Neonatal Nutrition Review

Melanie Newkirk, MS, RDN, CSP, LD
Neonatal Dietician
All Children’s Hospital/Johns Hopkins Medicine, St. Petersburg, FL

The speaker has signed a disclosure form and indicated she has no significant financial interest or relationship with the companies or the manufacturer(s) of any commercial product and/or service that will be discussed as part of this presentation.

Session Summary

This session provides a general overview of enteral and parenteral nutrition to help prepare the participant for certification exams.

Session Objectives

Upon completion of this presentation, the participant will be able to:

- explain the physiology of digestion and absorption in the digestive tract in premature infants;
- discuss parenteral and enteral nutritional requirements in premature infants;
- list enteral feeding modalities, including what to feed and how to advance enteral feedings;
- compare and contrast the composition of human milk, types of human milk fortifiers, and preterm formulas;
- classify birth weight as AGA, SGA and LGA and explain expected changes in growth outcomes (weight, length, head circumference);
- name three vitamins/minerals which premature infants require at higher levels.

Test Questions

1. An infant with galactosemia should receive which formula?
   a. Similac Sensitive
   b. Enfamil Gentlease
   c. Enfamil ProSobee

2. To prevent essential fatty acid deficiency, it is important to provide within the first 72 hr which of the following?
   a. Glucose
   b. Intralipids
   c. Amino acids

3. The preterm infant has the same protein needs as a term infant.
   a. True
   b. False
4. Which of the following is a nutritional risk factor in the preterm infant?
   a. Increased glycogen stores
   b. Low bile salts and pancreatic lipase
   c. Normal gastric emptying times

5. In the infant with cholestasis still receiving parenteral nutrition due to severe short bowel syndrome, which trace elements should be decreased?
   a. Copper and manganese
   b. Selenium and copper
   c. Selenium and chromium

References

Session Outline
See presentation handout on the following pages.
Fetal growth increases with advancing gestational age (GA)
- At 21 wk GA – 10 gram/day; 3rd trimester – 30 to 35 gram/day

Fetal composition changes throughout gestation
- With advancing GA and birth weight (BW), total body water, extracellular water, sodium content and chloride content decrease
- With advancing GA and BW, intracellular water, protein, fat, calcium, phosphorus, magnesium and iron increase

Estimated fetal energy expenditure: 35 to 55 kcal/kg/day

Energy Sources:
- Maternal glucose is transferred across placenta by facilitated diffusion (primary fetal energy source). Glycolysis is major pathway for fetal glucose utilization
- Placental lactate
- Maternal amino acids are transferred across placenta by active transport. Important for fetal tissue growth, metabolic fuel, and source of gluconeogenic substrates

Minimal glycogen stores
- Decreased fat stores
- Decreased absorption & retention of nutrients
- Decreased glucose tolerance
- Inadequate vitamin and mineral stores/needs

Higher nutrient needs
- Higher growth rate/synthesis of new tissue
- Inadequate vitamin and mineral stores/needs
NUTRITIONAL RISK FACTORS IN PRETERM INFANTS

- Decreased absorption & retention of nutrients
- Low bile salts and pancreatic lipase
- Decreased lactase activity
- Delayed gastric emptying
- Immature suck/swallow
- Inadequate GI motility and digestion

DIRECT METHOD OF ASSESSING NUTRITION—ABCD

- Anthropometric
- Biochemical
- Clinical
- Dietary intake

ANTHROPOMETRIC ASSESSMENT

Classifications

- Gestational age (< 37 weeks)
- Birth weight
  - LBW (< 2500 gm)
  - VLBW (< 1500 gm)
  - ELBW (< 1000 gm)
- Size (Using Fenton Curve)
  - SGA (weight < 10% tile)
  - AGA (weight 10–90% tile)
  - LGA (weight > 90% tile)
Appropriate for Gestational Age (AGA)
- 10–90th %ile

Small for Gestational Age (SGA)
- < 10th %ile

Large for Gestational Age (LGA)
- > 90th %ile

IUGR VERSUS SGA
- Intrauterine growth restriction (IUGR)
  A fetus whose estimated fetal weight is < 10th percentile for gestation age
- Symmetric IUGR
  Occurs < 32 weeks; wt/length/HC all < 10%; normal Ponderal Index; think about infections, chromosomal or congenital anomalies
- Asymmetric IUGR
  Occurs > 32 weeks; normal length and HC but wt < 10th %; low Ponderal Index; think uteroplacental insufficiency
- Small for gestational age (SGA)
  An infant born with a birth weight at the lower end of the normal weight distribution
Ponderal Index

- Ponderal index is an indicator of wasting. It is determined by taking a ratio of the weight and length.
- \[ PI = \frac{\text{Weight (GM)}}{\text{Length (CM)}^3} \times 100 \]
- Ponderal index values of < 2.0 between 29 and 37 weeks and <2.25 beyond 37 weeks are indicative of intrauterine fetal malnutrition.

