Nutrition and BPD: Challenges and Pitfalls

Nationwide Children’s Hospital

Ish Gulati, MD
Jennifer Curtiss MS, RD, LD, CLC
Annette Haban-Bartz MS, RD, LD, CLC
Objectives

• Describe nutrition risk factors associated with poor growth
• Identify key nutrients to improve growth in infants with BPD
• Discuss strategies to optimize nutritional intake and long term follow-up
Nutrition Concerns

**Preterm Infant**
- Limited stores/intake
- Immature GI tract
- Metabolic disturbances
- 120kcals/kg/d

**Preterm Infant w/ BPD**
- Limited stores/intake
- Immature GI tract
- Metabolic disturbances
- 130-150kcals/kg/d
- Fluid restriction
- Slower weight gain vs healthy controls
- Poor linear growth
- Poor bone mass accretion
- GERD, feeding difficulties
Adequate nutrition is important for:

<table>
<thead>
<tr>
<th>Benefits</th>
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<tbody>
<tr>
<td>decrease the risk and severity of BPD</td>
</tr>
<tr>
<td>improve lung growth, development, lung function and tissue repair</td>
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<tr>
<td>promote “catch-up” growth</td>
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<tr>
<td>improve neuro-developmental outcomes</td>
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<tr>
<td>increase immune defense</td>
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Nutrition Assessment

- Prenatal history
- Birth history
- Medical history
- Nutrition history
- Medication history
- Growth history
- Respiratory status
Nutrition goals: optimize supply & minimize demand

1. Determine fluid goals to meet nutritional & physiological needs
2. Provide adequate energy and protein intake to promote appropriate growth
3. Supply key vitamin and minerals
4. Monitor and evaluate progress
Energy: supply vs. demand

Supply:
- 130-150 kcals/kg
- Achieve with highly fortified breast milk or preterm infant formula
- Determine fluid goals to meet nutritional and respiratory goals

Demand:
- 15-25% higher energy expenditure
- Body temperature maintenance
- WOB, tachycardia, po feeding, more activity
- Respiratory plan

* At present, there are no available RCT that examine the effects of increased vs. standard energy regimens for infants with (or developing BPD)

(Cochrane Collaboration, 2011)
Nutrition strategies & growth in ELBW infants with BPD over the past 10 yrs

73% of current subjects grew at or above fetal rates.

Less EUGR in weight and HC with higher protein

Better weight gain and HC vs 10 yrs ago

Theile et al. 2010  *J of Perinatal*
Essential for tissue synthesis/somatic growth
Enteral goals: 3.5g-4g/kg/d
Needs decrease closer to term

- Achieve with fortified breast milk or preterm infant formula
- Protein modular

<table>
<thead>
<tr>
<th></th>
<th>Human milk (term)</th>
<th>w/ Liquid MJ HMF (24)</th>
<th>w/ pwd HMF (24)</th>
<th>w/ HMF + Neo pwd (30)</th>
<th>Preterm formula (30)</th>
<th>Post d/c formula (30)</th>
<th>Term formula (30)</th>
<th>Toddler RTF (30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (mL)</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Protein (g/L)</td>
<td>1.3</td>
<td>3.4</td>
<td>2.7</td>
<td>3.3</td>
<td>3.9</td>
<td>3.6</td>
<td>2.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>
**Protein**

**Supply:**
- Fortify human milk before PN discontinued
- Preterm human milk is higher in protein than term milk

<table>
<thead>
<tr>
<th>Example 1</th>
<th>Example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>at 2 weeks</td>
<td>at 2 weeks</td>
</tr>
<tr>
<td>Pro 1.32g</td>
<td>Pro 0.98g</td>
</tr>
<tr>
<td>24.3 kcal/oz</td>
<td>23 kcals/oz</td>
</tr>
<tr>
<td>at 19 weeks</td>
<td>at 12 weeks</td>
</tr>
<tr>
<td>Pro 1.00g</td>
<td>Pro 0.76g</td>
</tr>
<tr>
<td>27.3 kcal/oz</td>
<td>19 kcals/oz</td>
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</table>

**30% more protein**

(Zeigler, reference fetus; Lawrence, 1999)
switched from term to preterm milk 160ml/kg, 145 kcals/kg, 2.7g/kg/pro

changed fortifier to HMF 140ml/kg, 140 kcals/kg, 3.5g/kg/pro
Protein

- Consider a ready-to-feed 30kcals/oz toddler formula

Schanler, 2000, *J of Perinatal*

Results
- Similar growth, nutrition markers and feeding tolerance.
- Safe alternative in older, larger infants w/ BPD needing severe fluid restriction.

