Follow-up Care of the Premature Infant

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Yale School of Medicine
Director, Yale NICU GRAD Program
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• I have no disclosures.
Learning Objectives

By the end of today’s session, you will be able to describe:

1. How the nutritional needs of the premature infant differs from those of a term infant
2. The projected growth and developmental trajectories for premature infants
3. The importance of multi-disciplinary follow-up programs in the post-discharge care of at risk infants.
WHY Follow-up: The importance of follow-up planning for all high-risk neonates

- Advances in neonatal intensive care have improved the survival of high-risk premature and critically ill full-term infants

- Continue to need comprehensive and multisubspecialty clinical care after discharge from the neonatal intensive care unit (NICU)
  - Medical
  - Nutritional
  - Developmental
  - Surveillance
WHY Follow-up: The importance of follow-up planning for all high-risk neonates

Policy Statement, 2008 (reaffirmed 2018)
Hospital Discharge of the High-Risk Neonate

“To ensure continuity of care after discharge, infants with unresolved medical issues that persist after their hospital stay should be comanaged by a neonatologist or other medical subspecialist from the hospital at which most of the care was provided.”

“Most high-risk infants should also be enrolled in a follow-up clinic that specializes in the neurodevelopmental assessment of high-risk infants. This neurodevelopmental follow-up is sometimes integrated with the child’s visits to the neonatologist. Standardized assessments should be performed in the follow-up clinic at specific ages through early childhood.”
WHY Follow-up: A focus on growth

- Growth impairment during early infancy can have permanent detrimental effects.

  - Preterm infants are at risk for poor growth while in the neonatal intensive care unit (NICU) and after NICU discharge.

  - Abnormalities in growth during this time period may persist into adulthood, especially in patients who were born premature.

All premature infants require nutrition monitoring & intervention
What our premature infants *missed* in the third trimester

Period of major nutrient mobilization for growth and development:
- IUGR
- EUGR
- Mineral deposition
- Poor neurodevelopmental outcomes

Maturation of gastrointestinal tract:
- Decreased motility
- Reduced enzyme activity
- Malabsorption
Nutritional needs of the premature infant...

- Exceed those of the full term infant
- Feeding choice is important:
  - Increased caloric and mineral requirements
  - Human milk recommended
  - Human milk fortifier (HMF) for preterm infants weighing <2kg at birth (24kcal)
  - Preterm formulas (e.g. Similac Special Care High Protein 24kcal) up to 2.2kg or 36 weeks
  - Transitional formulas/fortification (e.g. Enfacare, Neosure) for discharge home
- Some infant populations require higher caloric density (BPD, CHD, etc.)
- Timing of transition to term formula depends on individual growth velocity:
  - Common to continue transitional formula until infant is gaining weight steadily, taking oral feedings well, and self-regulating intake (4-9 months).
  - Some providers will continue use until the infant has reached at least the 10-50th percentile weight for corrected age.

*All preterm infants should stay on human milk and/or formula until 12mo corrected age*
Breast(milk) is best...

Current guidelines:
- Recommended for the first 6 months of age and up to age 1
  - WHO, AAP
- Reduces risk of
  - Infection
  - Hospitalizations
  - Chronic disease
  - Non-specific gastroenteritis
  - NEC

Things to consider for premature infants:
- BM is lower in iron & vitamin D, kcal, protein, vitamins and minerals than formula
- Increased nutrient and calorie needs
- Less coordinated suck/swallow
- Tire easily, less endurance
### Increased Energy & Nutrient Needs

#### Premature Infant

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>110-130 kcal/kg</td>
</tr>
<tr>
<td>Protein</td>
<td>2.5-3.5 g/kg</td>
</tr>
<tr>
<td>Fat</td>
<td>4.8-6.6 g/kg</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>400-1000 IU/day</td>
</tr>
<tr>
<td>Iron</td>
<td>2-3 mg/kg</td>
</tr>
<tr>
<td>Calcium</td>
<td>120-200 mg/kg</td>
</tr>
<tr>
<td>Sodium</td>
<td>69-115 mg/kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>78-195 mg/kg</td>
</tr>
</tbody>
</table>

