Objectives

– Overview the metabolism of the preterm infant.
– Understand the energy, fluid, and micronutrient requirements.
– Review monitoring and evaluation of growth parameters.
– Learn the history of parenteral nutrition and how early nutrition improves clinical outcomes.
– Discuss how nutrition support should be initiated and advanced to meet goals for growth.
– Describe the importance of fortification of enteral nutrition.
– Highlight the role and benefits of human milk.
– Discuss post-discharge goals for growth.
Disclaimer

I do not have an affiliation, financial or otherwise conflict of interest with the websites and companies discussed, it is solely for educational reasons.
Defining the Preterm Infant (WHO)

Classification by Gestational Age (GA)

- Preterm: < 37 wks
  - Extremely Preterm: < 28 weeks
  - Very Preterm: 28 - < 32 weeks
  - Moderate-Late Preterm: 32 - < 37 weeks
- Term: 37-42 wks
- Late Term: > 42 wks
Birth Weight Classification

Dependent of Gestational Age:
- AGA: 10-90th %ile
- LGA: >90th %ile
- SGA: <10th %ile
- IUGR: Intrauterine Growth Restriction

Independent of Gestational Age
- LBW: < 2500g
- VLBW: < 1500g
- ELBW: <1000g
Why is Nutrition So Important?

– Better nutritional support is associated with improved growth, neurodevelopmental outcomes, and less extra uterine growth restriction (EUGR)
– Better growth is associated with improved neurodevelopmental outcomes
– Early total and adequate nutrition associated with faster growth velocities, less comorbidities, fewer deaths, shorter LOS at 18-22months corrected age (Ehrenkranz, et al. 2011)
Why is Nutrition So Important?

- Ehrenkranz et al. described relationship between in-hospital growth velocity and outcomes at 18-22months corrected.

- As rate of weight gain increases:
  - Incidence of clinical morbidities decreases
  - Incidence of neurodevelopmental impairment (i.e. Cerebral Palsy) significantly decreases
  - Less likely to fall below 10th %ile for weight, length and HC at 18-22months corrected

Guiding Principle of Nutritional Management

“To provide nutrients to approximate the rate of growth and composition of weight gain for a normal fetus of the same postmenstrual age (PMA), to maintain normal concentrations of blood and tissue nutrients, and to achieve a satisfactory functional development”

## Energy Requirements in the Fetus

<table>
<thead>
<tr>
<th>Carbon-calorie balance</th>
<th>Carbon, g/kg/day</th>
<th>Calories, kcal/kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accretion in body: non-fat (sheep)</td>
<td>3.2</td>
<td>32</td>
</tr>
<tr>
<td>Accretion in body: non-fat (human)</td>
<td>3.2</td>
<td>32</td>
</tr>
<tr>
<td>Accretion in body: fat (human)</td>
<td>3.5</td>
<td>33</td>
</tr>
<tr>
<td>Excretion as CO₂</td>
<td>4.4</td>
<td>0</td>
</tr>
<tr>
<td>Excretion as urea</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>Excretion as glutamate</td>
<td>0.3</td>
<td>2</td>
</tr>
<tr>
<td>Heat (measured as O₂ consumption)</td>
<td>0.0</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without fat (sheep)</td>
<td>8.1</td>
<td>86</td>
</tr>
<tr>
<td>With fat (human)</td>
<td>11.6</td>
<td>119</td>
</tr>
<tr>
<td><strong>Uptake</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amino acids (sheep and human)</td>
<td>3.9</td>
<td>45</td>
</tr>
<tr>
<td>Glucose (sheep)</td>
<td>2.4</td>
<td>17</td>
</tr>
<tr>
<td>Glucose (human)</td>
<td>3.7</td>
<td>26</td>
</tr>
<tr>
<td>Lactate (sheep)</td>
<td>1.4</td>
<td>14</td>
</tr>
<tr>
<td>Lactate (human)</td>
<td>1.7</td>
<td>21</td>
</tr>
<tr>
<td>Fructose (sheep)</td>
<td>1.0</td>
<td>7</td>
</tr>
<tr>
<td>Acetate (sheep)</td>
<td>0.2</td>
<td>3</td>
</tr>
<tr>
<td>Fatty acids (human)</td>
<td>1.1–2.2</td>
<td>17–34</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>8.9</td>
<td>86</td>
</tr>
<tr>
<td>Human</td>
<td>10.4–11.5</td>
<td>109–126</td>
</tr>
</tbody>
</table>
Energy Requirements