Questions
- What is the effect on body composition?
- What is the effect on linear growth?
# Nutrient comparison: Similac Neosure vs. Pediasure

<table>
<thead>
<tr>
<th>Nutrients per 100mL</th>
<th>Neosure* (30kcals/oz.)</th>
<th>Pediasure*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>2.8</td>
<td>3.0</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>5.5</td>
<td>3.8</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Phos (mg)</td>
<td>62</td>
<td>84</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Vit D (IU)</td>
<td>70</td>
<td>51</td>
</tr>
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* Abbott Nutrition products
Growth comparison changing from Neosure 30 to Pediasure
Protein

Demand:

- **Corticosteroids**
  - alters protein metabolism and composition of weight gain
  - suppresses growth factors (growth hormone, IGF-1)

- Recurrent illness, stress, and/or inflammation suppress growth

- Under-nutrition can lead to catabolism

- Continuation of high calories may lead to high Wt/Lt status, altered body composition

(Thureen 2006; Neonatal Nutrition and Metabolism; Ramel 2012, Neonatology)
Calcium, phosphorus, Vitamin D

Infants with BPD are at greater risk for decreased bone mineralization

Supply:
- Ca 120-140mg/kg
- Phos 60-90mg/kg
- Vitamin D 400IU/d (minimum)

Demand:
- increased urinary calcium loss with diuretics
- corticosteroids reduce bone mineralization
- unfortified breast milk
- changing to term infant formula too soon
- medications that alter Vitamin D metabolism
Other Nutrients

**Zinc**

- Subcellular metabolism
- Cell division and differentiation
- Growth stimulating hormone (insulin, IGF-1)

**Brunton et al. 1998, J of Pediatrics**

**Results**

- At 38wk, enriched-formula fed babies had greater nitrogen, mineral retention
- At 3mos CA, EF-fed babies had better linear growth, bone mineral content, greater lean mass
**Other Nutrients**

**Vitamin A**
- Antioxidant
- Key nutrient for maintaining lung epithelial cell integrity

**Cochrane Review, 2011**
- May reduce oxygen at 1 mo of age and at 36 weeks

**Current practice**
- IM injections 3 x/week for 1 month
- Lacks long-term respiratory and neuro-developmental outcomes
- Use remains controversial
## Nutrition monitoring and involvement

- **Daily weights; twice weekly for older infant**
- **Weekly lengths using a length board**
- **Weekly head circumference**
- **Close attention to intake/output**
- **Frequent, but cautious, weight adjustment of feeds**
- **Nutrition lab monitoring (every 2 weeks to once monthly)**
- **Weekly and monthly meetings with the BPD team (OT/PT, Physicians, RN’s, Respiratory, Social work, Case management, Psychology, Nutrition)**
Transition to Home

- Change to home-going breast milk fortifier or formula
- Liberalize fluid intake/ decrease caloric density
- Incorporate direct breastfeeding
- If fluid restricted, provide 2 wk feeding advancement schedule
- If G-tube, 3-4 daytime feeds (PO/gavage) with remainder pumped over 8hrs overnight
- Wean O2 and diuretics, if able
Transition from hospital to home

Why are these infants at risk for growth failure once they are home?