#### Term Infant

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>108 kcal/kg</td>
</tr>
<tr>
<td>Protein</td>
<td>2.2 g/kg</td>
</tr>
<tr>
<td>Fat</td>
<td>31 g/day</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>400 IU/day</td>
</tr>
<tr>
<td>Iron</td>
<td>0.27 mg/day</td>
</tr>
<tr>
<td>Calcium</td>
<td>200 mg/day</td>
</tr>
<tr>
<td>Sodium</td>
<td>120 mg/day</td>
</tr>
<tr>
<td>Potassium</td>
<td>400 mg/day</td>
</tr>
</tbody>
</table>
## Nutrition Composition Comparison

<table>
<thead>
<tr>
<th>Nutrition</th>
<th>Breastmilk</th>
<th>Fortified BM</th>
<th>Preterm Transitional Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong></td>
<td>13-20</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>(kcal/oz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>1.5</td>
<td>2.8</td>
<td>3.0</td>
</tr>
<tr>
<td>(g/100 kcal)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>0.35</td>
<td>X</td>
<td>14.6</td>
</tr>
<tr>
<td>(mg/L)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>41</td>
<td>175</td>
<td>168-182</td>
</tr>
<tr>
<td>(mg/100 kcal)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phosphorus</strong></td>
<td>21</td>
<td>98</td>
<td>84-101</td>
</tr>
<tr>
<td>(mg/100 kcal)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Iron & Vitamin D Supplementation

- 14% preterm infants develop iron deficiency between age 4-8 months

- Iron deficiency is associated with
  - Poor neurocognitive development
  - Lower Bayley Psychomotor Developmental Stores

**GOAL:**
Iron: 2 mg/kg/day
Vitamin D: 400 IU/day

Premature infants receiving breastmilk and fortified breastmilk:
- Supplemental multivitamin and iron
- Begin at 1 month of age
- Continue to age 1 year

Infants on Transitional or Term formulas:
- Likely meeting iron nutrient needs
- May need additional nutrients
- Should receive multivitamin if taking:
  < 800 ml of transitional formula
  < 1000 ml term formula
Assessing Growth: Nutrition Assessment

- Growth trends
- Weight gain velocity
- Dietary intake and adequacy
- Feeding difficulties
- Developmental milestones
- Malnutrition

We need the WHOLE picture!
Premature Growth & Feeding Milestones

**Growth** is corrected for prematurity until a corrected age of 2 years or until infants plot solidly on standard growth curves.

Tracking growth:

- Fenton (up to 50 weeks of age)
- WHO (50 weeks -2 years), corrected for prematurity
- CDC (beyond 2 years)

*Track height, weight, head circumference and growth velocity*

*Monitor for abnormal catch-up growth patterns*
Growth Charts - WHO

Girls 0-2 years   Boys 0-2 years
Height/age   Weight/age   Head circumference/age   Weight/Length
Goals for Premature Growth

- **Ultimate goal** is to achieve the same body composition and be gaining at the same weight and length velocity as a full term infant of the same corrected age.
- Time to reach this goal varies by patient.
- Premature infants are expected to meet these goals until they have “caught up” with their term peers.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight gain</td>
<td>15-50 g/day</td>
</tr>
<tr>
<td>Length gain</td>
<td>0.17 cm/day</td>
</tr>
<tr>
<td>Head circumference</td>
<td>0.5-0.9 cm/week</td>
</tr>
</tbody>
</table>
“Catch-up growth” is a loose term, generally defined as an acute, accelerated growth velocity

- Infants needing catch up growth:
  - Below the 25th percentile weight/length or BMI/age (if 2+ years old)
  - Failure to meet weight and length gain velocities for corrected age
  - Weight/age trending <10th percentile (per discretion)

- Once infant meets these goals - we expect them to grow at the rate of a term infant of the same age
Growth velocity

Premature infants are expected to grow at the term equivalent for **corrected age**