GROWTH ASSESSMENT

- Growth charts: Use Fenton Growth Curve to monitor extrauterine growth in preterm infants, CDC/WHO curves for postterm infants
- Maximum weight loss (should be < 15% BW) with regain to birth weight by DOL 7–10 in preterm infants
- Term infant should lose < 10% BW.
- Average rate of gain:
  - <1 kg 10–15gm/kg/day
  - >1–2 kg 15–20 gm/kg/day
  - > 2 kg 25–35 gm/day
- Term infants will double BW by 6 months of age & triple BW by 1 year

GROWTH ASSESSMENT

- Length
  - Reflects lean tissue mass and is not affected by fluid status.
  - 0.8 – 1.1 cm/wk in preemie; 0.66 cm/wk in term (birth–6 months)
- Head circumference
  - 0.8–1 cm/wk in preemie; 0.5 cm/wk in term (birth–6 months)
GROWTH ASSESSMENT

- Measures to optimize weight gain/growth
- Maintain a neutral thermal environment
- Minimize unnecessary activity
- Optimize nutrient intake
- Utilize proper feeding techniques

BIOCHEMICAL ASSESSMENT

- Glucose
- Electrolytes, Acid base balance
- Calcium, Phosphorus, Magnesium
- Alkaline Phosphatase
- BUN/Creatinine
- Serum Proteins (Albumin, prealbumin)
- Triglycerides
- LFTs
- CBC
- Vitamin/Trace Element levels as indicated

CLINICAL ASSESSMENT
CLINICAL ASSESSMENT

- Physical assessment including skin integrity, color, presence of edema
- Vital signs
- Apgar scores
- Urine and stool output
- Review of medical records for feeding tolerance or intolerance

DIETARY ASSESSMENT

NEONATAL ENERGY EXPENDITURE & REQUIREMENTS

- Estimated caloric expenditure
  - Resting metabolic rate = 40–60 kcal/kg/day
- Increased with prematurity, disease states & LBW
  - Cold stress = 0–5 kcal/kg/day
  - Activity = 0–5 kcal/kg/day
  - Nutrition procession (excretion, storage & synthesis) = 50–60 kcal/kg/day

NUTRITIONAL INTAKE

- Recommended Daily Requirements
- Calculated versus actual
- Parenteral Nutrition
- Enteral Nutrition
- Vitamin and Mineral supplements
**Total Parenteral Nutrition (TPN):** Provides fluids, carbohydrates, protein, fatty acids, electrolytes, vitamins, minerals, and trace elements

- **Goals:** Initial goal to prevent catabolism then to promote growth
- **Indications:** Prematurity, not able to achieve adequate enteral intake within a few days, GI issues, surgical infant.

**Starter TPN**
- Contains Dextrose, Protein and Calcium
- Goal is to prevent catabolism
- Should provide 2–3 grams protein/kg in the first 24 hours of life

**Fluid Needs in Parenteral Nutrition**
- Initial fluids should be prescribed to allow postnatal diuresis on 10–15% of body weight
- Consider urine output as well as insensible losses
- Prevent dehydration or over-hydration
- Monitor weight, I&O, serum electrolytes, BUN/Cr, and urine osmolarity/specific gravity
- Consider medical conditions
  - ELBW: 100–120 ml/kg/day
  - VLBW: 80–100 ml/kg/day
  - LBW: 80 ml/kg/day
  - Term: 60–80 ml/kg/day
- Increase by 10–20 ml/kg/day to reach a goal of 130–150 ml/kg/day
**Parenteral Energy Needs**
- Preterm: 80–100 kcals/kg/day
- Term 85–105 kcals/kg/day

**Carbohydrate (CHO)**
- Essential energy source
- Should provide 35–65% of total kcal/day
- Limited endogenous production in preemies
- 1 gram (gm) CHO provides 3.4 kcal

**CHO Requirement**
- Initial Glucose Infusion Rate (GIR) = 4–6 mg/kg/min
- Advance as tolerated by 1–2 mg/kg/min daily to maximum of 8–12 mg/kg/min
- Maintain sugars between 50–120 mg/dL

