Care and Office Follow-Up of the Near-Term Infant

Preterm infant: treatment goals — 1) focus on nutritional issues; 2) achieve normal weight and length by expected date of delivery or hospital discharge; 3) discharge babies weighing 1800 to 2000 g and ≥35 wk, if tolerating feeds; nutrient deficits — amplified by medical conditions (eg, chronic lung disease [CLD]), inappropriate formula, and unfortified human milk (HM); may result in extrauterine growth restriction (in weight, length, and head circumference [HC]); in preterm and late preterm babies; Embleton et al (2001) reported significant protein deficits in first weeks of life for preterm infants; deficits compounded by use of unfortified HM or term formula

Nutrition at discharge: concerns — 1) extrauterine growth restriction; 2) accumulated protein, energy, and deficits of bone mineralization; rickets can develop from prolonged parenteral nutrition, or unfortified or inappropriately fortified HM; hypophosphatemia most common cause of rickets; monitor bone health in babies receiving unfortified HM; deficits increase with decreasing gestational age; 3) anemia; term and preterm infants receive iron (as well as magnesium, zinc, protein, calcium, and polyunsaturated fatty acids) in third trimester; 38% of anemia in premature infants iatrogenic; 4) small premature infants expend more energy than term infants at discharge (89 vs 58 kcal/kg/day); design feeding strategies to provide more energy to compensate for deficits; 5) inadequate length gain despite weight-to-length increases (ie, shorter, fatter babies); insufficient amount of protein relative to amount of energy (most common feeding mistake); protein and energy must be supplemented proportionally

Transition to discharge: feeding plan — 1) provide 150 mL/kg/day (preterm formula [24 kcal/oz] for very low birth weight [VLBW] babies; otherwise, fortified HM); discharge formula usually 22 kcal/oz (intake increases 25-30 cm³/kg when transitioning from 24 to 22 kcal/oz); 2) expect increased consumption with ad libitum feedings (2-3 times over intake in hospital); 3) target weight gain ≥15 g/kg/day; 4) follow growth curves; goals — achieve body composition and rate of growth of normal fetus; minimize postnatal weight loss

Approach to feeding for low birth weight (LBW) and VLBW babies: use high-protein or routine preterm formula or fortified HM; preterm HM sufficient only for 2 to 4 wk, then add calcium, phosphorus, protein, and energy; supplement babies receiving <1800 g, then transition to 22 kcal/oz formula or routine preterm or HM; continue same diet until 6 to 9 mo of age; feed complementary foods at postdevelopmental age; larger preterm babies may not require fortifiers; bone health — monitor alkaline phosphatase at 1 to 2 mo of age; check phosphorus level if alkaline phosphatase elevated; HM lacks adequate calcium and phosphorus to sustain bone growth in preterm babies

Growth and body composition: Aimone et al (2009) — infants predominantly fed HM, then randomized to half-feedings of fortified HM for 12 wk showed better weight, length, and bone mineral content, compared to infants receiving HM alone at ≤12 mo; smaller babies (<1200 g) also saw benefit in HC; no difference seen in mental scores at 18 mo of age; Fcov et al (1999)—early diet of HM or preterm formula in preterm babies did not affect bone mass after ages 8 to 12 yr; Young et al (2013)—no evidence that fortification 3 to 4 mo after discharge affects growth rates in infancy; Young et al (2012)—preterm infants fed nutrient-enriched formula after discharge showed increased weight, length, and HC growth through infancy, compared with preterm infants fed standard term formula; no difference seen between formulas at 18 mo of age

Vitamin D: 400 IU/day for term babies recommended; studies for preterm infants not undertaken; deficiency contributes to metabolic bone disease in premature infants (along with lack of adequate calcium and phosphorus) and due to relative immobility, total parenteral nutrition, and unfortified HM; recommendations range from 400 to 1000 IU/kg/day; assessment of compliance encouraged

Iron: LBW and preterm babies at high risk for iron deficiency; constipation most frequent complaint with iron supplementation; accretion occurs in last trimester; iron deficiency associated with intrauterine growth restriction, maternal anemia, hypertension, diabetes mellitus (DM), and poor neurodevelopmental outcomes; iron deficiency not identifiable until ≥9 mo in term babies; recommendations — American Academy of Pediatrics recommends 2 mg/kg/day of iron for preterm babies ≤1 yr of age; 14% of preterm infants develop iron deficiency between 4 and 8 mo of age despite receiving iron-containing formulas; 5. Counsel parents about the relationship between infant-feeding practices and pediatric and adult obesity.