- Energy is required for basal metabolism and growth.
- Factors that influence energy requirements:
  - Body size
  - Postnatal age
  - Physical activity
  - Dietary intake
  - Environmental temperatures
  - Energy losses in stool and urine
  - Clinical conditions and diseases
  - Body composition
## Energy Requirements - Parenteral

### AAP Committee on Nutrition

<table>
<thead>
<tr>
<th>Energy Requirement</th>
<th>Calorie needs (kcal/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting energy expenditure</td>
<td>50</td>
</tr>
<tr>
<td>Activity</td>
<td>0-5</td>
</tr>
<tr>
<td>Thermoregulation</td>
<td>0-5</td>
</tr>
<tr>
<td>Thermic effect of feeding (synthesis)</td>
<td>10</td>
</tr>
<tr>
<td>Energy storage</td>
<td>25</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>85-95</strong></td>
</tr>
</tbody>
</table>
# Energy Requirements: Enteral

<table>
<thead>
<tr>
<th>AAP Committee on Nutrition</th>
<th>Calorie needs (kcal/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting energy expenditure</td>
<td>50</td>
</tr>
<tr>
<td>Activity (0-30% above REE)</td>
<td>0-15</td>
</tr>
<tr>
<td>Thermoregulation</td>
<td>5-10</td>
</tr>
<tr>
<td>Thermic effect of feeding (synthesis)</td>
<td>10</td>
</tr>
<tr>
<td>Fecal loss of energy</td>
<td>10</td>
</tr>
<tr>
<td>Energy storage (growth)</td>
<td>25-35</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100-130</strong></td>
</tr>
</tbody>
</table>
Protein Requirements

- Based on fetal accretion rate of protein
- Higher protein intake correlates with lower gestational ages
- Preterm infants require MINIMUM of 1.2g/kg/day of amino acids (AA) to match protein breakdown and urinary losses
- VLBW infants: minimum 2-3g/kg within first few hours of life
  - Preserve body stores
  - Maximize plasma concentrations
- No significant increases in metabolic acidosis, BUN concentration, serum ammonia concentration with early AA administration
Protein-Energy Balance

- Positive nitrogen balance and anabolic state:
  - 60kcals/kg/day (CHO/Fat)
  - 2.5-3g/kg/day (10-12kcals/kg)
- Nitrogen retention at fetal rate:
  - 80-85kcals/kg/day (non-protein)
  - 2.7-4g/kg/day (11-16kcals/kg)
- Minimum parenteral non-protein intake required for growth:
  - 70kcals/kg
Fluid and Electrolyte Balance

- Chief routes of water and electrolyte loss: evaporation (skin+lungs) and urinary losses
  - 65% of insensible water loss occurs via the skin
    - Related to surface area
  - 33% insensible water loss occurs via the lungs
    - Related to respiratory rate and environmental humidity
# Water Losses

<table>
<thead>
<tr>
<th>Weight (g)</th>
<th>Evaporative</th>
<th>Urine</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1000</td>
<td>65</td>
<td>45</td>
<td>110 (145)¹</td>
</tr>
<tr>
<td>1001-1250</td>
<td>(100)¹</td>
<td>45</td>
<td>100 (125)¹</td>
</tr>
<tr>
<td>1251-1500</td>
<td>(80)¹</td>
<td>45</td>
<td>83 (105)¹</td>
</tr>
<tr>
<td>&gt;1500</td>
<td>(25)¹</td>
<td>45</td>
<td>62 (90)¹</td>
</tr>
</tbody>
</table>

¹Increases due to radiant warmer, phototherapy or extreme prematurity
Fluid Requirements

- Goals of Fluid Therapy:
  - Avoid dehydration or overhydration
  - Prevent hypoglycemia
  - Provide protein-sparing carbohydrate calories at basal metabolism rate
  - Avoid abnormal acid-base balance
  - Provide protein-sparing AA in VLBW
  - Limit negative fluid balance to 1-2% of birth weight per day
## General Fluid Guidelines