**Calculations–GIR**
- To calculate GIR use:
  \[(\text{grams of glucose/100 mL}) \times \text{IV rate/hr} \div \text{kg} \div 6 = \ldots \text{mg/kg/min}\]
- To figure out concentration of dextrose to use:
  \[(\text{mg/kg/min desired}) \times \text{kg} \div \text{IV rate/hr} \times 60 \times 0.1 = \text{dextrose in IV}\]
**REASONS FOR LIMITED GLUCOSE TOLERANCE**

- Decreased insulin production
- Insulin resistance
- Increased hepatic glucose production
- Immature hepatic enzyme system
- Abnormal number or function of insulin receptors

**PROTEIN (PRO)**

- Essential for growth especially lean tissue accretion and organ development.
- Promotes weight gain and nitrogen retention
- Crystalline amino acid solutions provide the nitrogen source in PN (not just an adult solution)
  - TrophAmine and Aminosyn PF
  - Contain essential amino acids (preterm infants): cysteine, tyrosine, arginine & taurine
- Cysteine can lower pH to maximum Ca & Phos; may need to buffer the TPN solution with acetate as it can cause metabolic acidosis. 60–120 mg/kg/day recommended

**PRO REQUIREMENT**

- Should provide 7–15% of total kcal to avoid negative nitrogen balance
- 1 gm protein = 4 kcal; 1 gm protein = 1 gm amino acid = 0.16 gm nitrogen
- Initial dose 2–3 gm/kg/day and increase by 1 gm/kg/day gain (gm/kg/day)
  - Preterm infant: 3.5–4 gm/kg/day
  - Term infant: 3 gm/kg/day
- Monitor: weight gain, length, BUN, albumin (?) & prealbumin

**FATS**

- Concentrated energy source
- Essential for normal growth and development
- Can prevent essential fatty acid deficiency with as little as 0.5 gm/kg/day initially
- Common commercially available preparation is Intralipid solution; 20% solution preferred
**PREScribing Parenteral Lipids**
- Begin 0.5–1 gram/kg/day on DOL 1
- Increase by 0.5–1 gram/kg/day until at 3 gram/kg maximum
- Keep lipid infusion rate at maximum of 0.15 gram/kg/hour
- To calculate: hourly rate $\times$ 0.2 $\div$ weight in kg

**Fat Requirement**
- Fats should provide 30–50% of total kcal/day
- 1 gm fat = 9 kcal (for 20% IL, 1 ml = 2 kcal)
- Risk for EFA deficiency within 72 hr if an exogenous source is not provided
- Some studies suggest limiting IL with sepsis, hyperbilirubinemia, and in early course of VLBW infant
- Monitor: serum triglyceride levels if getting > 2 gram/kg/day. Do not stop lipid if elevated but can decrease by 0.5–1 grams/kg/day

**Essential Fatty Acid Deficiency: Who is at risk?**
- Preterm infants, LBW infants, infants with fat malabsorption, infants on long-term TPN without adequate lipid provision, infants receiving long-term MCT as fat source, and infants with short bowel syndrome
- Signs and symptoms of EFA deficiency: Skin atrophy, scaly dermatitis, hemorrhagic dermatitis, edema, high blood pressure, impaired growth

**Electrolytes**
- Adjusted as needed to maintain serum levels of electrolytes and to maintain acid-base balance
- Usually do not need until DOL 2–6
- Balance K and Na with chloride and acetate
- Other sources of electrolytes

\[
\text{NS} = 154 \text{ mEq/L} = 0.154 \text{ mEq/mL} \\
\frac{1}{4} \text{NS} = 37 \text{ mEq/L} = 0.037 \text{ mEq/mL}
\]
## ELECTROLYTES

- **Sodium**
  - 2–4 mEq/kg
- **Potassium**
  - 2–3 mEq/kg
- **Chloride**
  - 2–3 mEq/kg

## MINERALS

- **Calcium**
  - 2 – 4 mEq/kg = 60 – 80 mg/kg (1 mEq = 20 mg elemental Ca)
- **Phosphorus**
  - 1 – 1.5 mM/kg = 31 – 46 mg/kg (1 mM = 31 mg)
  - Ca:P ratio: 1.3–1.7:1 (2.1 mEq/mM = 1.3:1 mg:mg) to promote maximal retention (bone)
- **Magnesium**
  - 0.3 – 0.6 mEq/kg

