.
4. Tube 4: for viral culture and/or HSV PCR.
O. If a blood specimen is obtained in the 1st tube, observe for clearing in the 2nd and 3rd tubes.
1. If bleeding clears, the tap was traumatic.
2. If blood does not clear but forms clots, a blood vessel has probably been punctured. Since CSF has not been obtained, a repeat tap may be done.
3. If blood does not clear and does not clot, the infant probably has intraventricular bleeding.

IV. Complications
A. Infection. If sterile technique is not used, bacteria may be introduced into the CSF and cause infection. Bacteremia may result if a blood vessel is punctured after the needle has passed through contaminated CSF.
B. Intraspinal epidermoid tumors can occur as a result of performing a lumbar puncture with a needle that does not have a stylet.
C. Herniation of cerebral tissue through the foramen magnum. This is not a common problem in neonatal intensive care units because of the open fontanelle in infants.
D. Spinal cord and nerve damage. To prevent this complication, do not use interspaces above L2.
E. Apnea and bradycardia sometimes occur from respiratory compromise caused by the infant being held too tightly during the procedure.
Mary L. Johnson Developmental and Behavioral Pediatric Program

The Developmental and Behavioral Unit (DBU) Model is an interdisciplinary model. This designation means that multiple disciplines evaluate and work with a child and family. They integrate their findings into a single, comprehensive, family-centered evaluation and plan.

I. Team Values

A. Family-centered practice: elicit family concerns, engage families in decision-making.

B. Active interdisciplinary teaming: efficient sharing of information.

C. Flexible role: definitions, willingness to assure comprehensive examination by stretching beyond conventional disciplinary boundaries.

D. Cultural humility: willingness to adapt recommendations as a function of culture, willingness to ask families about cultural and personal preferences.

E. Community inclusion: promoting the engagement of all children and families in their communities, regardless of abilities or needs.

II. Program

A. In-patient Johnson Center Developmental Program

1. The Developmental Care Team is comprised of infant development specialists including an educator, a psychologist, nurse practitioners, and physical and occupational therapists. The team’s purpose is to encourage relationship-based individualized developmental care to support parental attachment, support the developing nervous system of high-risk infants, make developmental recommendations for transition to home, and to promote access to community early intervention resources. Each baby referred for Developmental Care Team services will have a primary team member working with the family and the baby. The “primary” takes responsibility for documentation of the Developmental Assessment that will be noted in the Care Forms Section of the Electronic Medical Record in LINKS.

2. These Developmental Assessment findings and recommendations should be dictated into the Medical Discharge Summary to facilitate access to early intervention services and consistency in care.

3. Criteria for Referral to the Developmental Care Team:

   a. Birthweight <1500 gm
   b. Prolonged hospital course
   c. Suspected CNS abnormalities
   d. Syndromes associated with developmental compromise
   e. Maternal drug use
   f. Sensory impairment
   g. Congenital anomalies
   h. Status post-extracorporeal membrane oxygenation/persistent pulmonary hypertension of the newborn
   i. Any baby or family who needs extra support with developmental information/reading cues
B. High-Risk Infant Follow-up (HRIF) Program

1. As a tertiary center, Packard Children's Hospital is required by California Children Services (CCS) to offer follow-up for all eligible infants for a period of up to 3 yrs of age. Most infants are seen in the Neurosciences section of the Ambulatory Care Clinic at Lucile Salter Packard Children’s Hospital, or at the appropriate satellite clinic in Santa Cruz or Newark. Some infants may be seen in clinic regardless of CCS eligibility. See below for eligibility and process of referrals.

2. Purpose of evaluations
   
   a. Follow-up of children with risk factors for developmental compromise
   b. Early identification of developmental delays and disorders
   c. Referral to appropriate community-based services
   d. Referral for appropriate medical interventions
   e. Counseling families on appropriate child rearing and management strategies
   f. Reassurance, when appropriate
   g. Reduced likelihood of vulnerable child syndrome

3. HRIF Patients

   a. CCS HRIF eligibility

      1) CCS medical condition or approved NICU stay and the birth weight was <1500 gm or the gestational age at birth was <32 wks.

