IT’S ALL ABOUT THE PROTEIN for VLBW INFANTS

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Director of Nutritional Research
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October 2012
Eskimo Diet Rich in Omega 3 FAs
It’s The Protein Outline

- Standardized early parenteral nutrition
- Higher Protein Preterm Formulas
- Human Milk Content
- Fortifiers
- Lactoengineering
- Post Discharge Nutrition
ELBW Nutritional Challenge

Protein (80%)

- Inadequate nutrition

Energy (20%)

- Postnatal Growth failure
- Impaired neurocognitive development

Intrauterine growth (50th and 10th percentile) for postmenstrual age:
- 24-25 weeks
- 26-27 weeks
- 28-29 weeks

Postnatal Growth Failure

Return to birth weight

NICHD Growth Observational Study

Postnatal Growth Failure is surrogate for Inadequate Nutrition

Fetus 15g/k/d

X = Return to Birth Weight

Protein Catch-up Intakes

Extraterine Growth Restriction

Early TPN MEN

Post discharge

Intrauterine growth (10th and 50th)

24-25 weeks

26-27 weeks

28-29 weeks

Postmenstrual Age (Weeks)

Alexander
Extrauterine Growth Restriction is Common in Preterm Infants

- Extrauterine growth restriction (EUGR) has been observed in 28%\(^1\) to 75%\(^2\) of preterm infants
- EUGR was associated with gestational age (GA) at birth\(^1\)

Postnatal Weight Loss Has Two Components

POSTNATAL WEIGHT LOSS
A. Excess ECF: (50%)
   - Adaptation to extrauterine life
   - Of no consequence nutritionally
B. Endogenous Protein / Fat Stores (50%)
   - ICF
   - Nutritional
Change In Body Protein Stores (ELBW) leucine and phenylalanine tracers

## PARENTERAL NUTRITION AND GROWTH

<table>
<thead>
<tr>
<th>Protein g/k/d</th>
<th>N Balance (mg/k/d)</th>
<th>Decrease Early Wt Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>5g/kg/d</td>
</tr>
<tr>
<td></td>
<td>(1g/k/d endogenous protein + accompanying 4g ICF)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>160</td>
<td>10g/kg/d</td>
</tr>
<tr>
<td></td>
<td>same as above (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ deposit (5)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>320</td>
<td>15g/kg/d</td>
</tr>
<tr>
<td></td>
<td>intrauterine rate of protein deposition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2000-01</td>
<td>2002-04</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Age @ TPNi</strong></td>
<td>22.4±22.3</td>
<td>9.5±12.2</td>
</tr>
<tr>
<td><strong>Total Protein</strong>&lt;sup&gt;*&lt;/sup&gt; (g/kg/d)</td>
<td>1.2±0.4</td>
<td>1.8±0.6</td>
</tr>
<tr>
<td><strong>Days TPN</strong></td>
<td>25.8±12.4</td>
<td>31.5±26.9</td>
</tr>
<tr>
<td><strong>Total intake</strong>&lt;sup&gt;*&lt;/sup&gt; (cc/k/d)</td>
<td>141.5±32.6</td>
<td>150.1±31.3</td>
</tr>
<tr>
<td><strong>Total kcal/k/d</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>41.4±10.2</td>
<td>45.5±9.7</td>
</tr>
<tr>
<td><strong>Insulin</strong></td>
<td>8.6%</td>
<td>3.2%</td>
</tr>
<tr>
<td><strong>Age @ nadir</strong></td>
<td>4.9±3.4</td>
<td>4.4±6.2</td>
</tr>
<tr>
<td><strong>% wt change</strong></td>
<td>-14.0±7.7</td>
<td>-10.6±6.2</td>
</tr>
<tr>
<td><strong>RTBW</strong></td>
<td>13.9±6.3</td>
<td>10.7±5.7</td>
</tr>
<tr>
<td><strong>EUGR&lt;sub&gt;W&lt;/sub&gt; @ d/c</strong></td>
<td>57.1%</td>
<td>34.7%</td>
</tr>
<tr>
<td><strong>EUGR&lt;sub&gt;HC&lt;/sub&gt; @ d/c</strong></td>
<td>10.0%</td>
<td>6.1%</td>
</tr>
</tbody>
</table>

<sup>*</sup>first five days (average)}
Louisville TPN Experience
Glucose by epoch and day of life