## WATER & FAT SOLUBLE VITAMINS

- Pediatric vitamin preparations added to TPN to prevent deficiencies

## TRACE ELEMENTS—ZINC

- Important for maintenance of cell growth & development; an important component for several enzymes
- Premature: 400 mcg/kg/day
- < 3 months: 250 mcg/kg/day
- Acquired deficiencies associated with malabsorption, poor wt gain, poor wound healing and iron deficiency anemia
- Preterm infants receiving inadequate amounts of zinc are at risk for deficiencies
- Consider those with increased losses
**TRACE ELEMENTS (CONT)**

- **Copper**
  - Critical for production of RBCs, hemoglobin formation, absorption of Fe and needed in multiple enzyme activities
  - 20 mcg/kg/day; decrease with impaired biliary excretion and/or cholestatic liver disease.
  - Deficiencies may result in anemia, osteoporosis, neutropenia & poor wt gain
- **Manganese**
  - Important for normal bone structure; plays a role in CHO metabolism and enzyme activation
  - 1 mcg/kg/day; decrease with impaired biliary excretion and/or cholestatic liver disease

**Selenium**

- Involved in protecting cell membranes from peroxidase damage through detoxification of peroxides and free radicals.
- 2 mcg/kg/day; decrease in renal failure
- Deficiencies have been associated with cardiomyopathy

**Chromium**

- Potentiates the action of insulin, regulating glucose levels
- 0.2 mcg/kg/day; decrease in renal failure

**CARNITINE**

- A nitrogen-containing compound required for the transfer of fatty acids into the cell mitochondria in the mitochondria
- Carnitine deficiency can develop within 2 weeks after birth if not provided in diet
- 8–10mg/kg/day
- Breast milk contains 3–5 mg/dl carnitine

**COMPLICATIONS ASSOCIATED WITH PARENTERAL NUTRITION**

- Cholestasis
- Metabolic bone disease
- Nosocomial infections
- Metabolic acidosis
- Anemia
- Hyperglycemia
- Risk of vitamin/mineral deficiency or toxicity
- Complications associated with IL
- Catheter related complications
Peripheral vs. Central TPN

- Peripheral TPN has limit of 900 mOsm/kg which limits protein, dextrose and calcium
- Consider central access when TPN need is anticipated need > 7 days

DIGESTION AND ABSORPTION

- Digestion: Process by which food is converted into chemicals used for the body
  Takes place in mouth, stomach and small intestine
- Absorption: Transfer of digestive end products into the circulation
  Takes place primarily in the small intestine; facilitated by villi
### Benefits of Enteral Nutrition
- Minimizes potential complications from prolonged parenteral nutrition
- May reduce duration of phototherapy
- Stimulates GI hormone productions
- Enhances enzyme maturation
- Reduces intestinal permeability
- Reduces sepsis

### What Are Normal Infant Nutrition Requirements?
#### DRIs (Dietary Reference Intakes)
- Recommended Dietary Allowance (RDA)
  - Set to meet the needs for 97–98% individuals in a group
  - Not established for all nutrients
- Adequate intakes (AI)
  - Used when there is no RDA. Believed to be what is adequate to meet the needs of a population.
- Tolerable Upper Intake Levels (UL)
  - Maximum level of daily nutrient that is likely to pose no risk of adverse effects. Represents total intake from food, water & supplements

### Recommendations for Enteral Nutrition—Energy
- **Energy Intake (stable growing phase)**
  - Preterm infants: 110–130 kcal/kg/day
  - Term Infants (Birth to 6 months): 105–115 kcal/kg/day

### Recommendations for Enteral Nutrition—Protein
- **Infants (Birth to 6 months):** 2.2 gm/kg/day;
- Preterm infants may need as much as 4 gm/kg/day
- **Digestion and absorption of protein**
  - Small bowel is site of most protein digestion
  - Proteins have to be broken down to di- and tripeptides to be absorbed.
  - Stomach: pepsin & renin
  - Pancreatic enzymes: trypsin, chymotrypsin, elastase
PROTEINS

- Major sources of proteins: whey and casein
- Whey has greater cysteine and less methionine than casein
- Common whey-to-casein ratios
  - Colostrum – 80:20
  - Mature milk – 55:45
  - Preterm formulas – 60:40
  - Cow’s milk – 20:80
- Essential amino acids in preterm infants include cysteine, tyrosine, arginine, & taurine

ENTERAL PROTEIN AND ENERGY REQUIREMENTS OF PRETERM INFANTS

<table>
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<th>Body weight, g</th>
<th>Protein, g/kg/d</th>
<th>Energy, kcal/kg/d</th>
<th>P/E, g/100 kcal</th>
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P/E = Ratio of protein to energy, expressed as grams of protein per 100 kcal.


