“Feed Me!” Neonatal Nutrition Review

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The speaker has signed a disclosure form and indicated she has an affiliation with one or more persons or entities that could be perceived as having a bearing on her presentation of this subject.

Session Summary

This session provides a general overview of neonatal nutrition to help prepare the participant for NCC Certification.

Session Objectives

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

- discuss parenteral nutrition requirements;
- identify enteral nutrition requirements;
- compare and contrast formulas utilized in the preterm and term infant;
- discuss the need for possible enteral feeding supplementation.

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 handout on following pages.
FEED ME! NEONATAL NUTRITION REVIEW

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FETAL GROWTH AND COMPOSITION

- Fetal growth increases with advancing gestational age (GA)
  - At 21 wk GA – 10 gram/day; 3rd trimester – 30 to 35 gram/day until 32-34 wk
- 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

FETAL ENERGY EXPENDITURE & SOURCES

- Estimated fetal energy expenditure
  - 35 to 55 kcal/kg/day
- Energy Sources
  - Maternal glucose
    - Transferred across placenta by facilitated diffusion (primary fetal energy source)
    - Glycolysis is major pathway for fetal glucose utilization
  - Placental lactate
  - Maternal amino acids
    - Transferred across placenta by active transport
    - Important for fetal tissue growth, metabolic fuel, and source of gluconeogenic substrates

PURPOSE OF NUTRITION

- Maintenance
- Growth/Development
- Replace losses
- Meet stress needs

NUTRITIONAL RISK FACTORS IN PRETERM INFANTS

- Minimal glycogen stores
- Decreased fat stores
- Higher nutrient needs
  - Higher growth rate/synthesis of new tissue
  - Decreased absorption & retention of nutrients
- Decreased glucose tolerance
- Immature suck/swallow
- Inadequate GI motility and digestion
  - Low bile salts and pancreatic lipase
  - Decreased lactase activity
  - Delayed gastric emptying
- Inadequate vitamin and mineral stores/needs

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
- Recommended neonatal caloric requirement: 120-150 kcal/kg/day (preterm), 105-115 kcal/kg/day (term)
- 1 kcal = 1 cal
- Parenteral nutrition uses nonprotein calories (NPC); enteral nutrition uses total calories

Brodsky & Martin, 2010
ABC’S OF ASSESSING NUTRITION

- Anthropometric
- Biochemical
- Clinical
- Dietary intake
- Evaluation of gestational age and size for gestational age

GROWTH ASSESSMENT

- Growth charts
  - Weight
    - Preterm
      - Maximum weight loss (should be < 15% BW) expected by day of life (DOL) 4-6
      - Average rate of gain is 15 gm/kg/day (20 gm/kg/day for catch-up)
    - Term infant
      - Should lose < 10% BW; goal for weight gain is 15-30 gm/day
      - Term infants will double BW by 5-6 months of age & triple BW by 1 yr.
      - “Dry” versus “Actual” weight
        - Suggested to use dry weight if severe anasarca and decreased urine output (UOP)

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

GROWTH ASSESSMENT

- Growth charts
  - 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-6mon)
  - Head circumference
    - 0.9 cm/wk in preemie; 0.5 cm/wk in term (birth-6 mon); head growth in term infant will be 12 cm in first year

GROWTH ASSESSMENT

Fenton Preterm Growth Chart
**DETERMINANTS: GESTATIONAL AGE AND BIRTH WEIGHT CATEGORIZATION**

- Gestational age determination
  - First trimester ultrasound ideal
  - Maternal dates may not be accurate
  - Ballard exam

- Birth weight
  - Normal weight, low birth weight (LBW), very low birth weight (VLBW) or extremely low birth weight (ELBW)

- Size for gestational age
  - Small for gestational age (SGA), appropriate for gestational age (AGA) or large for gestational age (LGA)