Improved glucose tolerance with higher protein dose

Protein 1.2 g/k/d epoch 1
1.8 g/k/d epoch 2
3.0 g/k/d epoch 3

*p<0.008
**One baby with glucose of 539 mg/dL

Radmacher P and Adamkin DH J of Peri 2009
ELBW INFANTS WITH HYPERGLYCEMIA - HYPERKALEMIA IN THE FIRST WEEK OF LIFE

EARLY ADMINISTRATION of AMINO ACIDS

Delayed TPN

↓ INSULIN

arginine
leucine
"other" amino acids

GLUCOSE

Na+K+ATPase

FETAL GROWTH

GLUCOSE

Na+ CELL K+

Hyperglycemia

Hyperkalemia

Transport
Improved Nutrition in First Week of Life Improves Outcomes

First week protein and energy intakes associated with 18-months developmental outcome in ELBW infants

Day 1: 0.4 g AA/kg*day and 31 kCal/kg*day
Day 7: 2.9 g AA/kg*day and 81 kCal/kg*day

Stephens BE, 2009
## Protein Dose in Stock TPN (g/k/d)

<table>
<thead>
<tr>
<th>AA</th>
<th>60ml/k/d</th>
<th>80ml/k/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>4%</td>
<td>2.4</td>
<td>3.2</td>
</tr>
<tr>
<td>5%</td>
<td>3.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

- If you start with 5% AA you can’t increase the fluid rate!
- Additional fluids can be co-infused if glucose and/or electrolyte requirements change.
ENTERAL FEEDING VLBW

And whom?
Protein and Energy Requirements of Preterm Infants Change With Body Weight

P/E = protein-to-energy ratio.
Comparison of Protein Requirements and Enteral Options*

<table>
<thead>
<tr>
<th>Requirement</th>
<th>(g/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1000 g</td>
<td>3.5–4.5</td>
</tr>
<tr>
<td>1000–1500 g</td>
<td>3.5–4.0</td>
</tr>
</tbody>
</table>

Unfortified preterm breast milk 2.7
Fortified preterm breast milk 3.7 - 4.8
Fortified Donor breast milk 3.0 – 4.1
Preterm Formula 24 3.6
Preterm Formula 24 High Protein 4.0 – 4.2

*Includes factorial and empirical methods

Adapted from Revised Recommended Protein Intake/P/E Ratio/PCA and Catch-Up Needs

<table>
<thead>
<tr>
<th>PCA</th>
<th>Protein (g/k/d)</th>
<th>P/E (g/100cal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 – 30</td>
<td>4.4</td>
<td>3.3</td>
</tr>
<tr>
<td>30 – 36</td>
<td>3.6 – 4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>36 – 40</td>
<td>3.0 – 3.4</td>
<td>2.6 – 2.8</td>
</tr>
</tbody>
</table>

Enteral Protein Intake Associated With Improved Weight Gain (3g prot and 100cal/k/d)

Average Protein Intake (g/kg/d)

N=69 infants <1000 g.

Enteral Protein Intake Associated With Improved Head Circumference Gain (>0.9 cm/wk) goal

HC gain 0.4 cm/wk each additional g of protein

N=69 infants <1000 g.

Michelangelo’s famous statue, David, has returned to Italy this week after an amazingly successful 12 week, 20 city, U.S. tour which was sponsored by McDonalds.
Impact of Protein/Energy Ratio (P/E) on Body Composition

To increase LBM accretion and limit fat mass deposition, an increase in P/E is mandatory.

Advantages of a Higher Protein 24 Cal Preterm Formula (INCREASED P/E RATIO)

“More Protein without more energy”
Meet Protein Requirement with Less Volume

Grams Protein/100 kcal P/E
Preterm Formulas Reaching 4g/kg/d Protein

<table>
<thead>
<tr>
<th></th>
<th>Preterm Formula 24 kcal</th>
<th>High Protein Preterm Formula 24 kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein/energy, g/100 kcal</td>
<td>3.0</td>
<td>3.3/3.5</td>
</tr>
<tr>
<td>Protein intake at 120kcal/k/d [g/kg/d] (150ml/k/d)</td>
<td>3.6</td>
<td>4.0/4.2</td>
</tr>
<tr>
<td>Protein intake at 144kcal/k/d [g/kg/d] (180ml/k/d)</td>
<td>4.0</td>
<td>4.7/4.9</td>
</tr>
</tbody>
</table>

LSRO Protein > 5.0g/k/d may be undesirable
Species Specific Milk
Human Milk Alone Does Not Meet the Nutritional Needs of VLBW Infants