Protein and Preterm Infants: Summary

- The recommended protein intake for preterm infants ranges from 3.4-4.3 g/kg/day with an energy intake of approximately 120 kcals/kg/day

RECOMMENDATIONS FOR ENTERAL NUTRITION–FAT

- Digestion and absorption of fat: Lingual lipase, pancreatic lipase, and bile salts
- Body fat stores are formed by lipogenesis from glucose
- Neonates rely on intragastric lipases for digestion of fatty acids
- Neonates are better able to digest fatty acids with decreased chain length and unsaturated form
FATS

- Most common fatty acids: Stearic acid, oleic acid & palmitic acid
- Essential fatty acids: linoleic and linolenic acid
- Short and medium–chain triglycerides (MCT)
- Long chain polyunsaturated (LCPUFA): DHA & ARA

ABSORPTION OF MEDIUM CHAIN TRIGLYCERIDES

- Require much less pancreatic lipase and bile salts for effective digestion.
- Absorbed more rapidly and directly through the portal vein
- Do not require micellar or chylomicron formation for digestion and absorption

ABSORPTION OF LONG CHAIN TRIGLYCERIDES

- LCTs are emulsified by bile salts into micelles and hydrolyzed to fatty acids and glycerol by pancreatic lipase.
- The emulsified fat enters the epithelial cells, combining with protein to form chylomicrons which are directly transferred into the lymphatic system.
- Chylomicrons are transported through the thoracic duct into the blood system and finally to the liver

DHA AND ARA

- Docosahexaenoic acid (DHA) and arachidonic acid (ARA) are fatty acids important for visual acuity and motor development
- DHA accumulates in the brain and retina in last trimester and early months after birth suggesting physiologic requirement is highest during this time
- Evidence suggests improved visual acuity and motor development in term & preterm infants when receiving recommended amounts of DHA/ARA
- Term infant: 0.2–0.4% DHA & 0.35–0.7% ARA
- Preterm infant: 0.35–1.0% DHA/0.4–2.0% ARA
Lactose is the predominant CHO in breast milk and most standard formulas. Premature formulas often replace some of the lactose content with corn syrup and short-chain glucose polymers. Lactose enhances absorption of calcium and magnesium, and promotes intestinal growth of lactobacilli. Digestion and absorption of CHO include salivary amylase, pancreatic amylase, and intestinal amylase, lactase, sucrase isomaltase, maltase.

### RECOMMENDATIONS FOR ENTERAL NUTRITION—CHO

- Determining type of feeding
  - Use breast milk when available, otherwise, choose appropriate formula
- Determine the volume goal to meet infant’s calorie needs
  - Initially, this will include parenteral and enteral nutrition components
- Need to consider feeding ability (may only want to start with trophic or minimal stimulation feedings) and clinical status
- Determine kcal/oz needed to meet the calorie goal within the desired volume
- Determine the route of feeding
  - Gavage (Bolus or continuous)
  - Transpyloric feeds
  - Breast or bottle feeding

### ENERAL FEEDING – HOW, WHAT & WHY?

- Stomach Content of the Newborn
  - Sign needing evaluation by NNP
  - Gastric residuals (＞50% previous feeding volume)
  - Bilious aspirates/emesis
  - Emesis
  - Abnormal stools
  - Abnormal abdominal exam (change in girth＞2 cm)
  - Deterioration in respiratory status

- Feeding Problems
  - Transpyloric feeds
  - Breast or bottle feeding
The American Academy of Pediatrics (AAP) recommends breast feeding for all infants regardless of birth weight.

Premature infants should receive either mother’s own milk or donor breast milk.

Breast milk is the preferred nutrition for all infants but is formulated to meet the growth needs of term infants.

If fortified and provided in adequate amounts, premature infants can thrive with a little patience and assistance from the healthcare team.