**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

**BIOCHEMICAL ASSESSMENT OF NUTRITIONAL STATUS**

- Alkaline phosphatase
- Phosphorus
- Calcium
- Albumin

- To assess for other metabolic, renal and GI abnormalities
- Blood gases, serum electrolytes, glucose, BUN and creatinine

**CLINICAL ASSESSMENT**

- Physical assessment
- Vital signs
  - Apgar scores
  - Urine and stool output
  - Review of medical records

**DIETARY INTAKE**

- Recommended daily requirements
  - Calculated versus actual
- Parenteral Nutrition
- Enteral Nutrition
  - Don’t forget to include vitamin and mineral supplements and other modulars
PARENTERAL NUTRITION

Total Parenteral Nutrition (TPN)
• Provides fluids, carbohydrates, protein, fatty acids, electrolytes, vitamins, minerals, and trace elements

Goals
• Initial goal to prevent catabolism
• Maintenance goal is to promote growth

Indications
• Prematurity, not able to achieve adequate enteral intake within a few days, GI issues, surgical infant
• Ideally start on admission “starter” or “vanilla” TPN
• Prevent protein store losses

FLUID NEEDS
• Goal is to maintain normal volume and tonicity of body fluids
  • Consider insensible losses
  • Prevent dehydration or over-hydration
    • Monitor weight, I&O, serum electrolytes, BUN/Cr, and urine osmolarity/specific gravity
  • Consider medical conditions
• Begin fluids at 60-80 ml/kg/day and progress to goal of 120-160 ml/kg/day
  • ELBW may need much higher total fluids (TF) to keep up with urine output > 3.5 ml/kg/hr

ENERGY
• Requirements lower for TPN vs. enteral
• Factors affecting energy needs
  • Prematurity, infection, chronic lung disease, wound healing
• Goal
  • Initial: approximately ~ 60 NPCs/kg/day
  • Maintenance goal: approximately 70-90 NPCs/kg/day
    • Delivered as 30-50% fat, 35-65% CHO, and 7-15% protein
  • Preterm growth: 80-105 NPCs/kg/day
  • Term growth: 70-95 NPCs/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
• For positive nitrogen balance, need 6 gm glucose for each gm of protein
• Only D5 is isotonic (252 osmo)

CHO REQUIREMENT
• Preterm Infant
  • Initial Glucose Infusion Rate (GIR) = 5.8 mg/kg/min
  • Advance as tolerated by 1-2 mg/kg/min daily to maximum of 11-12 mg/kg/min
  • D10 at 80 ml/kg = 5.5 mg/kg/min
  • Target: blood sugar 50-120 mg/dL
• Term Infant
  • Initial GIR = 3.5 mg/kg/min
GIR calculation formula

\[(\text{mg of glucose/ml}) \times \text{IV rate/hr} ÷ \text{kg} = \text{___mg/kg/min}\]

- D5W = 50 mg/ml, D10W = 100 mg/ml, etc

To figure out concentration of dextrose to use

\[(\text{mg/kg/min desired}) \times \text{kg} ÷ \text{IV rate/hr} \times 60 \times 0.1 = \text{dextrose in IV}\]

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

CALCULATIONS

- Essential for growth
- Goals
  - Maintain normal plasma amino acid levels
  - Promote weight gain and nitrogen retention
- Crystalline amino acid solutions provide the nitrogen source in PN (not just an adult solution)
  - TrophAmine and Aminosyn PF
  - 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

PROTEIN

- Essential for growth
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  - 60-120 mg/kg/day recommended

- 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 1 – 1.5 gm/kg/day and increase by 1 gm/kg/day (newer research suggests starting with 2-3 gm/kg)
- Preterm infant: 2.5 – 3.5 gm/kg/day
- Term infant: 2 – 2.5 gm/kg/day
- Monitor: weight gain, length, BUN, albumin & prealbumin

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- 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
- Hang-time > 12hr may be associated with coagulase-negative staphylococcal bacteremia