Educational Objectives

The goals of this program are to improve outcomes of near-term infants and prevent adult diseases by promoting appropriate maternal and infant nutrition. After hearing and assimilating this program, the clinician will be better able to:

1. Establish goals for appropriate weight gain of preterm infants.
2. Design feeding strategies to compensate for nutrient deficits experienced by the preterm infant.
3. Provide appropriate vitamin D and iron supplementation.
4. Recognize maternal and fetal influences on the development of disease in adulthood.

5. Counsel parents about the relationship between infant-feeding practices and pediatric and adult obesity.

Faculty Disclosure

In adherence to ACCME Standards for Commercial Support, Audio Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in health care and not a proprietary business or commercial interest. For this program, Dr. Bhatia and the planning committee reported nothing to disclose.
iron supplementation required for preterm infants fed formula or HM; speaker recommends combination vitamin D and iron supplement

**New bronchopulmonary dysplasia:** mild form does not require high pressures or oxygen; increased rates of survival results in more infants at risk of developing CLD; increased work of breathing results in growth failure after discharge (energy requirement increased by 25%-75%); malnutrition delays lung growth and increases susceptibility to infection; study —≈70% of babies discharged with CLD had growth failure; attributed to lack of intense surveillance of hospital feedings; enriched formulas — provide energy-dense feedings; however, no differences seen in pulmonary outcome despite improved nutrition

**Benefits of growth in hospital:** Ehrenkranz et al (2006) — independent factor associated with better weight gain in higher quartile and decreased incidence of cerebral palsy, mental retardation, abnormal neurologic examination, neurodevelopmental impairment, chronic lung disease, and need for rehospitalization

**Late preterm infant: problems** — increased risk for hypoglycemia, respiratory distress, jaundice, sepsis, feeding difficulty, and readmission

**Nutritional issues:** requirement for parenteral nutrition; tube feedings when establishment of breastfeeding difficult; poor weight gain; developmental issues (same as those for preterm infants); long-chain polyunsaturated fatty acids — rationale exists for supplementing in formula feedings; HM contains preformed docosahexaenoic acid (DHA), but breastfed babies can become deficient within weeks; supplementing breastfeedings mothers with DHA encouraged

Other concerns: increased risk for cerebral palsy and speech and behavioral problems

**Recommendations:** assess need for calcium, phosphorus, protein, and energy; monitor nutrition by body weight, not gestational age; breastfeeding preferred; larger infants may not need fortification; monitor bone health

**Postdischarge:** encourage breastfeeding, but also feed twice daily with formula; use discharge formula (22 kcal/oz) if growth between 25th and 75th percentiles; change to term formula by 6 to 9 mo of age

**Goals:** promote HM feeding; minimize nutritional deficits; avoid over- or underfeeding during first year of life to reduce risk for metabolic syndrome; underfeeding also increases risk for poor neurocognitive development

**Growth:** Fenton growth charts smoothed into reference growth charts for term babies and validated for preterm infants; use Fenton charts for babies ≤50 wk, then transition to WHO growth charts if they perform well

**Early Origins and Prevention of Adult Diseases**

**Maternal nutrition:** evidence supports association between birth weight and risk for obesity, cardiovascular disease, and DM; maternal and infant undernutrition in low-income countries associated with adverse consequences throughout life; in high-income countries, poor-quality diet and increasing maternal obesity associated with long-term effects on offspring; poor intrauterine environment induced by unbalanced maternal diet, body composition, or endocrine factors results in offspring with phenotype characterized by increased risk for cardiovascular disease and metabolic syndrome

