



Neonatal Nutrition for the Discharging Preterm Infant

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I have no conflict of interest to disclose



Growth in the Neonatal Intensive Care Unit Graduate

Poor growth is a common outcome of the NICU hospitalization, with postnatal growth failure the norm, and need for “catch-up growth” post-discharge the expectation.




Population Considerations

Preterm infants: 22-37 6/7 weeks

- Preterm is defined as babies born alive before 37 weeks of pregnancy are completed.
- There are sub-categories of preterm birth, based on gestational age:
 - extremely preterm (less than 28 weeks)
 - very preterm (28 to 32 weeks)
 - moderate to late preterm (32 to 37 weeks)

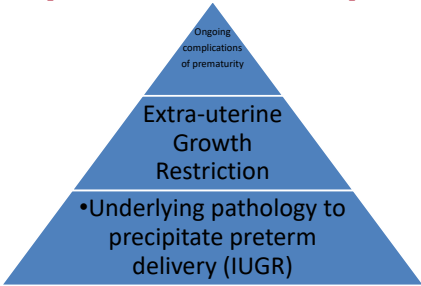
WHO, 2019




Placenta is the Best Source of Nutrition




Disruption in Development



- Underlying pathology to precipitate preterm delivery (IUGR)



Reasons for growth failure

Difficulty with feeding, food absorption, or tolerance.

Increased metabolic demands of conditions such as BPD, congestive heart failure, and hypertonia

Require increased caloric intake to establish a return to standardized growth curves.



Bronchopulmonary Dysplasia BPD

Old BPD

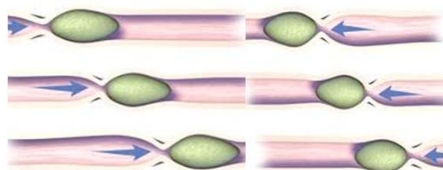
- Damage caused to lungs and airway by mechanical ventilation and/or oxygen
- Resulting in inflammation and fibrosis
- This type of BPD may occur in premature and term infants
- Greatly reduced by the administration of surfactant and high frequency ventilation

New BP

- Abnormal or arrest in lung development
- Fewer and larger alveoli
- Decreased microvascular development
- Typically in [ELBW](#) infants



Dysmotility of Prematurity



Reflux

“Happy Spitter” Failure to Thrive

- | | |
|--|---|
| <ul style="list-style-type: none"> • Normal Growth • Parental concern • Normal Growth | <ul style="list-style-type: none"> • Poor Growth • Weight • Length • Head Circumference |
|--|---|



Hypertonicity /Cardiac

PVL and IVH leading to spasticity

Congenital heart disease, especially if uncorrected with pulmonary overflow

Surgical NEC, especially if resulting in short bowel syndrome

History of intrauterine growth restriction



Post Discharge Growth



Important Goals

The goal should be to achieve the **body composition** and **rate of growth** of that of a normal fetus of the same postmenstrual age during the entire first year of life

Weight doesn't equal body composition

Support lean body mass and BRAIN growth



Goals For Growth

Before term corrected age: weight increase of 18 g/kg/d and head circumference growth of 0.9 cm/wk.

After term corrected age and over 2 kg: 25 to 30 g/d, length to match the weight velocity, and head circumference growth closer to 0.5 cm/wk.



Goals for Growth Post-discharge

The American Academy of Pediatrics recommends that the goal for growth of premature infants should match fetal growth rate and body composition.¹⁵

"Extra-uterine growth restriction" is a well-known entity in premature infants and is usually dealt with by altering calories of expressed breast milk or formula.

Post-discharge diet should also meet protein and mineral needs for linear growth, as rapid weight gain without an increase in length leads to increased adiposity and future risks for hypertension, cardiovascular disease, and type II diabetes.^{16, 17}

Post-discharge diet should correct for deficiencies of micronutrients (essential fatty acids, iron), as well as calcium and phosphorous, protein and energy.



What to consider?