- 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 exogenous source is not provided
- Limit to 3 gm/kg/day
  - Some studies suggest limiting IL with sepsis, hyperbilirubinemia, and in early course of VLBW infant
- Rate of lipid infusion should not exceed 0.15-0.20 gm/kg/hr
- Monitor: serum triglyceride levels if rec > 2 gm/kg/day

FATS

FAT REQUIREMENT
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
- Make sure you balance K and Na with chloride and acetate
- Forgotten sources of electrolytes
  - NS = 154 mEq/L = 0.154 mEq/ml
  - NS ¼ = 37 mEq/L = 0.037 mEq/ml
  - Amino acids contain some potassium

ELECTROLYTES

- Sodium
  - 2.4 mEq/kg
- Potassium
  - 2.3 mEq/kg
- Chloride
  - 2.3 mEq/kg

MINERALS

- Calcium
  - 2 - 3 mEq/kg = 40 – 60 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 (2.1mEq/mM = 1.3:1 mg:mg) promote maximal retention
  - Potassium phosphate has high aluminum content so sodium phosphate preferred
- Magnesium
  - 0.4 - 0.6 mEq/kg = 4.8 - 7.2 mg/kg

WATER & FAT SOLUBLE VITAMINS

- Water soluble
  - Needed to prevent deficiencies
  - Current formulations may provide excessive amounts
- Fat soluble (A, D, E, and K)
- MVI Pediatric solution
  - Contains Vitamins A, B, B, C, D, E & K; niacin, thiamin riboflavin, biotin, folic acid & pantothenic acid
  - < 1kg = 1.5 ml/24 hrs; 1.3 kg = 3.25 ml/24 hrs; > 3 kg = full vial (5 ml/24 hrs)

### 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
- Premature infants receiving inadequate amounts of zinc are at risk for deficiencies

**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

**Molybdenum**
- 0.25 mcg/kg/day; decrease in renal failure

**Carnitine**
- Essential for optimum oxidation of fatty acids in the mitochondria
- Carnitine deficiency can develop within 6-10 days after birth if not provided in diet
- 8-10 mg/kg/day

### 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

### ENTERAL NUTRITION

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Dietary Reference Intakes
- Recommended Dietary Allowance (RDA)
- Set to meet the needs of 97-98% of individuals in a group
- Not established for all nutrients
- Adequate intakes (AI)
  - For healthy breastfed infants, AI is the mean intake
- Tolerable Upper Intake Levels (TUI Levels)
  - Maximum level of daily intake that is unlikely to pose no risk of adverse effects
  - Represents total intake from food, water & supplements

ENZYMES INVOLVED IN DIGESTION
- Pancreatic juice (from pancreas)
  - Amylase (digests carbohydrates)
  - Lipase (digests triglycerides)
  - Bile (from liver)
- Dietary fiber, mannose, fucose, etc.

Energy Intake (stable growing phase)
- Preterm infants: 120 kcal/kg/day
- Infants (birth to 6 months): 105-115 kcal/kg/day
- Fluid Intake
  - Most babies tolerate 150-180 ml/kg/day

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WHAT ARE NORMAL INFANT NUTRITION REQUIREMENTS?
- Dietary Reference Intakes
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- Not established for all nutrients
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RECOMMENDATIONS FOR ENTERAL NUTRITION
- Protein Intake
  - Infants (birth to 6 months): 2.2 gm/kg/day; preterm infants may need as much as 4 gm/kg/day
  - 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

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BENEFITS OF ENTERAL NUTRITION
- Regain birth weight quicker
- Minimizes potential complications from prolonged parenteral nutrition
- May reduce duration of phototherapy
- Stimulates GI hormone productions
- Enhances enzyme maturation
- Reduces intestinal permeability
- Reduces sepsis
**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

**RECOMMENDATIONS FOR ENTERAL NUTRITION**

- Fat Intake
  - 4-6 gm/kg/day
- 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

**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
- Evidence also suggests improved growth rate in preterm infants receiving DHA/ARA supplemented formula.