<table>
<thead>
<tr>
<th>Age</th>
<th>Weight (g/day)</th>
<th>Height (cm/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 months</td>
<td>25-35</td>
<td>.10</td>
</tr>
<tr>
<td>3-6 months</td>
<td>15-21</td>
<td>.07</td>
</tr>
<tr>
<td>6-12 months</td>
<td>10-13</td>
<td>.05</td>
</tr>
<tr>
<td>1-2 years</td>
<td>10</td>
<td>.03</td>
</tr>
<tr>
<td>2-6 years</td>
<td>5-8</td>
<td>.02</td>
</tr>
<tr>
<td>7-10 years</td>
<td>5-11</td>
<td>.02</td>
</tr>
</tbody>
</table>

Ex. A 6 month chronological age (4 months corrected age) should be gaining 15-21 g/day
Ways to achieve "Catch Up" Growth

• Increase caloric density of formula
  – 22 kcal to 24, 27 kcal etc.
  – Reduces water intake

• Increase calories in diet
  – Added oils (1 tsp = 40 kcal)
  – High kcal foods (full fat dairy, cheese, heavy cream, peanut butter, avocado, eggs, etc.)
  – Nutritional supplement
    • Depends on age and intake
    • Toddler formula, Pediasure, Duocal, Benecalorie, etc.
Introduction of solids:

- Follow the same developmental readiness cues that one would use for term infants.
- Most premature infants are not ready for solids until **4 to 6 months corrected age**.
- Families should be reminded regularly about growth and developmental expectations specific to their infants.

**Early introduction may lead to:**
- Decreased intake of formula (can slow weight gain)
- Excessive weight gain
- Oral aversion
- Intolerance

**Late introduction may lead to:**
- Oral aversion
- Delayed feeding milestones
WHY Follow-up: Focus on development

**Developmental milestones** are expected to occur based upon corrected age:

- Correct development for prematurity through 2-2 ½ years
- Motor, cognitive, language development
- Sleeping through the night, tooth eruption, colic, reflux, initiation of solids
- Not all areas mature at the same rate
WHY Follow-up: Focus on development

- Increased risk for impaired neurodevelopmental outcome
  - Cognitive, motor, language deficits
  - Cerebral palsy
  - Vision and hearing deficits

- More likely to develop psychological and behavioral problems
  - ADHD
  - Difficulty in peer interactions
  - General anxiety and depression
  - Autism spectrum disorder (ASD)

- School-age children born preterm are at increased risk for functional disabilities that impact managing daily activities
  - Problems of motor coordination
  - Social skills
  - Executive function.
Developmental surveillance

- Development should be monitored at each visit throughout childhood
- Use developmental tools consistently and as designed
- Select screening tools that are practical
- Tools for Developmental and Behavioral Assessment:
  - Infant Development Inventory
  - Ages and Stages
  - Denver Developmental Screening
  - Vineland Adaptive Behavior Scales
  - MCHAT
- Monitor for externalizing behaviors/ADHD, atypical social-communication behaviors/autism
- Identify areas for increased vigilance and/or refer for further evaluation by subspecialists
Neuromotor Development and Assessment

- Preterm infants, especially those born at less than 1500 grams, may have abnormal findings on muscular and neurologic exam for the first 12-18 months.

- Typical findings near term corrected age and post-discharge:
  - Extensor bias
  - Truncal hypotonia, head lag
  - Extremity hypertonicity (heel cords, hips, shoulders) –”loves to stand!” but not yet sitting
  - Jitteriness

- Preterm infants with abnormal tone are typically late walkers and may have a certain degree of toe walking

- Majority of tone issues resolve, but it is difficult to predict in whom.
Neuromotor Development and Guidance

- Demonstrate supportive positioning techniques
- Early intervention is recommended to minimize the effects of the abnormal patterning on the normal progression of development.
- Advised to not use walkers, standers, or jumpers since they encourage extensor posture.
- Confirm types and frequency of services (Birth to three vs outpatient OT/PT)
- Serial exams → transient dystonia vs. concern for cerebral palsy
Additional Screening Recommendations

Hearing:

...all infants who received care in a NICU for more than 5 days should be referred for diagnostic audiological assessment at least once by 9-12 months corrected age (2019 Position Statement of the Joint Committee on Infant Hearing)

Vision:

Infants diagnosed with ROP have up to 10 times the risk for refractive errors than their same gestational age peers as well as a higher incidence of other visual disorders including strabismus, amblyopia, and cataracts in preterm infants.