Human milk (HM) preferred feeding for all infants

“Gold Standard” upon which all infant formulas are modeled and compared

HM composition varies with gestation, within a feeding, diurnally, throughout lactation and with maternal diet

- Composition preterm: 52% fat, 39% CHO, 8% protein
- Composition term: 52% fat, 42% CHO, 6% protein

Whey predominant

Ease of digestion/absorption of nutrients

Low renal solute load

Increased absorption of fat, zinc, & iron

Immune–enhancing properties/antibodies

Contains secretory IgA

Improved neurodevelopment

Possible protection against GI infections

Fosters maternal–infant bonding
HUMAN MILK

- Carbohydrate
  - Lactose (greater in foremilk versus hind milk)
  - Provides 40% of total calories
- Protein
  - Whey predominant
  - 1.1 gm/dl
  - Amino acid content varies
- Fat
  - Contributes 40–50% of total calories (greater in hind milk)
  - Contains enzymes to improve absorption
  - Primarily long-chain fatty acids (including DHA & ARA)

CONTRAINDICATIONS TO BREAST FEEDING IN THE UNITED STATES

- Maternal Factors
  - Infection
  - Maternal HIV
  - Mother with HSV lesions on breast
  - Active TB – symptomatic mother with positive PPD & CXR
  - Active breast abscess
  - Some maternal medications
  - Cocaine (or other drugs of abuse)
- Infant Conditions
  - Galactosemia
  - Certain inborn errors of metabolism may limit amount of breast milk offered

WHO MAY NEED FORTIFIERS?

- Infant born at ≤ 34 weeks estimated gestational age or weighing < 1500 grams
- Infant > 1500 grams with suboptimal growth or increased energy needs (cardiac babies)

Feeding Preterm Babies in the NICU

- Breast milk is the best choice for all babies, including preterm infants
  - Human Milk Fortifier (HMF)
  - Prolacta
- Preterm Formulas
  - Similac Special Care 20, 24, 30 and Special Care 24 High Protein
  - Enfamil Premature 20, 24, 30 and Enfamil 24 High Protein
  - Good Start Premature 24 and High Protein
- Combination of breast milk and preterm formula
Human Milk Fortifier (HMF)

- Indications
  - < 34 weeks EGA
  - < 1500 g birth weight
- Provides additional nutrients to meet needs of preterm infants
- Fortify to breast milk 22 at 80 mL/kg/d
- Fortify to breast milk 24 at 100 mL/kg/d
- For preterm infants only!

Comparison of HMF products

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Formula Selection

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<tr>
<td>Breast Milk with HMF or Special Care 24 High Protein</td>
<td>&lt; 34 weeks EGA and/or weight &lt; 1500 gms</td>
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<tr>
<td>Breast Milk fortified with term formula</td>
<td>&gt; 34 weeks EGA requiring increased kcaals</td>
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<tr>
<td>Premature Discharge Formula</td>
<td>&gt; 34 weeks EGA and/or BW &gt; 1500 gms</td>
</tr>
<tr>
<td>Standard Cow’s Milk Term Formula</td>
<td>Healthy infants &gt; 35 weeks</td>
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Are Preterm and Term Infant Formulas the Same?

- Lactose & glucose polymers
- Meets increased protein needs (3–4 gm/kg)
- 50% fat as MCT
- Increased mineral and vitamin content
- Lactose
- Meets needs of term infant (2.2 gm/kg)
- All LCT as vegetable oils
- Mineral & vitamin content to meet needs of term infant

Preterm Formulas | Term Formulas
**PRETERM DISCHARGE FORMULAS**

- Standard dilution is 22 kcal/oz
- Higher levels of protein, vitamins & minerals
- Available in powder for retail

**WHO SHOULD RECEIVE PRETERM DISCHARGE FORMULAS?**

- AAP states, "Use of preterm discharge formula to postnatal age of 9 months results in greater linear growth, weight gain and BMC compared with use of term infant formula."
- Preterm infants < 2000 gm nearing discharge from hospital
- Not recommended for term infant with increased calorie needs

**Infant Formula**

- Most acceptable alternative nutrient source for infants for whom breast milk is contraindicated or unavailable
- Standard caloric density for formula preparation is 20 kcal/oz (1 scoop per 2 oz)
- Available in ready-to-feed, liquid concentrate and powder
**Types of Formula**

- **Standard (Cow’s Milk)**
- **Soy**
- **Protein Hydrolysate (Hypoallergenic)**
- **Elemental (Free Amino Acid)**
- **Premature**
- Follow-up formulas
  - 3 main brands: Gerber (Nestle), Enfamil (Mead Johnson) and Similac (Abbott)
  - Generic brands also available

**Standard (Cow’s Milk) Formula**

- 40–50% of energy from fat, 7–11% from protein, rest from carbohydrate
- DHA/ARA
- Prebiotics and probiotics
- Added rice starch
- Iron fortified
- Lactose reduced and lactose free
  - Congenital lactase deficiency is rare