**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 thru the thoracic duct into the blood system and finally to the liver.
**RECOMMENDATIONS FOR ENTERAL NUTRITION**

- Carbohydrates
  - 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
    - Salivary amylase, pancreatic amylase, & intestinal amylase (lactase, sucrase isomaltase, maltase)
- Total calories: 6% from proteins, 42% from carbohydrates, and 52% from fats

**DIGESTION OF CARBOHYDRATES**

- **VITAMINS**
  - Water-soluble
    - Vitamin B complex
    - Vitamin C
    - Not formed by precursors
    - Daily intake required
    - Does not accumulate in the body
    - Placental transfer by active transport
  - Fat-soluble
    - Vitamins A, D, E & K
    - Synthesized from precursors
    - Daily intake typically required
    - Not easily excreted
    - Placental transfer by simple or facilitated diffusion

- **VITAMIN DEFICIENCIES**
  - Preterms at risk for vitamin deficiencies as well as toxicities
  - Vitamin B6 (pyridoxine)
    - Dermatitis, seizures; associated with hypochromic anemia, seizures & homocystinuria
  - Vitamin B12 and folic acid
    - Breast-fed infants of vegetarian mothers who do not eat eggs or dairy products are at risk (B12)
    - Megaloblastic anemia, poor weight gain
  - Vitamin C (ascorbic acid)
    - Associated with poor wound healing and transient tyrosinemia

- **VITAMIN DEFICIENCIES (CONT)**
  - Vitamin A (retinol)
    - May play a role in the development of CLD; can lead to FTT
  - Vitamin D
    - Can lead to osteopenia/rickets, FTT and possibly tetany.
    - AAP recommendations: 400 IU per day
  - Vitamin E
    - Antioxidant properties
    - Anemia with reticulocytosis, thrombocytosis and neurologic deficits associated with deficiency
  - Vitamin K
    - Risk factors: Newborn, certain maternal medications, breast fed infants
    - Deficiency associated with hemorrhagic disease of the NB

- **TRACE ELEMENTS**
  - Iron
    - Component of hemoglobin and myoglobin
    - Deficiencies may result in microcytic and hypochromic anemia as well as FTT
ENTERAL FEEDING – HOW, WHAT & WHY?

- Determining feeding mixture
  - 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

HUMAN MILK

- Human milk (HM) preferred feeding for all infants
- Maternal decision supported by Medical team
- “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 (ADA, 2009)
  - Composition preterm: 52% fat, 39% CHO, 8% protein
  - Composition term: 52% fat, 42% CHO, 6% protein

HUMAN MILK ADVANTAGES

- 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

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), cyclosporin, lithium, methotrexate, phenycyclidine, radioactive agents
- Infant Conditions
  - Galactosemia
  - Certain inborn errors of metabolism may limit amount of breast milk offered

FEEDING PROBLEMS

- Signs needing evaluation by NNP
  - Gastric residuals
  - Bilious aspirates/ emesis
  - Emesis
  - Abnormal stools
  - Abnormal abdominal exam
  - Deterioration in respiratory status

Carbohydrate
  - Lactose (greater in foremilk versus hindmilk)
  - 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 hindmilk)
  - Contains enzymes to improve absorption
  - Primarily long-chain fatty acids (including DHA & ARA)
SUPPLEMENTS IF RECEIVING HUMAN MILK

- Vitamin D
  - AAP recommends 400 I.U./day; Multivitamin provides this amount in 1 ml dose
- Iron
  - Preterm infants will need Fe when tolerating full feeds
  - 2-4 mg/kg/day
- For preterm infants
  - Some nutrients may not be met in HM collected > 2 weeks postpartum: Protein, calcium, phosphorus, sodium, zinc, vitamins, and calories

HUMAN MILK FORTIFICATION

WHO MAY NEED FORTIFIERS?