      2) If birth weight was >1500 gm and the gestational age at birth was >32 wks and 1 or more of the following:

         a) Cardiorespiratory depression at birth (defined as pH <7.0 on an umbilical blood sample or a blood gas obtained within 1 hr of life) or an Apgar score of ≤3 at 5 min.

         b) A persistently and severely unstable infant manifested by prolonged hypoxia, acidemia, hypoglycemia, and/or hypotension requiring pressor support.

         c) Persistent apnea, which required medication (e.g., caffeine) at discharge.

         d) Required oxygen for more than 28 days of hospital stay with radiographic evidence of chronic lung disease (CLD).

         e) Infants placed on ECMO.

         f) Infants who received inhaled nitric oxide >4 hrs for PPHN.

         g) History of documented seizure activity.

         h) Evidence of intracranial pathology, including but not limited to, intracranial hemorrhage (grade II or worse), periventricular leukomalacia (PVL), cerebral thrombosis, cerebral infarction, developmental central nervous system (CNS) abnormality or other CNS problems associated with adverse neurologic outcome.
d. When transporting a baby back to a community CCS-approved hospital please remind the community hospital to send their CCS registration and HRIF appointment request to:

DBP HRIF  
750 Welch Road, Suite 212  
Palo Alto, CA 94304

A copy of the NICU Medical Discharge Summary should accompany the referral.

e. Additional Information can be directed to Sheryl Goldstein RN, HRIF Coordinator.

7. Non-CCS referrals for HRIF (see II.B.4 above “Non-CCS HRIF eligibility”) are faxed to the Developmental and Behavioral Pediatrics Office 650/724-6500.

C. Preemie Graduate Services Program (PGS)

PGS provides access to resource referral and multidisciplinary team evaluations from age 3 through the school years for children born prematurely. Evaluations are highly individualized based on family concerns. Appropriate referral questions include, but are not limited to, poor school performance, motor difficulties, inattention, and difficulty making or keeping friends.

D. Outpatient Developmental Consultation Programs

For children who have a concerning aspect to their development, the team provides developmental consultations which facilitate diagnosis and entry into treatment. Inquiries can be directed to the Mary L. Johnson Developmental and Behavioral Pediatric Program Office at 650/725-8995.
i) Other problems that could result in a neurologic abnormality (e.g., history of CNS infection, documented sepsis, bilirubin in excess of usual exchange transfusion level, cardiovascular instability, hypoxic ischemic encephalopathy).

4. Non-CCS HRIF eligibility

a. Intrauterine drug exposure

b. Complex congenital heart disease that does not meet CCS criteria

5. Schedule

CCS supports 3 visits up to age 3 yrs. Additional visits before age 3 yrs for children as needed. Children with ongoing unmet needs are able to access the Preemie Graduate Services program after age 3 yrs.

<table>
<thead>
<tr>
<th>Evaluators</th>
<th>4 Months</th>
<th>12 Months</th>
<th>18-22 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD or NP</td>
<td>MD or NP</td>
<td>MD or NP</td>
<td>MD or NP</td>
</tr>
<tr>
<td>Social Worker</td>
<td>Social Worker</td>
<td>Social Worker</td>
<td>Social Worker</td>
</tr>
<tr>
<td>OT or PT</td>
<td>OT or PT, as needed</td>
<td>OT or PT, as needed</td>
<td>OT or PT, as needed</td>
</tr>
<tr>
<td>Dietitian, as needed</td>
<td>Dietitian, as needed</td>
<td>Dietitian, as needed</td>
<td>Dietitian, as needed</td>
</tr>
<tr>
<td>Special Requirements</td>
<td>Report results of hearing screening</td>
<td>Additional hearing tests for PPHN, ECMO, CMV</td>
<td>Plan for subsequent follow-up</td>
</tr>
<tr>
<td></td>
<td>Report follow-up of vision testing</td>
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</tbody>
</table>

6. Enrollment process in HRIF

a. The CCS HRIF enrollment process has changed. It is now the responsibility of the CCS-approved NICU discharging the baby to home to register the baby with CCS for HRIF and obtain an appointment.