<table>
<thead>
<tr>
<th>Birth Weight (g)</th>
<th>Day 0-1</th>
<th>Day 2</th>
<th>&gt;Day 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;750</td>
<td>130</td>
<td>140</td>
<td>150</td>
</tr>
<tr>
<td>751-1000</td>
<td>110</td>
<td>130</td>
<td>150</td>
</tr>
<tr>
<td>1001-1250</td>
<td>80-110</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>1251-1500</td>
<td>80</td>
<td>100-120</td>
<td>150</td>
</tr>
<tr>
<td>1501-2000</td>
<td>65-80</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>&gt;2000</td>
<td>65-80</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

*Neonatal replacement fluid requirements vary widely depending upon environmental conditions, body weight, and gestation.*

Fluid Balance Monitoring

- Daily body weight
- Measure of total fluid intake (strict I/Os)
- Measure of urine and other fluid losses
- Monitor serum sodium (indicates extracellular tonicity)
Weight Gain and Growth
# Goals for Growth: Preterm Infants

<table>
<thead>
<tr>
<th>Weight Classification</th>
<th>Weight Velocity*</th>
<th>Length (cm/week)</th>
<th>Head-Circumference (cm/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELBW/VLBW</td>
<td>15-20 g/kg/day</td>
<td>0.8-1</td>
<td>0.8-1</td>
</tr>
<tr>
<td>IUGR/ELBW/SGA</td>
<td>15-25 g/kg/day</td>
<td>0.8-1</td>
<td>0.8-1</td>
</tr>
<tr>
<td>&gt; 2,000 grams</td>
<td>23-40 g/day</td>
<td>0.8-1</td>
<td>0.8-1</td>
</tr>
</tbody>
</table>

Weight Velocity:
- <2000g: measured in g/kg/day in the last 7 days (divide by oldest weight)
- >2000g: measured in g/day in the last 7 days
Fenton Growth Curve (2013)

- Most widely used curves to monitor growth of preterm infants
- 22-50 completed weeks gestation
- Combine data from 6 large population-based studies that include measurements from ~4 million infants at birth
- Infants born between 1991-2007
- Germany, USA, Italy, Australia, Scotland, and Canada
Fetal-infant Growth Chart for preterm infants - girls

(Curves equal the female WHO Growth Standard at 35 weeks)

Length

Height Circumference

Weight

Curves equal the girls' WHO Growth Standard at 35 weeks.

Severe malnourished, severe - Germany (12), Spain (12), Brazil (12), World Health Organization Growth Standards (Child Growth
Survey), Birth to 28 weeks, 0-4 weeks, 4-6 weeks, 6-8 weeks, 8-10
weeks, 10-12 weeks, 12-14 weeks, 14-16 weeks, 16-18 weeks, 18-20
weeks, 20-22 weeks, 22-24 weeks, 24-26 weeks, 26-28 weeks.

http://www.members.shaw.ca/growthchart
# Goals for Growth: Term Infants

<table>
<thead>
<tr>
<th>Age</th>
<th>Weight Velocity*</th>
<th>Length (cm/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3 months</td>
<td>25-35 g/day</td>
<td>2.6-3.5</td>
</tr>
<tr>
<td>3-6 months</td>
<td>15-21 g/day</td>
<td>1.6-2.5</td>
</tr>
<tr>
<td>6-12 months</td>
<td>10-13 g/day</td>
<td>1.2-1.7</td>
</tr>
</tbody>
</table>
WHO Growth Curve

– Growth curve used for term infants (≥40 weeks gestation) 0-2 years of age
– 6 diverse countries: Brazil, Ghana, India, Norway, Oman, USA
– Predominantly breastfed infants until at least 4 months and up to 12 months
Assessment of Weight Velocity

- Adequate: meets weight velocity goal defined in above table (x 7 days)
- Decreased:
  - >10 to <15 g/kg/day (<2000 grams) x 7 days or
  - >15 to <23 g/day (>2000 grams) x 7 days
- Suboptimal:
  - < 10 g/kg/day x 7 days (<2000 grams) or
  - <15 g/day (> 2000 grams) x 7 days
Catch-Up Growth

– Necessary for IUGR, SGA or infants with prolonged inadequate weight gain.
– Velocity of weight gain must be higher than that expected for age for a period of time.
– Use of growth chart to monitor weight gain trends/catch-up growth.
Why Z-Scores?

- **Definition:** The number of standard deviations (SD) away from the mean, when the distribution is normal.