- Infant born at ≤ 34 weeks estimated gestational age or weighing < 1500 grams
- Infant on TPN > 2 weeks with suboptimal Ca/Phos intake
- Infant > 1500 grams
  - With suboptimal growth
  - With limited ability to tolerate increased volume intake

ADA, 2009

PRETERM INFANT FORMULAS

- Enfamil Premature – 20 and 24 kcal/oz, Iron fortified; also now High Protein 24 calorie/oz
- Gerber Good Start - Premature 24 kcal/oz, High Protein 24 calorie/oz; also now Nourish 22 cal/oz
  - 100% whey proteins
- Similac Special Care (SSC) – 20, 24 and 30 kcal/oz, Iron fortified; also High Protein 24 calorie/oz
- All have added DHA & ARA (0.32-0.33/0.67 for Enfamil & Good Start products; 0.25/0.4 for Similac products)
**ARE PRETERM AND TERM INFANT FORMULAS THE SAME?**

- **Preterm Formulas**
  - Lactose & glucose polymers
  - Meets increased protein needs (3-4 gm/kg)
  - 50% fat as MCT
  - Increased mineral and vitamin content
    - 180 ml/kg/day of 20 kcal or 150 ml/kg/day of 24 kcal

- **Term Formulas**
  - 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 DISCHARGE FORMULAS**

- Enfamil Enfacare, Good Start Nourish, & Similac Expert Care NeoSure
- Standard dilution is 22 kcal/oz
- Higher levels of protein, vitamins & minerals
- Available in powder for retail
- Enfamil & Similac products both have greater amount lactose than preterm hospital-based formulations

**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
- Bigger preterm infant with increased calorie and/or protein needs
- Not recommended for term infant with increased calorie needs
- Guidelines for VLBW infants at discharge
  - 105-130 kcal/kg; 2-4 mg/kg/day iron; 400 IU Vit D daily; Multivitamins

**TERM FORMULAS**

- Enfamil Premium Newborn or Enfamil Premium (20 cal/oz), Enfamil with Iron (24 cal/oz)
  - Lactose
  - Intact cow milk protein, Whey dominant (60:40) except for Premium NB (80:20)
  - Fat includes palm, soy, coconut and sunflower oils
  - DHA & ARA levels correspond w/ expert panel recommendations
  - Premium NB has increased Vit D to meet lower intake of NB
- Gerber Good Start Gentle or Protect
  - Lactose & corn maltodextrin
  - Partially hydrolyzed cow milk protein, 100% Whey
  - Fat includes palm, soy, coconut and sunflower oils
  - DHA & ARA levels correspond w/ expert panel recommendations
- Similac Advance or Similac with Iron (24 cal/oz)
  - Lactose
  - Intact cow milk protein, Casein dominant (48:52)
  - Fat includes soy, coconut and safflower oils

**STANDARD COW MILK TERM FORMULAS**

- Enfamil Premium Newborn or Enfamil Premium (20 cal/oz), Enfamil with Iron (24 cal/oz)
  - Lactose
  - Intact cow milk protein, Whey dominant (60:40) except for Premium NB (80:20)
  - Fat includes palm, soy, coconut and sunflower oils
  - DHA & ARA levels correspond w/ expert panel recommendations
  - Premium NB has increased Vit D to meet lower intake of NB
- Gerber Good Start Gentle or Protect
  - Lactose & corn maltodextrin
  - Partially hydrolyzed cow milk protein, 100% Whey
  - Fat includes palm, soy, coconut and sunflower oils
  - DHA & ARA levels correspond w/ expert panel recommendations
- Similac Advance or Similac with Iron (24 cal/oz)
  - Lactose
  - Intact cow milk protein, Casein dominant (48:52)
  - Fat includes soy, coconut and safflower oils

**NEWER ADDITIONS TO FORMULAS**

- Probiotics
  - Live microorganisms added to help support a healthy immune system; adds a specific bacterial colony to gut flora
  - Gerber Good Start Protect (Bifidobacterium lactis)
- Prebiotics
  - Nondigestible food ingredient (CHO) that stimulates growth/activity of beneficial bacteria in the colon; enhances gut flora already present
  - Enfamil Premium, Good Start Gentle and Similac Advance (differences in GOS and/or polydextrose components)
### Modified Cow Milk Term Formulas