...all infants born <1500g should have an ophthalmology examination 8-10 months after discharge (AAP 2018 Policy Statement on ROP)
Overview of the Yale NICU GRAD Program
(est. 2013)
The NICU GRAD Program is a comprehensive, multidisciplinary medical and developmental follow-up program designed specifically to provide a continuum of care for at-risk infants and young children due to conditions faced in the newborn period.

Our Mission:

- “...to provide family-centered, post-discharge medical and developmental care to support high risk infants and their parents during the transition from the hospital to home.”
Who is GRAD? (We can’t do this work alone!)

• Neonatologists
• Physician Assistant
• Nurse Coordinator
• Occupational Therapists
• Dietitian
• Yale Child Study Center Psychologists
• Social Work
• Trainees:
  - Neonatal-Perinatal Fellows
  - Yale Child Study Center Psychology Fellows
  - Developmental Behavioral Pediatric Fellows
  - Yale Pediatric Residents
  - Yale Medical Students
  - NP students
Who is GRAD: Meet our team!

- Angela M. Montgomery, MD, MSEd
  Director, Neonatologist
- Christie J. Bruno, DO
  Associate Director, Neonatologist
- Soo Hyun Kwon, MD
  Neonatologist
- Alexis Rodriguez, MD
  Pediatric Hospitalist
- Sarah Beres, MS, PA
- Eleanor Blythe, PA
- Stephanie Fiorentino, PA
- Dana Carman, MS, RD, CD-N
  Dietitian
- Amanda Lowell, PhD
- Angie Maupin, PhD
- Kelly K. Powell, PhD
  Psychologists
- Caitlin Condon, OTR/L
- Sara Cave, OTR/L
- Kim Gramlich, OTR/L
  Occupational Therapists
- Lisa Giard, RN
  Nurse Coordinator
## Who is GRAD: Meet our patients!

<table>
<thead>
<tr>
<th>Condition</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight ≤ 1500 grams</td>
<td>Hypoxic ischemic encephalopathy</td>
</tr>
<tr>
<td>Gestational age ≤ 32 weeks</td>
<td>Seizures</td>
</tr>
<tr>
<td>Bronchopulmonary dysplasia</td>
<td>Meningitis</td>
</tr>
<tr>
<td>Pulmonary hypertension</td>
<td>Hydrocephalus</td>
</tr>
<tr>
<td>Congenital diaphragmatic hernia</td>
<td>Intrauterine growth restriction/SGA</td>
</tr>
<tr>
<td>Infants treated with ECMO</td>
<td>Congenital cardiac defects</td>
</tr>
</tbody>
</table>
| Intraventricular hemorrhage       | Other congenital malformations requiring surgery  
  (i.e. esophageal atresia, tracheoesophageal fistula,  
  gastroschisis, omphalocele)       |
| Periventricular leukomalacia      | Neonatal Abstinence Syndrome                  |
| Neonatal Stroke                   | Other medically complex conditions            |
WHERE is GRAD: Locations

Locations:

Yale-New Haven Children’s Hospital
Pediatric Specialty Center
One Long Wharf Drive, 2nd Floor
New Haven, CT 06511

Yale-New Haven Hospital
Old Saybrook Medical Center
633 Middlesex Turnpike
Old Saybrook, CT 06475

Hours: Tuesday 8:30a-12:30p (Old Saybrook)
Thursday 8:30a-12:30p, 1-5p (Long Wharf)
Friday 12:30-4:30p (Long Wharf)
### WHEN is GRAD: Schedule of visits