- **Strengths:**
  - Allowing comparisons across ages and sexes
  - Able to quantify the extreme values
  - Good for assessing the longitudinal changes in growth status
  - Better definition of nutritional status below 10\textsuperscript{th} %ile and beyond 90\textsuperscript{th} %ile
Parenteral Nutrition
A Brief History

Historical Reasons TPN not provided in NICU:

- Catabolic state
- Nutrient intolerance
- Venous Access
- Preoccupied with clinical state
- No starter TPN available
Indications for TPN

- Slow advancement of enteral feedings
- Supplemental enteral feedings
- Respiratory problems
- Limited gastric capacity
- Intestinal hypomotility
- GI Anomalies
- NEC
- Short Gut
- CHD
- Intractable Diarrhea
Goals for Early TPN

- Continue nutrition to small infants
- Maintain hydration
- Maintain serum glucose levels WNL
- Promote nitrogen balance
- Prevent essential fatty acid (EFA) deficiency
## Initiation and Advancement

### Initiation Goals for Growth

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initiation</th>
<th>Goals for Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid (mL)</td>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>Glucose (mg/kg/min)</td>
<td>4.5-6</td>
<td>11-12</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>30-50</td>
<td>90-100</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>2-3</td>
<td>2.7-4</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>1-2</td>
<td>3</td>
</tr>
</tbody>
</table>

AAP CON Pediatric Nutrition Handbook 2014
Goals for Dextrose

- Prevent gluconeogenesis (catabolism)
- Energy for brain development
- Maintain euglycemia
- Provide energy only up until the point glucose oxidation is maximized
  - GIR: 10-14 mg/kg/min (increased due to higher brain-body ratios)
Goals for Amino Acids

– Optimal weight gain
– Nitrogen retention = fetal accretion
– Normal neurodevelopment
Goals for Lipids

- Prevent EFA deficiency by providing minimum 0.5g/kg/day
- Concentrated energy
- Provide 25-40% of non-protein calories
PN-Associated Cholestasis (PNAC)

- Liver complication of prolonged PN
- Serum conjugated bilirubin (CB) of 2 mg/dL or greater
- Elevated GGT, Alkaline Phosphatase, AST, ALT
- Occurs after on PN > 2 weeks
Therapeutic Strategies for PNAC

- Enteral feedings as soon as medically feasible
- Cycling of TPN (mixed results)
- Actigall/Ursodiol
- Lipid-lowering Strategy
  - Reduce IL to 1 g/kg/day
  - EFA deficiency if receive less than 0.5 g/kg/day
- Alternative lipids emulsions
  - Omegaven
  - SMOFL
Calcium and Phosphorus

- Early delivery of calcium via Starter TPN
- Difficult to meet fetal calcium and phosphorous accretion via parenteral nutrition
- Optimize via addition of cysteine to AA mix
- Goals of Calcium Intake:
  - 60-80 mg/kg/day
- Goals for Phosphorous Intake:
  - 39-67 mg/kg/day
- Optimal Molar Ratio: 1:1 Ca:Phos
High-Risk for Osteopenia of Prematurity

- Born at less than 27 weeks gestation
- Birth weight less than 1000g
- Long term parenteral nutrition (more than 4-5 weeks)
- Severe BPD with use of loop diuretics and fluid restriction
- Long-term steroid use
- History of NEC
- Failure to tolerate formulas or human milk fortifiers with high mineral content

Abrams SA and Committee on Nutrition, AAP, Pediatrics 2003
TPN Lab Monitoring

- BUN
- Electrolytes
- Blood Glucose
- Calcium, Phosphorous, Alkaline Phosphatase
- Direct Bilirubin
- ALT/AST
Enteral Nutrition
Enteral Feeding is the Goal

- Parenteral nutrition is a supplement to enteral feeding
- Enhanced nutrient intake
- Decreased complications
  - Cholestasis, Sepsis, Osteopenia
- Trophic feedings to smooth transition
Immature GI Tract of Preterm Infant

- Suck-Swallow-Breathe Coordination: 32-34 weeks GA
- GI Dysmotility
- Decreased Lactase, bile salts, pancreatic lipase
- Decreased GI hormones and peptides
- Immature host defenses
Barriers to Feeding

- Fear of NEC
- Respiratory Distress Syndrome
- Hypotension
- PDA
- Sepsis
- Blood Transfusion
- Gastric residuals
- First day of life
- It’s the weekend
Colostrum Oral Care

- Colostrum is rich in cytokines, growth factors, and immune cells
- Provide antiviral, anti-inflammatory and immunomodulatory protection against infection
- Close in composition to amniotic fluid → optimal transition for immature GI tract
- Should be initiated within 4 hours after birth
- Contraindications: align with medical contraindications to breastfeeding (maternal HIV, TB infection)