- **Enfamil Gentlease**
  - Lactose (1/5 regular Enf) & corn syrup solids
  - Partially hydrolyzed cow milk protein; Whey dominant (60:40)
- **Gerber Good Start Soothe**
  - Special CHO blend: 30% lactose; probiotic L. Reuten
- **Similac Sensitive**
  - Sucrose & corn maltodextrin
  - Milk protein isolate; Casein dominant (48:52)

### Cow Milk W/ Rice Starch Additive Formulas

- **Enfamil A.R. and Similac for Spit-Up**
  - Part of CHO from rice starch
  - May be less effective if used in conjunction with antacid therapy
  - Contraindicated in infants with galactosemia, strong family history of true cow milk allergy, or vegan parent preference

### Soy Protein Formulas

- **Enfamil ProSobee, Gerber Good Start Soy, and Similac Isomil**
- Protein is soy protein isolate with added amino acids lost in process
- Fat composition (including DHA & ARA) similar to corresponding blend in cow milk formula
- Mineral content higher as phytates bind Ca & Phos, mineralization acceptable

### When or When Not to Use Soy Formulas?

- **When to use?**
  - Galactosemia or primary lactase deficiency
  - Vegetarian parent preference
  - IgE mediated allergy to cow milk protein
  - Isomil DF clinically shown to reduce duration of liquid stools
- **When not to use?**
  - Infants < 1800 grams
  - Insufficient protein, calcium & phosphorus for growth
  - Cow milk protein-induced enteropathy or enterocolitis
  - Colic

### Lactose Free Formulas

- **Enfamil ProSobee**
  - Corn syrup solids
  - Soy protein isolate
- **Similac Sensitive/Similac Soy Isomil**
  - Sucrose & corn maltodextrin
  - Milk protein isolate
- Contraindicated for infants with galactosemia, strong family history of true cow milk allergy, or vegan parent preference

### Miscellaneous Formulas

- **Organic cow milk-based formulas**
  - Must contain at least 95% organic ingredients by weight
  - Increase in popularity in some regions due to concerns about the use of antibiotics, pesticides and hormones in the dairy animal industry
- **Similac Organic with Iron**
  - Organic nonfat dry milk; Casein dominant (48:52)
  - CHO: Organic corn maltodextrin, organic cane sugar & organic lactose
**Indicated for fat malabsorption and allergy or sensitivity to intact proteins (milk and/or soy)**

**Hypoallergenic**

**Disadvantages:** Poor taste, high cost & high osmolality

**Enfamil Nutramigen**
- CHO: Corn syrup solids, modified corn starch
- Fat blend: MCT oil (55%)

**Enfamil Pregestamil**
- CHO: Sucrose & modified corn syrup
- Fat blend: MCT oil (33%)

**Similac Alimentum**
- CHO: Corn syrup solids
- Fat blend: MCT oil (33%)

**Indications:** protein maldigestion, severe malabsorption, extreme protein hypersensitivity persisting even with hydrolyzed protein formulas

**Hypoallergenic**

**Disadvantage: Poor taste and high cost**

**Enfamil Nutramigen AA, Neocate, Similac Elecare**
- All have Free L-amino-acids; CHO source is corn syrup solids

**Metabolic**
- Used for infants with inborn errors of metabolism
- Must be used under the continuous supervision of the MD/ARNP and the dietitian

**Enfamil Portagen –** for infants with poor ability to digest, absorb, or utilize fats

**Enfamil Enfaport –** for infants with chylothorax or LCHAD deficiency (30 cal/oz concentrate)

**Similac PM 60/40 –** for infants predisposed to calcium disorders & for those who would benefit from lowered mineral levels