b. Babies discharged from the LPCH intensive care nurseries will be registered by the CCS HRIF Coordinator. Appointments will be made prior to discharge (as long as primary care provider is listed in Cerner). A program brochure and letter about the appointment are provided to the family by either the Developmental Specialist or the Social Worker working with the family.

c. Appointment dates and times can also be viewed in Cerner.
Neonatal Withdrawal Scoring: Guideline and Definitions:

**Iatrogenic Exposure:** Infants who have received continuous or around the clock opiate medication for 3 days or greater, or more than 3 doses per day for greater than 5 days.
- Score every 4 hours; every 2 hours if score is 8 or greater.
- Every 4 hour scoring should continue until the patient is off all opiates for 48-72 hours.
- Consider weaning opiates by gradually decreasing the dose, not by increasing the dosing interval.

**Score Interventions for Opiate Weaning Iatrogenic Withdrawal:** Change opioids per orders, and reassess score in 1-2 hours

<table>
<thead>
<tr>
<th>Total score ≤8 for 24 hour period</th>
<th>Wean opioids by 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score &gt;8 for 3 consecutive scores</td>
<td>Increase opioid dose by 10%</td>
</tr>
<tr>
<td>Total Score &gt;12 for 2 consecutive scores</td>
<td>Increase opioid dose by 10%</td>
</tr>
</tbody>
</table>

**Prenatal Exposure:** Symptomatic while the toxicsology screen is pending/positive:
- Infants are assessed and scored at 2 hours of life.
- Score infants every 2 hours for the first 48 hours of life regardless of the score.
- After the first 48 hours of scores of 7 or less, the interval may be decreased to every 4 hours (or every three hours with feedings).
- For scores of 8 or greater at any time, increase scoring interval to every 2 hours for 24 hours or more.
- For scores consistently greater than 8, pharmacological intervention is indicated.
- Consider weaning opiates by gradually decreasing the dose, not by increasing the dosing interval.

**Score Interpretation for Abstinence Scoring Prenatal Exposure:**

<table>
<thead>
<tr>
<th>Total score 0-7</th>
<th>Low Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score 8-25</td>
<td>Moderate Risk</td>
</tr>
<tr>
<td>Total Score 26 or &gt;</td>
<td>High Risk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excessive High-Pitched Cry:</strong> Unable to use self-consoling measures (finger/fist sucking) or calm with interventions from the caregiver (holding, rocking, pacifier) from 5 seconds, up to 5 minutes</td>
</tr>
<tr>
<td><strong>Continuous High-Pitched Cry:</strong> Continues to cry intermittently or continuously &gt; 5 minutes despite consoling measures.</td>
</tr>
<tr>
<td><strong>Sleep:</strong> Scoring based on the longest period of sleep displayed, within the entire scoring interval.</td>
</tr>
<tr>
<td><strong>Hyperactive Moro:</strong> Exhibits pronounced jitteriness (slight jitteriness normal) of the hands during or at the end of a moro reflex.</td>
</tr>
<tr>
<td><strong>Marked Hyperactive Moro:</strong> Jitteriness and sustained clonus of the hands/arms (during or after a moro reflex).</td>
</tr>
<tr>
<td><strong>Mild Tremors Disturbed:</strong> Exhibits observable tremors of one or both hands/feet while being handled (disturbed).</td>
</tr>
<tr>
<td><strong>Moderate Tremors Disturbed:</strong> Exhibits observable tremors of arm(s) or leg(s).</td>
</tr>
<tr>
<td><strong>Mild Tremor Undisturbed:</strong> Same as mild tremors, while not being handled.</td>
</tr>
<tr>
<td><strong>Moderate-Severe Tremors Undisturbed:</strong> Same as moderate tremors, while not being handled.</td>
</tr>
<tr>
<td><strong>Increased Muscle Tone:</strong> Tone should be assessed when infant asleep or crying. No head lag when being pulled to sitting position/total body rigidity/tight flexion of arms and legs.</td>
</tr>
<tr>
<td><strong>Excoriation:</strong></td>
</tr>
<tr>
<td>------------------</td>
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<tr>
<td><strong>Myoclonic Jerks:</strong></td>
</tr>
<tr>
<td><strong>Sweating:</strong></td>
</tr>
<tr>
<td><strong>Yawning:</strong></td>
</tr>
<tr>
<td><strong>Excessive Sucking:</strong></td>
</tr>
</tbody>
</table>
| **Poor Feeding:** | 1. Infrequent sucking during feeding.  
2. Gulping formula or breast milk and stopping frequently to breathe (unless related to prematurity). |
Algorithm for Hearing Screening.