Section of Neonatology, Department of Pediatrics, Baylor College of Medicine. Ch. 13 Nutrition Support, *Guidelines for Acute Care of the Neonate*. 24th ed. Houston, TX: 2016-17.
Trophic Feedings

- 1-25 mL/kg/day (AAP 2014)
- Feeds/primes the gut
- Not a major contributor to nutritional intake
- Has many benefits...
Benefits to Trophic Feeds

- Improved feeding tolerance
- Achieve full enteral feeds sooner
- Achieve full PO sooner
- Improved motility
- Increased gut hormone secretion
- Improved mineral absorption
- Less days phototherapy
- Decreased cholestasis
- No increase in NEC
- Decreased LOS

Feeding Protocol

- Guidelines according to birth weight
- Specify when trophic feedings should be initiated
- How long to continue trophic feeds before volume increased
- Specify type of initial feedings (mother’s own milk, donor milk, preterm formula)
- Outline strategy to evaluate and manage feeding intolerance
- Aim to maintain steady rate of postnatal growth

Feeding Protocol: The Benefits

- Reduction in time to reach full enteral feedings
- Decrease in duration of parenteral nutrition
- Rapid growth velocity
- Suggest offer the best protection against NEC (Patole SK 2005; Gephart SM 2013).
Sample Feeding Protocol: <1000g BW

(all calculations based on birth weight):

<table>
<thead>
<tr>
<th>FP Day 1</th>
<th>10 mL/kg/day ( ___mL ) every 6 hours of EBM or PF 20 kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP Day 2</td>
<td>20 mL/kg/day ( ___mL ) every 6 hours of EBM or PF 20 kcal</td>
</tr>
<tr>
<td>FP Day 3</td>
<td>20 mL/kg/day ( ___mL ) every 3 hours of EBM or PF 20 kcal</td>
</tr>
<tr>
<td>FP Day 4</td>
<td>40 mL/kg/day ( ___mL ) every 3 hours of EBM or PF 20 kcal</td>
</tr>
<tr>
<td>FP Day 5</td>
<td>60 mL/kg/day ( ___mL ) every 3 hours of EBM or PF 20 kcal</td>
</tr>
<tr>
<td>FP Day 6</td>
<td>80 mL/kg/day ( ___mL ) every 3 hours of EBM or PF 20 kcal</td>
</tr>
<tr>
<td>FP Day 7</td>
<td>100 mL/kg/day ( ___mL ) every 3 hours of EBM 24 kcal or PF 24 kcal</td>
</tr>
<tr>
<td>FP Day 8</td>
<td>120 mL/kg/day ( ___mL ) every 3 hours of EBM 24 kcal or PF 24 kcal</td>
</tr>
<tr>
<td>FP Day 9</td>
<td>140 mL/kg/day ( ___mL ) every 3 hours of EBM 24 kcal or PF 24 kcal</td>
</tr>
<tr>
<td>FP Day 10</td>
<td>160 mL/kg/day ( ___mL ) every 3 hours of EBM 24 kcal or PF 24 kcal</td>
</tr>
</tbody>
</table>
Human Milk
Components of Human Milk

- Contains nutritional and non-nutritional components
  - Nutritional
    - Carbohydrate, fat, and protein
    - Free water
    - Long-chain and essential fatty acids, and essential amino acids
    - Minerals, vitamins, and trace elements
  - Non-nutritional
    - Antimicrobial factors
    - Digestive enzymes
    - Hormones
    - Growth modulators
Nutritional Components of HM

- More than 98% of fat is in the form of triglycerides from medium chain and long chain fatty acids
- Approximately 75% is protein, composed of a ratio of 70:30 of whey to casein
  - Whey promotes more rapid gastric emptying, more easily digestible, may play a role in host defense
- Principal carbohydrate is lactose, additionally there is a significant amount of oligosaccharides
Lipids in Human Milk

Factors that affect lipid concentration:

– Duration of lactation
– Time of day
– Phase of milk expression (Hind milk = more fat dense)
– Delivery of Milk
  – Can adhere to collection of containers, tubing, syringes
  – IMPORTANT to use bolus feeds (whenever possible), short tubing, and vertical syringes
Non-Nutritional Components of HM