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**Cow’s Milk Based Formulas**

<table>
<thead>
<tr>
<th>Brand</th>
<th>Formula Indication for use</th>
<th>Macronutrient Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good Start Gentle</strong> Gerber</td>
<td>Contains DHA/ARA</td>
<td>• Standard infant formula</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Standard infant formula</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Good Start Protect</strong> Gerber</td>
<td>Contains <em>Bifidobacterium lactis</em></td>
<td>• Standard infant formula</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Enfamil Premium</strong></td>
<td>Contains DHA/ARA, Prebiotics</td>
<td>• Standard infant formula</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Available in ‘Newborn’ or ‘Infant’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Similac Advance</strong></td>
<td>Contains DHA/ARA</td>
<td>• Standard infant formula</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Good Start Soothe</strong> Gerber</td>
<td>Contains probiotics - <em>L. Reuteri</em></td>
<td>• Reduced lactose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Enfamil Gentlease</strong></td>
<td>Reduced lactose</td>
<td>• Partially hydrolyzed protein but not hypoallergenic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Similac Sensitive</strong></td>
<td>Lactose free</td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Enfamil AR</strong></td>
<td>Added rice starch</td>
<td>• Added rice starch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Similac Sensitive for Spit-up</strong></td>
<td>Added rice starch and lactose free</td>
<td>• May be used for frequent spit-ups</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td><strong>Similac Organic</strong></td>
<td>Made with organic ingredients</td>
<td>• Contains DHA/ARA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contains DHA/ARA</td>
</tr>
</tbody>
</table>

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**Soy Based Formula**

- AAP last updated position paper in May 2008
- Few indications for use over cow’s milk formula
- High frequency of sensitivity to both cow milk and soy

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**Pediatrics.** 2008;121:1062–1068
Use of Soy Formula

Indications
- Galactosemia
- Hereditary lactase deficiency (rare)
- Preference for vegetarian diet

Contraindications
- Sucrase–isomaltase deficiency
- Hereditary fructose intolerance.
- Cow’s milk protein allergy (10–14% of these infants also have soy protein allergy)
- Preterm infants
- Infants with colic or fussiness
- Cow’s milk protein–induced enteropathy or enterocolitis
- Prevention of atopic disease

Pediatrics. 2008;121:1062–1068

Soy Based Formulas

<table>
<thead>
<tr>
<th>Good Start Soy Garber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy Gerber</td>
</tr>
<tr>
<td>Contains DHA/ARA</td>
</tr>
<tr>
<td>Milk free-lactose free</td>
</tr>
<tr>
<td>Not recommended for pre-term infants</td>
</tr>
<tr>
<td>CHO- corn maltodextrin, sucrose</td>
</tr>
<tr>
<td>FAT- palm olein, soy, coconut, safflower oils</td>
</tr>
<tr>
<td>PRO- hydrolyzed soy protein isolate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prosobee Enfamil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains DHA/ARA</td>
</tr>
<tr>
<td>Milk free-lactose free</td>
</tr>
<tr>
<td>Not recommended for pre-term infants</td>
</tr>
<tr>
<td>CHO- corn syrup solids</td>
</tr>
<tr>
<td>FAT- palm olein, soy, coconut, sunflower oils</td>
</tr>
<tr>
<td>PRO- soy protein isolate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Isomil Similac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains DHA/ARA</td>
</tr>
<tr>
<td>Milk free-lactose free</td>
</tr>
<tr>
<td>Not recommended for pre-term infants</td>
</tr>
<tr>
<td>CHO- corn syrup and sucrose</td>
</tr>
<tr>
<td>FAT- safflower oil, soy, coconut oil</td>
</tr>
<tr>
<td>PRO- soy protein isolate</td>
</tr>
</tbody>
</table>

Protein Hydrolysate

- Extensively hydrolyzed proteins–hypoallergenic
- Indications for use:
  - Cows milk protein allergy
  - Soy protein allergy
  - Gastrointestinal or liver diseases
  - At risk for atopic disease when exclusive breastfeeding for 4–6 months not possible
  - AAP takes no position on the use of these formulas for the treatment of colic or irritability
  - *If allergic symptoms persist, switch to free amino–acid based formula