- Unfortified mother's breastmilk has been shown to provide suboptimal growth in preterm infants
- Term formulas have inadequate minerals and vitamins to offset deficits incurred by prematurity



Catch up Growth Needs

- Very premature and high-risk infants sustain poor growth in the NICU
- Need to establish some catch-up growth post-discharge
- Breast milk alone usually has insufficient energy, protein, and minerals, such as calcium and phosphorous, to meet their nutritional needs after discharge

| | Energy | Protein | Calcium | Phosphorus |
|---|-------------------|----------------|----------------|---------------|
| Recommended for premature infants after discharge | 120-130 kcal/kg/d | 2.5-3.1 g/kg/d | 70-140 mg/kg/d | 35-90 mg/kg/d |
| Human milk without fortification | 100 kcal/kg | 1.5 g/kg | 44 mg/kg | 14 mg/kg |
| Term infant formula | 100 kcal/kg | 2 g/kg | 80 mg/kg | 42 mg/kg |
| Post-discharge premature formula | 110 kcal/kg | 3.1 g/kg | 117 mg/kg | 69 mg/kg |



Breastfeeding

- Ideal form of nutrition for well term infants
- Compromised rates at NICU discharge (fewer mothers still breastfeeding)
- Improving initiation in recent years
- Lactation support
- Peer Support
- Education
- Social determinants
- Return to work
- Maternal illness
- Chronic infant illness
- Pumping vs Breast feeding
- Less than one-fourth are actually feeding at the breast at the time of discharge
- Only about one-fourth of very low-birth-weight infants are still receiving human milk at 6 months of age



Exclusive Human Milk Diet at Discharge

Infants fed human milk after discharge are of the greatest concern as human milk does not in theory meet the requirements for growth in these infants.

Such infants should remain on supplemental vitamins and Fe while breastfeeding, and growth as well as serum levels of phosphorus and alkaline phosphatase should be carefully monitored.

Many recommend supplementation with two feeds/day transitional care formulas for NICU graduates for a period of time to ensure growth and development



Supporting Breastfeeding after Discharge

- Use a breastfeeding scale to measure pre-/post-breastfeeding weights, mothers and providers can get a sense of how much breast milk the infant takes with each breastfeed, which will guide how much expressed breast milk or formula should be given by bottle or tube
- Lactation specialists and skilled nurses should be available post-discharge, to help support the mother and teach techniques to maximize efficiency at the breast
- A common misconception is that mothers of infants in the NICU only need to use a breast pump because they are separated from their infants, and, once their baby is discharged to home, they will feed their infant on demand and discontinue pumping
- Studies have shown that continuing pumping in the home environment actually helps maintain the mother's supply and allows for the transfer of milk despite a weaker suck in those first few months after going home from the NICU



Recommendations for achieving Energy Protein and Mineral Needs on Breast Milk

Feed at the breast a couple of times daily and then supplement with either fortified expressed breastmilk by bottle or 2 to 4 feedings of a transitional preterm formula (Enfacare or Neosure concentrated to at least 24 cal/oz).

The growth chart and bone health indices (calcium, phosphorus, alkaline phosphatase) should be followed monthly until catch-up growth has been established. Simply fortifying the expressed breast milk with formula powder often does not meet the protein and mineral needs for these high-risk infants.

If an infant is not demonstrating appropriate linear growth to match weight gain or if bone health becomes a concern (phosphorus <4.2 mg/dL, alkaline phosphatase >400 IU/L), supplementing with 2 to 4 pure formula feedings daily for increased protein is recommended.



NICU Infants Receiving Formula

Infant formulas have standard mixing instructions without regard to specific needs of the NICU graduate.

Post-discharge / transitional premature infant formulas mixed to standard dilution are 22 cal/oz.

Term infant standard and specialty formulas are all 20 cal/oz.

Specific formula recipes are available for increasing caloric density up to 30 cal/oz.



Formula Considerations

Post-discharge premature formulas have increased protein and mineral content (especially calcium and phosphorus) intended for former premature infants

Many NICU graduates are discharged home on special term infant formulas, regardless of gestational age at birth, because of comorbidities (eg, GERD, NEC, short gut) leading to poor linear growth and/or osteopenia

All growth parameters need to be followed closely, and caloric density increased as tolerated to establish steady, symmetric catch-up growth.

When increasing to 27 cal/oz or higher, the high osmolality can lead to intolerance with constipation (especially if on diuretics), malabsorption, or high serum calcium and phosphorus levels. These parameters should be closely monitored.



Concern for Overgrowth

- Common concern for preterm infants who are discharged on transitional formulas to be feeding well and growing appropriately
- Discontinued from these formulas soon after discharge
- Composition is 10% increase in calories (20-22 cal/oz)
- 30-35% increase in protein, calcium, phosphorus, vitamins, minerals and micronutrients that preterm infants have in low stores due to decreased placental transfer




Focus on linear Growth

Post-discharge diet should meet **protein and mineral needs for linear growth**


Rapid weight gain **without** an increase in length leads to:

- increased adiposity
- future risks for hypertension
- cardiovascular disease
- type II diabetes




Catch up Growth and Metabolic Syndrome

The increased risk of preterm infants for obesity and the metabolic syndrome secondary to the metabolic/nutritional events early in life (programming) is likely to be small compared with the contribution of other risk factors:



- parental size
- weight as an adolescent
- various lifestyle factors
- physical activity.