- Epidermal growth factor:
  - Activates mucosal function
  - Reduces gastric breakdown of macromolecules
  - Protects the gut epithelium
- Cytokines: Anti-inflammatory and epithelial barrier function
- Immunoglobulin: Coats the intestinal mucosa and prevents bacteria from entering the cells
Benefits of Human Milk

- ↓ Respiratory tract infections and otitis media
- ↓ in SIDS and mortality
- ↓ GI infections
- ↓ Risk of celiac disease and IBD
- ↓ Asthma, atopic dermatitis, and eczema
- ↓ Incidence of NEC
- Associated with ↓ in obesity and diabetes

AAP: Section on Breastfeeding; Feb 2012
Preterm vs. Term HM

**Preterm Milk**
- Produced up to 2 weeks after birth
- Higher protein content at 1.4 g/100mL of milk

**Term (Mature) Milk**
- Lower protein content at ~1 g/100mL of milk
Fortification: Why and When?

- Preterm Infants have increased needs that cannot be met by human milk or standard formulas alone
- Volume restriction
- Extra protein requirements
- Extra micronutrient requirements
  - Calcium and Phosphorous for Osteopenia
  - Vitamin D
- May stop fortifiers once >2000g and >35 weeks if growth and bone indices are appropriated and NOT fluid restricted
# Meeting Nutrient Needs of Preterm Infant

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Enteral Needs (kg/day) (AAP 2014)</th>
<th>HM 20kcals/oz 160mL/kg</th>
<th>HM + Bovine Fortifier (liquid) 24kcals/oz 160mL/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>105-130</td>
<td>105</td>
<td>~128</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>3.5-4</td>
<td>1</td>
<td>3.9-4.1</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>100-220</td>
<td>37</td>
<td>185-191</td>
</tr>
<tr>
<td>Phosphorous (mg)</td>
<td>60-140</td>
<td>21</td>
<td>101-108</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>2-4</td>
<td>0.1</td>
<td>0.7-2.4</td>
</tr>
</tbody>
</table>
Donor Breast Milk

- AAP recommends if mother’s own milk is unavailable pasteurized donor human milk should be used for the premature infants at risk for necrotizing enterocolitis (NEC)
- Pasteurized
- Obtained through commercial and non-commercial banks
- Strict inclusion criteria for donors
- Donor Milk Banks
  - HMBANA (non profit) – several participating banks
  - Prolacta (profit)
Donor Breast Milk: Eligible Candidates

Candidates for use of donor human milk include but not limited to:

– Premature infants with GA < 34 weeks and / or birth weight is ≤ 1500 grams.
– Infants with apparent intolerance to formula (Malabsorption syndromes, short gut syndrome).
– Post – surgical nutrition if indicated (e.g. NEC, bowel surgery).
– Short term usage of donor milk may be indicated for specific medical condition. (E.g. Fetal distress/hypoxia as evidenced by low APGARs, Renal failure, Cardiac disease, inborn errors of metabolism, Immune Disorders)

Infant will remain on donor milk:

– When an infant gestation is > 34 weeks and weight is > 1500 grams.
– For those infants on short duration of donor breast milk supplementation, duration be until mother’s own milk is available or after 5-7 days after the infant reaches full feedings.
# Milk and Fortifier Selection

<table>
<thead>
<tr>
<th>Milk</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Milk</td>
<td>Milk Initiation for all infants and single milk source for infants ≥1800-2000 g and ≥ 34wks PMA</td>
</tr>
<tr>
<td>Human Milk + bovine milk-based fortifier</td>
<td>Birth weight &gt; 1500-2000 g or &lt; 34wks PMA</td>
</tr>
<tr>
<td>Premature Infant Formula w/ Iron</td>
<td>Birth weight &lt; 1800-2000 g or &lt; 34wks PMA</td>
</tr>
<tr>
<td>Term Formula w/ Iron</td>
<td>Birth weight &gt; 1800-2000 g or &gt; 34wks PMA and able to consume 180 mL/kg</td>
</tr>
<tr>
<td>Premature Transitional Formula w/ Iron</td>
<td>Premature infants post-discharge with birth weight &lt; 1800 g</td>
</tr>
</tbody>
</table>
Overview of Formula

- Premature
- Transitional
- Standard Cow’s Milk Based
- Soy
- Protein Hydrolysates
- Amino Acid-Based
- Special Use
Premature Formula