Human milk requires fortification to provide nutritional needs of preterm infants

VLBW = very low birth weight.
<table>
<thead>
<tr>
<th></th>
<th>Protein g/kg</th>
<th>Calcium mg/kg</th>
<th>Phosphorus mg/kg</th>
<th>Sodium mEq/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Requirements</td>
<td>3 - 4</td>
<td>120 - 200</td>
<td>123-140</td>
<td>3 - 4</td>
</tr>
<tr>
<td>Banked HM*</td>
<td>1.8</td>
<td>52</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>PTHM**</td>
<td>2.25</td>
<td>52</td>
<td>26</td>
<td>2-3</td>
</tr>
</tbody>
</table>

*0.9g/dl @ 200ml/k/d
**1.5g/dl @ 150ml/k/d

Fomon SJ 1977
Groh-Wargo S 2000
Ziegler E 2007
Why Fortification for ELBW?

- Hyponatremia
- Hypoproteinemia
- Metabolic bone disease
- Growth Failure

Does fortification increase the risk of NEC??
Human Milk Fortification

- **Powder**
  - Bovine HMF
  - Human Milk

- **Liquid**
  - Human Milk
  - Exclusively Human Milk

**Standard**

**Exclusively Human**
Human Milk Protein and Fortification

Recommended Intake 3.5 – 4.4 g/kg/d

Schanler, 1980
**Assumed and Actual Protein, Fat and Energy Content of the Fortified Human Milk and Assumed and Actual Protein, Energy Intakes of the Infants**

N=32
600 – 1750g

<table>
<thead>
<tr>
<th>Intakes</th>
<th>STD</th>
<th>ADJ (BUN&lt;9,&gt;14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assumed values</td>
<td>Actual values</td>
</tr>
<tr>
<td><strong>Protein intake (g/kg/d)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First week</td>
<td>3.4±0.1</td>
<td>2.9±0.4</td>
</tr>
<tr>
<td>Second week</td>
<td>3.5±0.1</td>
<td>2.9±0.3</td>
</tr>
<tr>
<td>Third week</td>
<td>3.5±0.1</td>
<td>2.8±0.2</td>
</tr>
<tr>
<td><strong>Energy intake (kcal/kg/d)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First week</td>
<td>126.1±5.2</td>
<td>125.9±7.9</td>
</tr>
<tr>
<td>Second week</td>
<td>128.4±2.4</td>
<td>126.6±11.8</td>
</tr>
<tr>
<td>Third week</td>
<td>127.6±2.4</td>
<td>120.5±8.3</td>
</tr>
</tbody>
</table>

Protein Δ STD 0.5 to 0.7g/k/d
Protein Δ ADJ 0.8g/k/d

Arslanos, Ziegler et al J of Peri 2009
Lactoengineering
Mid Infrared Spectrophotometry (MIRSA)

- Point-of-care
- Accurate
- Measures Protein, Fat, Energy and Carbohydrates
- Uses only a small volume of milk
- Affordable
- Fast
- Small footprint

- Wavelength spectrum 1200 to 2400 nm
- Commercially available - validated for bovine milk

Lacto-engineering
MIRSA Results

99 discrete PT samples from 24 women were analyzed (mean ± SD; range)

<table>
<thead>
<tr>
<th>Fat (g/dL)</th>
<th>Protein (g/dL)</th>
<th>Lactose (g/dL)</th>
<th>Energy (kcal/oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 ± 1.2</td>
<td>1.6 ± 0.3</td>
<td>8.0 ± 0.5</td>
<td>20.1 ± 4.1</td>
</tr>
<tr>
<td>0.9, 7.43</td>
<td>0.9, 2.5</td>
<td>6.2, 10.1</td>
<td>11.2, 32.3</td>
</tr>
</tbody>
</table>

Range

M Adamkin unpublished observations
### Macronutrient analysis results (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Stage of lactation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-2 weeks</td>
<td>2-4 weeks</td>
</tr>
<tr>
<td>Protein (g/dL)</td>
<td>1.7 ± 0.3</td>
<td>1.5 ± 0.2</td>
</tr>
<tr>
<td>Fat (g/dL)</td>
<td>3.0 ± 0.9</td>
<td>3.6 ± 1.1</td>
</tr>
<tr>
<td>Lactose (g/dL)</td>
<td>6.5 ± 0.5</td>
<td>6.6 ± 0.3</td>
</tr>
<tr>
<td>Energy (kcal/oz)</td>
<td>17.2 ± 2.4</td>
<td>18.6 ± 2.9</td>
</tr>
</tbody>
</table>