Universal Newborn Hearing Screening, Diagnosis, and Intervention
Guidelines for Pediatric Medical Home Providers

Birth
- Identify a Medical Home for every infant
- Hospital-based Infant Screening (OAE/ABR)
  - Results sent to Medical Home

Home Birth
- At least two hearing screenings
  - Birth
  - 6-12 months

Birth Screening
- Hospital-based Infant Screening (OAE/ABR)
  - Results sent to Medical Home

Outpatient Screening
- Hospital-based Infant Screening (OAE/ABR)
  - Results sent to Medical Home

Before 1 Month
- Pediatric Audiologic Evaluation
  - Otoacoustic Emission
  - Tympanometry
  - Audiometry

Before 3 Months
- Report to State HEHI Program
  - Every child with a permanent hearing loss
  - Refer to IDEA Part C
  - Coordinating agency for early intervention

Before 6 Months
- Medical Evaluation
  - To determine eligibility and identify related conditions
  - Ophthalmologic (referral)
  - Genetic
  - Developmental, pediatrics, audiology, cardiology, and neurology

Ongoing Care of All Infants from the Medical Home Provider
- Provide parents with information about hearing, speech, and language milestones
- Identify and aggressively treat middle ear disease
- Provide vision screening and referrals as needed
- Provide ongoing developmental surveillance and referral to appropriate resources

Ongoing Care of Infants who have the following risk indicators for late-onset hearing loss:
- Parental or caregiver concern regarding hearing, speech, language, and/or developmental delay
- Family history of permanent childhood hearing loss
- Siblings or other abnormalities associated with a syndrome known to include a sensorineural or conductive hearing loss or a syndrome that includes characteristics of both
- Neonatal infections associated with sensorineural hearing loss including bacterial meningitis
- In utero infections such as cytomegalovirus, herpes, rubella, syphilis, and toxoplasmosis
- Neonatal jaundice—specifically hyperbilirubinemia at a serum level requiring exchange transfusion
- Persistent pulmonary hypertension of the newborn associated with mechanical ventilation, and conditions requiring the use of extracorporeal membrane oxygenation
- Syndromes associated with progressive hearing loss such as neurofibromatosis, osteopetrosis, and Usher syndrome
- Neurocutaneous disorders, such as Sturge-Weber syndrome, or sensory motor neuropathies, such as Friedrich ataxia and Charcot-Marie-Tooth disease
- Head trauma
- Recurrent or persistent otitis media with effusion for at least 3 months

*OAE = Otoacoustic Emission
*ABR = Automated Auditory Brainstem Response
*HEHI = Health Insurance Portability and Accountability Act
*IDEA = Individuals with Disabilities Education Act

Notes
- Newborns with a birth screening who do not have a follow-up within 4 weeks will be re-screened at 1 month
- Newborns with a follow-up who have abnormal findings will be referred for a Pediatric Audiologic Evaluation
- Newborns with a follow-up who have normal findings will be re-screened at 1 month

January 2003

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Repeat ALGO recommendations for WBN and PICN

Perform ALGO at discharge (even if prior ALGO done):
- Infant received more than 4 days of gentamicin*
- Infant had phototherapy for hyperbilirubinemia (any level)

*Do not need to repeat ALGO before discharge if admitted for rule out sepsis and negative work-up (only 2-3 days of antibiotics)

Readmission:
An ALGO is required per state mandate on all babies readmitted to the nursery (WBN/NICU/PICN) from home. If the MD decides a repeat screen is not medically indicated then this needs to be documented, ideally on the discharge summary. These are reported to the state and proper documentation is required if LPCH is audited.

Audiology outpatient follow-up (within 1-2 months):
- For any infant receiving Gentamicin for 10 days or greater
- Bilirubin over 20 mg/dL
- See AAP algorithm for reasons for referral (ALGO not adequate screening test)