<table>
<thead>
<tr>
<th>Type of Visit</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; medical visit</td>
<td>~ 1 month from discharge</td>
</tr>
<tr>
<td>Subsequent medical visits</td>
<td>Every 4 months over the 1&lt;sup&gt;st&lt;/sup&gt; year&lt;br&gt;Every 6 months over the 2&lt;sup&gt;nd&lt;/sup&gt; and 3&lt;sup&gt;rd&lt;/sup&gt; years&lt;br&gt;Every 8-12 months over the 4&lt;sup&gt;th&lt;/sup&gt; year for medically complex patients</td>
</tr>
<tr>
<td>Developmental visits</td>
<td>12 and 24 months corrected age (Bayley 3)&lt;br&gt;36 months actual age (Bayley 3)&lt;br&gt;4.5-5 years of age</td>
</tr>
</tbody>
</table>
What is GRAD: Services provided

• Medical management after hospital discharge (BPD, GERD, constipation, etc)
• Coordination of primary and subspecialty care
• Nutritional evaluation, recommendations and treatment
• Neuromotor assessment (HINE), recommendations and referrals
• Neurodevelopmental assessments/questionnaires
• Social work assessments as needed
• Referrals for services (Birth to Three, outpatient SLP/OT/PT and/or community-based programs)
• Referrals for developmental evaluations (autism, behavioral, etc)
• Referrals for recommended surveillance (audiology, ophthalmology)
• Training/teaching site for fellows, residents, PNP, and medical students
• Outcomes related research
GRAD Clinical Growth Over Time

Number of New Patients

Fiscal Year


- GRAD is born
- CHD infants in GRAD
- NAS infants in GRAD
- Documented referrals from L&M and Waterbury
- Addition of telehealth visits
- Planned expansion to Greenwich

GRAD Growth Over Time
GRAD Clinical Collaborations and Initiatives

- 2015 - Yale Child Study Center psychologists join GRAD team
- 2015 – Follow-up of infants with CHD (Pediatric Cardiology)
- 2016 - Follow-up of infants with NAS cared for under Eat, Sleep, Console (Pediatric Hospitalists)
- 2018 – Management of infants with feeding difficulties (Aerodigestive Program)
- 2019 – Streamline referral of infants with cerebral palsy (Pediatric Orthopedics/Tone Clinic)
- 2020 – Integrate hearing screening into visits at both GRAD sites (Audiology)
- 2021 – Early identification of infants with cerebral palsy (Pediatric Rehab and Orthopedics)
- 2021 – Early identification of infants/toddlers with autism (YCSC)
We established the first regional quality improvement collaborative solely dedicated to follow-up care of high-risk infants after NICU discharge.

Goals:
- Characterize extremely low birth weight (ELBW) follow-up in New England.
- Determine site-specific differences in outcomes.
- Standardize approach to follow-up care across sites.

14 follow-up programs in New England partnered with the Vermont Oxford Network (VON) ELBW project:
- Collect information about the health status and developmental outcomes of infants born younger than 28 weeks at the 18–26 months corrected age follow-up visit.
GRAD Ongoing Quality Improvement & Research Projects

- 2015-2019 VLBW birth cohorts: Open bay vs single family room NICU outcomes (growth and development at 2 years)
- 2016-2018 NAS birth cohorts: 1 and 2 year follow-up of infants with NAS cared for under “Eat, Sleep, Console”
- New England Follow-up Network (NEFUN) in collaboration with the Vermont Oxford Network
- Extremely Low Gestational Age Network (ELGAN) Study
  - 2002-2004 Yale birth cohort
  - Completed 15 year old visits, ongoing analysis
  - Completing 17-18 year old visits as part of the NIH supported Environmental Influences on Child Health Outcomes (ECHO) Consortium
GRAD: How to contact us

Referrals:

• For new referrals, please use the New Patient form found on the Yale NICU GRAD website:
  
  https://medicine.yale.edu/pediatrics/perinatal/grad/

• For questions regarding the NICU GRAD program, please contact Lisa Giard (GRAD nurse coordinator) at lisa.giard@ynhh.org or at 203-988-8925.
Questions or comments???