Common Feeding Problems in NICU Graduates



Common Feeding Problems for NICU Graduates:

Term to 3 months

Term to 3 months

Oral feeding skills are driven by primitive reflexes. Rooting, sucking, and swallowing are the basic skills newborns possess to breast or bottle feed shortly after birth. Protective reflexes including gagging, coughing, and the laryngeal chemotaxis provide safety measures to allow for successful early feeding. Any disturbance in the autonomic nervous system, as may be seen in extremely premature birth or neurologic injury, may interfere with this involuntary process.

Comorbidities such as BPD, necrotizing enterocolitis (NEC), or cGERD that may interrupt normal breathing and feeding schedules (eg, nil per os, continuous feedings) may negatively impact the natural progression of early feeding.


3 to 6 months

Feeding becomes a voluntary activity. Primitive reflexes integrate with brain development and the upper aerodigestive tract grows to resemble that of an adult by 6 months of age. With this, along with developing head control, a transition to solid foods is supported.

The infant must now coordinate the movement of food from the anterior oral cavity to the posterior pharynx to swallow, a much different eating pattern than sucking liquid from a nipple directly into the pharynx.

Oral exploration is abundant (hands, feet, clothing, toys to mouth) and works to desensitize the tongue to accept more textured foods.

Delays in head control or gross motor skills, as well as negative oral experiences (eg, occipital and endotracheal tubes, suctioning, CPAP), may disrupt this transition to voluntary feeding and may lead to oral aversion or difficulty in transition to textured foods.



Common Feeding Problems for NICU Graduates:

6 to 9 months

Infants begin eating thicker solids and finger foods, further increasing sensory stimulation with visual, auditory, tactile, taste, and smell contributing to the feeding process.


A more mature "munching" chewing pattern develops with vertical movement of the mandible and tongue protrusion coordinated with lip closure to retrieve food and keep it in the mouth.

Gross and fine motor skills begin to become more important as upright seating becomes the preferred feeding position, and reaching out and holding on to finger foods emerges.


9 to 12 months

Infants begin eating mixed textures, including table foods. Infants also develop a more mature "rotary" chewing pattern required to shred more textured foods.

More advanced gross and fine motor skills are necessary for trunk stability, self-feeding, and initiating drinking from a cup.



Monitoring

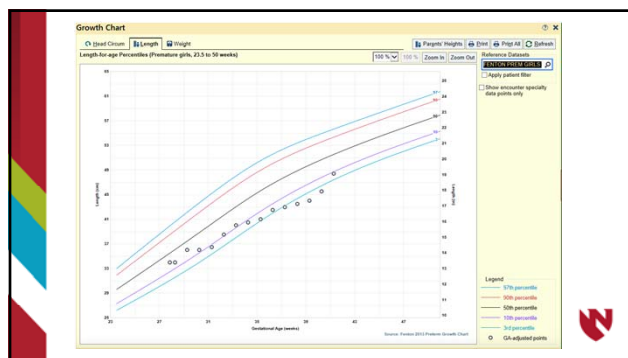
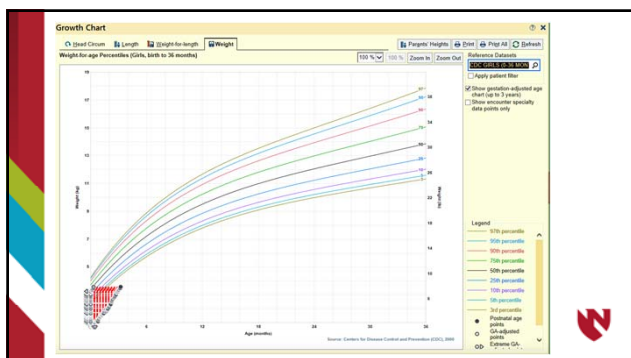
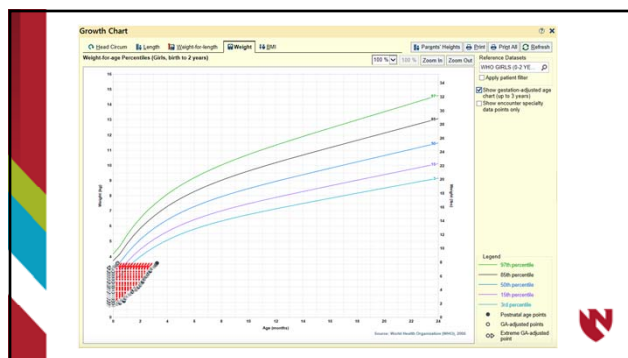
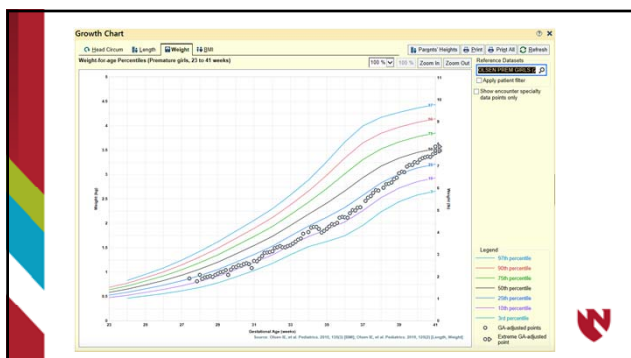
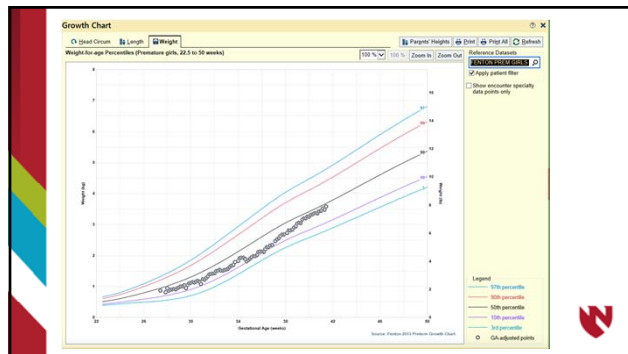