Pediatrics. 2008;121:1062–1068

Protein Hydrolysate Based Formulas

<table>
<thead>
<tr>
<th>Nutramigen Exsamil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alimentum Similac</td>
</tr>
<tr>
<td>Contains DHA/ARA</td>
</tr>
<tr>
<td>Extensively hydrolyzed proteins- hypoallergenic</td>
</tr>
<tr>
<td>For protein allergy/malabsorption</td>
</tr>
<tr>
<td>Gluten, lactose, sucrose and galactose free</td>
</tr>
<tr>
<td>CHO- corn syrup solids, modified cornstarch</td>
</tr>
<tr>
<td>FAT- palm olein, soy, coconut, sunflower oils</td>
</tr>
<tr>
<td>PRO-extensively hydrolyzed casein</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pregestimil Enfamil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains DHA/ARA</td>
</tr>
<tr>
<td>Extensively hydrolyzed proteins- hypoallergenic</td>
</tr>
<tr>
<td>High MCT oil content is easier to absorb in some infants with GI problems</td>
</tr>
<tr>
<td>Lactose free</td>
</tr>
<tr>
<td>CHO- corn syrup solids, dextrose and modified cornstarch</td>
</tr>
<tr>
<td>FAT- 55% MCT oil, soy, corn and vegetable oils</td>
</tr>
<tr>
<td>PRO- casein hydrolysate with amino acids</td>
</tr>
</tbody>
</table>
**Elemental (free amino acid)**

- Infants with severe protein hypersensitivity
- Benefits should be seen within 2–4 weeks and the formula continued until the infant is 1 year of age or older
- Extremely expensive and difficult for families to obtain (Elecare now available at Walmart)
- Available through WIC with proper diagnosis

<table>
<thead>
<tr>
<th>Element (Free Amino Acid) Based Formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elecare Infant</strong></td>
</tr>
<tr>
<td>- Hypoallergenic</td>
</tr>
<tr>
<td>- Protein maldigestion, malabsorption,</td>
</tr>
<tr>
<td>severe food allergies, short-bowel</td>
</tr>
<tr>
<td>syndrome, Eosinophilic GI disorders</td>
</tr>
<tr>
<td>- CHO- corn syrup solids</td>
</tr>
<tr>
<td>- FAT- safflower, 33% MCT and soy oil</td>
</tr>
<tr>
<td>- PRO- 100% free amino acids</td>
</tr>
<tr>
<td>Preferred at ACH due to ease of mixing</td>
</tr>
<tr>
<td>instructions</td>
</tr>
<tr>
<td><strong>Neocate Infant</strong></td>
</tr>
<tr>
<td>- Hypoallergenic</td>
</tr>
<tr>
<td>- Protein maldigestion, malabsorption,</td>
</tr>
<tr>
<td>severe food allergies, short-bowel</td>
</tr>
<tr>
<td>syndrome, Eosinophilic GI disorders</td>
</tr>
<tr>
<td>- CHO- corn syrup solids</td>
</tr>
<tr>
<td>- FAT- refined vegetable oil (soy,</td>
</tr>
<tr>
<td>coconut) sunflower, 33% MCT oil</td>
</tr>
<tr>
<td>- PRO- 100% free amino acids</td>
</tr>
</tbody>
</table>

**Super Special Formulas**

- RCF (CHO free)
- CALCULO XD (low calcium)
- ProViMin (CHO/fat free)
- PRO–PHREE (protein free)
- Enfaport (Very high MCT oil–90% fat)
- KetoCal (For ketogenic diet)
- Formulas for Inborn errors of Metabolism
  - Propimex, Cycinex

**VITAMIN AND MINERAL NEEDS**
Osteopenia of Prematurity

- Elevated Alkaline Phosphatase is marker for osteopenia
- Risk Factors
  - Bone mineralization occurs during last trimester
  - Long term TPN with suboptimal Ca/Phos
  - Diuretic use
  - Seizure meds
- Monitor Alk Phos, Serum Calcium & Phosphorus
- Start enteral feeds as soon as possible

Vitamin D

- AAP recommends 400 IU per day.
  - 1 ml Poly-Vi-Sol and D-Vi-Sol each contain 400 IU vitamin D
  - Breast milk has minimal vitamin D
  - 1 liter of infant formula provides 400 IU vitamin D

Iron

- At risk for Iron deficiency anemia:
  - Low stores at birth
  - Frequent blood draws
- Treatment
  - 2 – 4mg/kg
  - Iron fortified formula for 1st year
  - Breast fed infants need supplementation
  - Add iron for term breast fed infants at 4–6 months of age