**Fixed Nutrient Supplement**
- To increase protein content
  - Beneprotein – 1.3 g protein/tsp
- To increase fat content
  - MCT (does not contain any EFAs) OR corn oil
  - Use with bolus feeds
  - Microlipid – use with continuous feeds
- To increase CHO content
- Polycose

**Multinutrient Additive**
- Human milk fortifiers

**Starch-Based Thickener (Thick It)**
- Continues to thicken over time
- 2-3 tsp/4 fl oz for nectar consistency; 3-5 tsp/4 fl oz for honey consistency

**Rice Cereal**
- Starch-based thickeners & rice cereal have no effect on breast milk
CALORIC VALUES

- To calculate calories: \[ \text{ml/d} \times \frac{\text{kcal/ml}}{\text{kg}} = \text{kcal/kg/day} \]
  - 20 kcal/oz HM or formulas = 0.67 kcal/ml
  - 22 kcal/oz formulas = 0.74 kcal/ml
  - 24 kcal/oz formulas = 0.8 kcal/ml
- Thick It = 6 kcal/tsp
- Beneprotein = 5.4 kcal/tsp
- MCT oil = 7.76 kcal/ml
- Corn oil = 8 kcal/ml
- Microlipid emulsion = 4.5 kcal/ml
- Polycose liquid = 2 kcal/ml; powder = 8 kcal/tsp
- Rice cereal = 4.3 kcal/tsp

INCREMENTAL CALORIC DENSITY OF HUMAN MILK

<table>
<thead>
<tr>
<th>Caloric Density</th>
<th>Formula Powder to 120ml HM</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>½ tsp</td>
</tr>
<tr>
<td>24</td>
<td>1.5 tsp</td>
</tr>
<tr>
<td>26</td>
<td>2 tsp</td>
</tr>
<tr>
<td>28</td>
<td>1 tbsp</td>
</tr>
<tr>
<td>30</td>
<td>1 scoop</td>
</tr>
</tbody>
</table>

SELECTING A FORMULA BASED ON COMPONENTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Formula Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHO – Lactose</td>
<td>Enfamil: Premium, AR, Enfscare, Premature; Similar: Advance, Special Care, 60/40</td>
</tr>
<tr>
<td>CHO – Sucrose &amp; glucose polymers</td>
<td>Similac: Alimentum, Isomil, Sensitive; Portagen</td>
</tr>
<tr>
<td>CHO – Glucose polymers</td>
<td>Enfamil: Gentlease, Nutramigen, Pregestamil, Provobez; Nasure; Similar: Sensitive, Nusure (also contains lactose)</td>
</tr>
<tr>
<td>Protein – Cow’s Milk</td>
<td>Enfamil: Premium, AR, Enfscare, Premature; Portagen; Similar: Advance, Special Care, Nasure, Sensitive, 60/40</td>
</tr>
<tr>
<td>Protein – Soy Protein</td>
<td>Isomil; Provobez</td>
</tr>
<tr>
<td>Protein – Hydrolysates</td>
<td>Alimentum; Nutramigen; Pregestamil</td>
</tr>
<tr>
<td>Protein – Free amino acids</td>
<td>Nasure; Elecare</td>
</tr>
<tr>
<td>Fat – Long-chain triglycerides</td>
<td>Enfamil: Premium, AR, Gentlease, Nutramigen, Provobez; Nasure; Similar: Advance, Isomil, Sensitive, 60/40</td>
</tr>
<tr>
<td>Fat – Medium- and Long-chain Trig</td>
<td>Enfamil: Enfscare, Premature, Portagen; Pregestamil; Similar: Nasure, Special Care</td>
</tr>
</tbody>
</table>

“I WANT MORE!”

- Solid foods are generally started between 4-6 months
- Look for developmental signs of readiness
- Always introduce one new food at a time
- Only feed from spoon
- Consider toddler formulas when transitioning from infant formula or breast milk (Enfagrow; Good Start 2 Protect or 2 Gentle; and Similac Go & Grow)