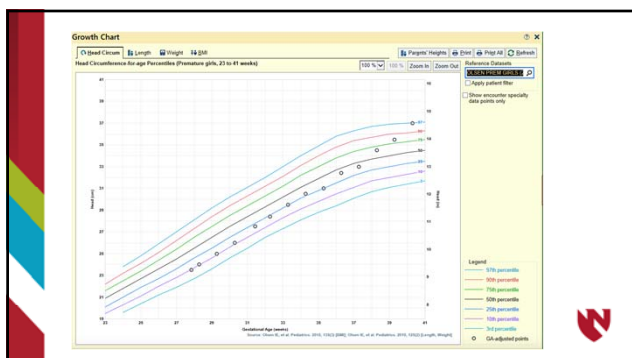
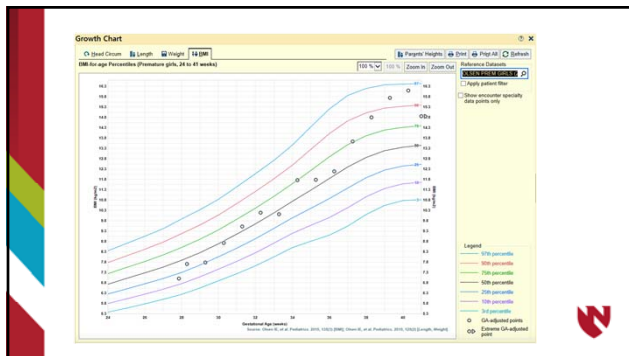
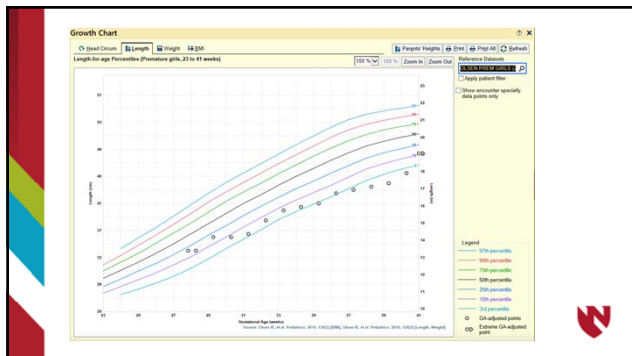
Growth Chart Selection

Standardized World Health Organization (0–24 months) and Centers for Disease Control and Prevention (24–36 months) growth charts with weight, length, and head circumference plotted according to corrected age should be recorded at all follow-up visits of premature infants

Weight should continue to be adjusted for degree of prematurity for 24 months, with length and head circumference adjusted closer to 36 months

Weight-to-length ratio is also an important growth parameter to monitor in premature infants, because body composition in very premature infants acquiring catch-up growth is a strong predictor for the development of the metabolic syndrome later in life





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Thank You!

References

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