*DHM: donor human milk

N=85 VLBW
Submitted J of Peri Aug 2012
Variability of human milk calories

51.2% fell either below 18 kcal/oz or above 22 kcal/oz 31% of the samples below 18 kcal/oz
14% were below 16 kcal/oz

N=85
Four Milk Samples to be “Fortified”

<table>
<thead>
<tr>
<th>Sample Description</th>
<th>Protein (g/dL)</th>
<th>Energy (kcal/oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low protein Low energy DONOR</td>
<td>1.0</td>
<td>13.6</td>
</tr>
<tr>
<td>Expected protein Expected energy</td>
<td>1.5</td>
<td>18.6</td>
</tr>
<tr>
<td>Expected protein High energy</td>
<td>1.4</td>
<td>24.2</td>
</tr>
<tr>
<td>High protein Marginal energy</td>
<td>1.9</td>
<td>16.9</td>
</tr>
</tbody>
</table>
Preterm Human Milk Protein (g) at 150 mL
Achieved with Four Different Fortifiers
Preterm Human Milk Protein (g) at 150 mL Achieved with Alternate Fortification Strategies
Preterm Human Milk Energy (kcal) at 150 mL Achieved with Alternate Fortifier Strategies

![Graph showing energy content of different fortifier strategies.](image-url)
The intake of protein from preterm human milk and donor milk

References:
Example of Lactoengineering

Protein Comparison per intake of 150 mL/kg/day.

Donor Milk

Preterm Human Milk

With Liquid Protein Fortifier (0.167 gms protein/ml)

With powdered human milk fortifier

Protein Content

Indications for Fortification or Additional Fortification

• BIRTHWEIGHT < 1000g

• BIRTHWEIGHT < 1500g
  -- BUN < 9
  – Analyzed Milk Protein < 1.2g/dl
  – Postnatal growth rate from RTBW < 15g/k/d
  – Serum P < 4

DHA August 2012
“conservative approach”
Police say that the gang usually is comprised of four members, one adult and three younger ones. While the three younger ones, all are appearing sweet and innocent, divert their 'mark' (or intended target) with a show of friendliness, the fourth -- and the eldest -- sneaks in from behind the person's back to expertly rifle through his or her pocket or purse for any valuables.

Here is a photo of how it works:
Caloric Dense
CALORIC DENSE FEEDINGS (>24kcal/oz)

- Feedings for infants who cannot meet their needs for growth with standard PTF or standard fortified human breast milk
- Proportional growth should be considered more than absolute weight gain

“It’s About the Protein”
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>PTF 24</th>
<th>PTF 24 High Protein</th>
<th>PTF 27 (PTF 24 HP + PTF 30)</th>
<th>PTF 30</th>
<th>30 kcal (PTF 24 + Polycose® + MCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g)</td>
<td>3.0</td>
<td>3.3</td>
<td>3.15</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>5.43</td>
<td>5.43</td>
<td>6.09</td>
<td>6.61</td>
<td>5.53</td>
</tr>
<tr>
<td>CHO (g)</td>
<td>10.3</td>
<td>10.0</td>
<td>8.9</td>
<td>7.73</td>
<td>10.73</td>
</tr>
<tr>
<td>Ca (mg)</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>133</td>
</tr>
<tr>
<td>P (mg)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>74</td>
</tr>
<tr>
<td>Vitamin D (IU)</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>122</td>
</tr>
<tr>
<td>OSMOL</td>
<td>280</td>
<td>280</td>
<td>305</td>
<td>325</td>
<td>N/A</td>
</tr>
<tr>
<td>Volume (mL)</td>
<td>124</td>
<td>124</td>
<td>111</td>
<td>99</td>
<td>100</td>
</tr>
</tbody>
</table>
Calorically-Dense Formula Feedings Strategy By Volume

<table>
<thead>
<tr>
<th></th>
<th>Volume (mL/kg/d)</th>
<th>Protein (g/kg/d)</th>
<th>Energy (kcal/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTF 30</td>
<td>100-130</td>
<td>3.0-3.9</td>
<td>100-130</td>
</tr>
<tr>
<td>PTF 27*</td>
<td>130-150</td>
<td>3.5-4.0</td>
<td>117-135</td>
</tr>
</tbody>
</table>