- Brands: Enfamil Premature, Similac Special Care, Gerber Goodstart Premature (d/c)
- Indicated for BW <1800-2000 g or < 34wks GA
- Available in 20, 24, 24 High Protein, 30 kcals/oz
- Ready-To-Feed (RTF)
- Easy to digest CHO and Fat (MCT and LCT)
Transitional Premie Formula

- Brands: Enfamil Enfacare 22kcal/oz, Neosure Neosure 22kcal/oz
- Indicated for use:
  - BW <1800g and now approaching discharge home
  - Fluid restriction
  - Abnormal laboratory indices
- Standard concentration 22kcal/oz
Standard Term Formula

- Standard Cow’s Milk Based
- Brands: Enfamil Infant, Gerber Good Start Gentle, Similac Advance
- Indicated for healthy, term infants.
- Usually 19-20kcals/oz
- Whey:Casein ratio varies among brands
- Various vegetable oils and DHA/ARA
Soy Formula

- Brands: Enfamil Prosobee, Gerber Good Starter Soy, Similac Soy Isomil
- Indicated in term infants w/ galactosemia, hereditary lactase deficiency, vegan diet
- NOT indicated:
  - Documented cow’s milk protein allergy or enteropathy
  - Preterm infants
Protein Hydrolysate Formula

- Brands: Gerber Extensive HA, Nutramigen, Pregestimil, Similac Alimentum
- Indicated for:
  - Cow’s milk and soy protein allergy or malabsorption
  - Lactose-free, hypoallergenic, some or no MCT oil, DHA and ARA
Amino-Acid Based Formula

- Brans: Alfamino Infant, Elecare Infant, Neocate Infant, PurAmino
- Indicated for severe intolerance to intact protein and protein hydrolysate
- 100% synthetic amino acids, hypoallergenic
- All contain DHA and ARA
- Powder only
Special Use Formulas

- Similac PM 60/40
  - Indicated for hypocalcemia and renal disease
- Enfaport
  - Indicated for lymphatic dysfunction (chylous fistula or chylothorax)
- Similac Sensitive/Enfamil Gentlease
  - Indicated for fussiness and gas due to lactose sensitivity (reduced lactose)
- Similac for Spit-Ups/Enfamil A.R.
  - Indicated for frequent spit-ups
Other Modulars

- Protein
  - Powder-Beneprotein (Nestle)
  - Liquid-Liquid Protein Fortifier (Abbott)
- Carbohydrate
  - Polycal (Nutricia)
- Fat
  - Vegetable/MCT oil/emulsified oil (Liquigen)
Risk of Infant Formula Powder

- Powdered infant formulas are not commercially sterile
- *Cronobacter spp* has been reported with its use
- When fed to immunocompromised infants, best to use ready-to-feed or liquid concentrate formulas
- Powdered formula is indicated when there is no available alternative that meets the infant’s nutrient needs
Post-Discharge Nutrition Monitoring

Home Sweet Home!
Discharge Planning

- Tolerating transitional premature formula
- If exclusively breastfed and needs supplementation, suggest:
  - 3 feeds with transitional premie formula
  - 5 feeds at the breast (after expressed milk has been quantified)
- Gaining 25-35g/day
- Growing along birth length percentile
At Home

- Premature infants may receive transitional formula up to 6-9 months corrected age
- If catch-up quickly, may transition to standard term formula at 48-52 weeks PMA
  - Weight, Length, Weight for Length at least in 25th %ile
- Encourage use of ready-to-feed formula until ~44 weeks PMA
Vitamin and Mineral Supplementation

- Exclusively breastfed infants require supplementation of 400 International units of Vitamin D
  - Poly-Vi-Sol drops
- Infants with history of Cholestasis may need extra Lipid-Soluble Vitamins supplementation
  - AquADEKs
- Iron supplementation for Anemia (iatrogenic, prematurity)
  - Fer-In-Sol or Poly-Vi-Sol with Iron
Follow-Up

– Close follow-up with PMD for adequate growth and weight trends
– Outpatient Nutrition follow-up for those patients with special needs (i.e. GI disorders)
  – Home TPN, Gtube dependent, Catch-up growth
– Outpatient follow-up with Speech Therapists and Occupational Therapists to determine developmental readiness for introducing solids
References:


– Section of Neonatology, Department of Pediatrics, Baylor College of Medicine. *Guidelines for Acute Care of the Neonate*. 24th ed. Houston, TX: 2016-17.