- Social factors
  - Follow through on medical and nutrition recommendations
- Delivery and availability of nutrition
  - Breast milk production/formula procurement
- Preparation and feeding errors
- Oxygen considerations
Late nutrition strategies – discharge and beyond

Up to 67% BPD infants have growth failure after discharge (Biniwale and Ehrenkranz 2006)

Nutrient intake may be insufficient may be due to:

• Social
• Feeding ability
• Increased nutrient demand
This is our BPD Clinic

Physician/Nurse Practitioner

Others
- Developmental pediatrician
  - Speech Therapist
  - Pulmonologist

Nurse

Physical Therapist

Dietitian

Occupational Therapist

Social Worker
Promoting Breastfeeding
Late Nutrition Strategies post-discharge

Case Study
WM 24 GA, discharged home with BPD at 3 weeks Corrected Age.
• Medical course in clinic uneventful except for lack of catch up growth.
• In house history of formula changes
  – Donor Breast Milk + HMF to 30 kcal
  – DBM + Neosure 30
  – Neosure 27
  – Neosure 30 to maintain appropriate growth rate in-house.
• Home going formula Neosure 30
• Tried to change formula to Pediasure at 4 months corrected age but local WIC office wouldn’t change formula. Kept on Neosure 30.
• Trial of both Pediasure and Nutren Junior ~ 9 months CCA; Nutren Junior tolerated best.
• Growth improved most when Nutren Junior used with high calorie, high protein table foods.
Hospital discharge on Neosure 30

On Neosure 30; changed to Nutren Jr at this visit

Actually started Nutren Jr

Nutren Jr + started table foods

Feeding Nutren Jr + high calorie, high protein foods

Oxygen weaning started

Oxygen stopped

Nutren Jr + started table foods

Hospital discharge on Neosure 30
Hospital discharge on Neosure 30
On Neosure 30; changed to Nutren Jr at this visit
Actually started Nutren Jr
Nutren Jr + table foods
Nutren Jr + high calorie, high protein table foods
Oxygen weaning started
Oxygen stopped
On Neosure 30; changed to Nutren Jr at this visit
Hospital discharge on Neosure 30
Oxygen weaning started
Long Term Research

- Keys to remember
- Limited BPD long-term studies
- Formulas and fortifiers provided may be been nutritionally different
- Less Breast Milk may have been used
- Medical care likely to be different
Long-term concerns – growth

M. Hack

- VLBW males remain significantly shorter and lighter than controls (especially if the child was SGA)
- VLBW females catch up in growth by 20 years age
- VLBW females as a group caught up in weight more than height.

M Hack et al, Pediatr 2003
Long-term concerns – growth

LW Doyle

Attained an average weight and their height was consistent with their parents’ height

Were “relatively heavy for their height”

LW Doyle et al. Arch Dis Child 2004
Long-term concerns – growth

A Farooqi

1. Poor growth in early childhood
2. Catch-up growth by age 11 years
3. Prematurity and parental height were significant predictors of 11 year height.
4. Remained smaller than their term-born peers.

A Farooqi et al, Pediatr 2006
Long-term concerns – bone

Despite large early nutrition differences and mineral intake during neonatal period, early diet had no significant effect on later height, peak bone mass or bone turnover.

Higher whole body bone mass was positively associated with human milk intake.

Reduced adult height and lumber spine Bone Mineral Density may not be a consequence of suboptimal early nutrition.

Prematurity may influence final height and bone mass by another mechanism.

Long-term concerns – cognition

- Link between linear growth suppression to neurodevelopmental scores at 24 months corrected age.
- For each 1 standard deviation (SD) of length gain following discharge (at 4 and 12 months corrected age) there was an improved cognitive score on the Bayley of 4-8 points.
- Comparison of length versus weight over time suggests an extended period of linear stunting.

SE Ramel et al, Neonatology 2012
Long-term concerns – cognition

Suggestions from Ramel study:

• First study to link linear growth to suppression of development at 24 months corrected age in PT infants
• Linear growth reflects lean body mass and protein accretion, which is closely related to organ growth and development.
• This study suggests that linear growth suppression is linked to neurodevelopment to a much greater degree than weight.
• May be related to Growth Hormone/Insulin-like growth factor 1 as this is important for length growth as well as neuronal growth and differentiation.
Epigenetics (Developmental origin of health and disease)

RB Canani

Early nutrition may be related to:

- Hypertension and cardiovascular disease
- Metabolic syndrome and diabetes
- Cancer
- More?

RB Canani et al Nutr Res Rev 2011
Summary

Nutrition and growth are important for the prevention and treatment of BPD.

Recognize there are nutritional and non-nutritional factors that influence growth.

Long-term nutrition follow-up is critical for optimizing growth; development; and outcomes.