*Made with SSC 24 High Protein + SSC 30.
(All Human)
Caloric Dense Human Milk Feeding for VLBW Infant (≤1500g BW) Requiring Restriction

<table>
<thead>
<tr>
<th>Human Milk Fortifier</th>
<th>Per 100 mL</th>
<th>+4</th>
<th>+6</th>
<th>+8</th>
<th>+10</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMM or BBM</td>
<td>80/20</td>
<td>70/30</td>
<td>60/40</td>
<td>50/50</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>80</td>
<td>87</td>
<td>93</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Protein (g)</td>
<td>2.1</td>
<td>2.5</td>
<td>2.9</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Fortifier (g)</td>
<td>(1.1)</td>
<td>(1.7)</td>
<td>(2.2)</td>
<td>(2.8)</td>
<td></td>
</tr>
<tr>
<td>OSM</td>
<td>331</td>
<td>337</td>
<td>347</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Per 120 cal/kg/d     | Protein    | 3.5   | 3.8   | 4.1   | 4.3   |
| Volume               | 150        | 137   | 130   | 120   |
| Ca                   | 110        |
| P                    | 78         |
Nutritional Strategies and Growth in ELBW /BPD Infants over Past 10 Years

N=88  
Theile, Radmacher, Adamkin et al J of Peri 2011

12 g/k/d vs 15 g/k/d vs 18 g/k/d  (26 wks, 800g)  
(27%)  (33%)  (40%)

Significant nutritional outcome data.

< fetal rate vs ≥ fetal growth

- HC (0.69cm/wk vs 0.85, 0.95)  Decrease brain growth
- EUGR_{wt} at D/C 71% vs 43, 45%  More Growth restriction
- EUGR_{HC} at D/C 42% vs 14, 14%
- 20 day Amino Acids average 2.9g/k/d vs 3.2, 3.3g/k/d  Less Protein
- Enteral 100kcal/k/d DOL 36 vs 24, 23  Feeding Delays
- Received caloric dense milk 83% vs 82%, 59%
- Length of stay 110 days vs 97 vs 80
Early Nutrition Mediates the Influence of Severity of Illness on ELBW

N = 1366 (NICHD Glutamine Study)

More critically ill received IMV for 7 days of life  (734g vs 842g BW)

Less critically ill less than 7 days IMV first 7 days of life  (41d Assist vent vs 13d)

Early Nutritional support is associated with later growth and other outcomes after controlling for critical illness 1st three weeks of life

Decreased 2% for each increase 1cal/kg/d of total energy intake first week of life

NEC
Late Onset Sepsis
BPD
Death
Take Home Messages For Nutritional Mediation of Severity of Illness ELBW

- Early Nutritional decisions for ELBW are influenced by our perception of severity of illness
- Early aggressive TPN/Enteral support are associated with lower rates of death and short term morbidities and improved growth and neurodevelopmental outcomes
- Early initiation of enteral nutrition was well tolerated and associated with an earlier achievement of full enteral and no increase NEC
- Daily energy intake first 7 days of life mediate the influence of critical illness on risk of adverse outcomes
- Management decisions made within the first several days of life may have long-lasting effects
### Nutritional Strategies and Growth in ELBW /BPD Infants Over Past 10 Years

#### 10 Year Comparison Data (significant diff)

<table>
<thead>
<tr>
<th></th>
<th>THEN</th>
<th>NOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>90</td>
<td>118</td>
</tr>
<tr>
<td>BW (g)</td>
<td>739</td>
<td>789</td>
</tr>
<tr>
<td>PWL (%)</td>
<td>18.5</td>
<td>10</td>
</tr>
<tr>
<td>RTBW (d)</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>TPN (initiation)</td>
<td>~2d</td>
<td>3 hrs</td>
</tr>
<tr>
<td>20 d Protein g/k/d</td>
<td>2.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Wt gain g/k/d</td>
<td>13</td>
<td>15</td>
</tr>
</tbody>
</table>
THE END

Of The Pizza?
First year of life provides an important opportunity for human somatic and brain growth to compensate for earlier deprivation.
Asymmetric EUGR with head sparing with altered adiposity (visceral fat)
Suboptimal Nutrition Can Lead to Significant Protein Deficits in Extremely Low Birth Weight Infants

Protein Intake (g/kg/d)

<table>
<thead>
<tr>
<th></th>
<th>Week 1</th>
<th>Week 2</th>
<th>Weeks 3-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (&lt;750 g)</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Group 2 (750-1000 g)</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Cumulative Protein Deficit (g/kg)

<table>
<thead>
<tr>
<th></th>
<th>Week 1</th>
<th>Week 5</th>
<th>Week 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (&lt;750 g)</td>
<td>-25</td>
<td>-15</td>
<td>-10</td>
</tr>
<tr>
<td>Group 2 (750-1000 g)</td>
<td>-20</td>
<td>-10</td>
<td>-5</td>
</tr>
</tbody>
</table>

Cumulative Protein Deficit During First Weeks Of Life For VLBW Infants
Total Energy Expenditure per Kilogram and Total Energy Expenditure per Kilogram of Fat-free Mass in ELBW and Term Infants

*\(p \leq .01\)

Guilfoyl et al. J of Peds Nov 2008
Human milk provides ~2.5 g/kg/d of protein.

Range of Protein Intakes for Discharge

2.1
3.1
3.6
4.0 - 4.2

g protein/kg/d at 150 mL/kg/d

- Term formula
- Nutrient-enriched formula
- Preterm formula 24
- High-protein preterm formula 24
Nutrient-Enriched Formula or Post-Discharge Formula (PDF) Contains

- Predominantly an increase in protein with extra energy
- Extra calcium, phosphorus, and zinc
- Additional vitamins and trace elements

Post-Discharge Strategy

- Replenish accumulated nutrient deficiencies
- Catch-up growth
- Promote lean body mass
- Bone Mineralization
- Enhance Neurodevelopment
Preterm Infants Gained More Weight and Length When Fed Post Discharge Formula the First Year

Preterm Infants Larger HC on PDF <1250g

*Weighing less than 1250 g.
HC = head circumference
Nutrient Enriched Formulas
Increased Bone Mineral Content to 9 mo CA

*Enriched versus term

Nutrient-Enriched Formula to 12 Months Corrected Age (CA) Improved Proportional Growth

- Gained more weight through 1 and 2 mo CA “Early”
- Longer at 3 mo CA
- <1250 g at birth “VLBW”
  - Weighed more at 6 and 12 mo CA
  - Longer at 6 mo CA
  - Larger HC at term and 1, 3, 6, 12 mo CA
- Appeared to be of particular benefit for growth of infants <1250 g and male infants “Male”
- Compared with the infants fed term formula, those fed the nutrient-enriched formula consumed
  - Less formula
  - More protein
  - Similar kcal

Differences in mean weight between male infants assigned to a preterm formula and male infants assigned to a standard term formula from discharge to 6 months of age

<table>
<thead>
<tr>
<th>Age</th>
<th>Difference in Weight, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>-9</td>
</tr>
<tr>
<td>Enrollment</td>
<td>118</td>
</tr>
<tr>
<td>Term</td>
<td>700</td>
</tr>
<tr>
<td>4 weeks</td>
<td>900</td>
</tr>
<tr>
<td>8 weeks</td>
<td>800</td>
</tr>
<tr>
<td>12 weeks</td>
<td>800</td>
</tr>
<tr>
<td>4 months</td>
<td>700</td>
</tr>
<tr>
<td>5 months</td>
<td>700</td>
</tr>
<tr>
<td>6 months</td>
<td>1000</td>
</tr>
<tr>
<td>12 months</td>
<td>900</td>
</tr>
<tr>
<td>18 months</td>
<td>1000</td>
</tr>
</tbody>
</table>

Symmetrical EUGR 1) PTF 24 cal strategy for 2 mos then PDF. 2) MBM must be fortified

Critical Growth Epoch
Treatment Recommendations

• Formula-fed preterm infants should be fed nutrient-enriched discharge formula in the first year of life to replenish nutrient deficits and promote growth
  – Duration of use varies depending on
    • Clinical history
    • Degree of postnatal growth failure
    • Bone health
    • Proportional growth

• Growth in breast-fed premature infants should be closely monitored
  – Employ individual feeding strategies as needed to optimize proportional growth
BREAST IS BEST!!

GI

Body Fat

Immunologic benefits

IQ

CV Health
Post-discharge Nutrition Choices

- **Human milk**
  - Human milk alone
  - Fortified human milk with post-discharge powder
  - Supplemental bottles of post-discharge formula
  - Liquid fortifier

**Reasons for Fortification**

1) Postnatal Growth Failure
2) Metabolic Bone Disease
THE END

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