**Maternal body composition:** maternal energy balance increases with maternal body mass index (BMI) and adiposity; maternal height, leg length, HC, and body weight predicts newborn size; low maternal weight, BMI, and skinfold thickness in pregnancy associated with higher blood pressure, insulin resistance, and risk for coronary artery disease in offspring

**Metabolic syndrome:** Lakshmi et al (2012) reported smaller term birth weight but higher percentage of visceral fat in Indian babies compared with British babies; Indian “small, fat babies” at increased risk for metabolic syndrome (good example of intrauterine programming); mechanisms for metabolic syndrome — postnatal overnutrition (“urbanization phenomenon”) starts with obesity and hyperglycemia, followed by pregestational and gestational hyperglycemia and DM, altered fuel metabolism to baby, fetal adiposity and pancreatic dysfunction, and macrogamia; postnatal undernutrition starts with undernourished, small mothers, followed by fetal undernutrition, small baby (“thin, fat syndrome”), and insulin resistance

**Heijmans et al (2008):** reported late gestational exposure to famine linked to DM; early gestational exposure to famine linked to obesity; famine effects independent of birth weight; consider prenatal pattern and time of conception in assessing fetal well-being

Large for gestational age (LGA): when secondary to gestational DM, risk for obesity and adult-onset DM increased; maternal obesity and LGA (even without gestational DM) predict increased risk for metabolic syndrome in childhood

**Feeding practices:** Owen et al (2005) found breastfeeding to be associated with reduction in risk for obesity of ≈13%, compared with formula feeding (even after adjusting for parental obesity, maternal smoking, and social class); low maternal social class and maternal obesity associated with formula feeding and increased risk for obesity in offspring

**Consequences of poor start:** birth weights at extremes of spectrum associated with compromised health; prepregnancy nutritional deficiencies predispose to chronic disease and negatively affect growth, muscle development, and cognition; other consequences of maternal obesity — hypertension; asthma; eating disorder; sleep disorder; dental disorders

**Feeding Infants and Toddlers Study 2008 (Butte et al, 2010):** estimated energy intake for all age groups exceeded estimated energy needs (diets contain excessive fat and inadequate fiber)

**Improvements in past decade:** increased breastfeeding rates (however, still below 2010 and 2020 goals); almost all formula iron fortified; solids now given at more developmentally appropriate times

**Recommendations:** 1) breastfeed exclusively for first 4 to 6 mo; continue breastfeeding through first year, but not exclusively; 2) introduce complementary foods between 4 and 6 mo of age; early foods should contain source of iron; 3) introduce reduced-fat (not nonfat) cow’s milk at 1 yr of age

**Areas for improvement:** reduce excessive energy intake (wean to homemade foods or food with low salt and sugar); decrease fiber; reduce intake of saturated fats; transition to family diet after 1 yr of age; minimize or avoid processed baby and toddler foods; reduce exposure to marketing by food companies

**Risks:** over- or underfeeding — poor neonatal growth may result in poor neurocognitive development and CLD; growth in higher quartiles results in better cognitive outcomes, but exceeding normal percentiles increases risk for obesity, hypertension, and DM; term infants with rapid growth in first 6 mo of life at increased risk for metabolic syndrome; prepregnancy — eating disorders, low body mass at conception, and severe nausea and vomiting alter
fetal growth trajectory and result in LBW and prematurity, which increases risk for metabolic syndrome; prematurity—increases blood pressure and risk for DM

Autoregulation of appetite: babies determine intake; babies small for gestational age eat to preset level and accelerate weight gain to catch up; follow trajectory of weight gain and alter diet as needed; feeding dilute formula or food poor in nutritional quality increases intake

Interventions: encourage breastfeeding or appropriate alternatives; develop family-centered approach to nutrition; develop better guidelines and materials to introduce complementary foods; educate families on transitioning from infant feeding to family table; increase support for mothers breastfeeding for first time; educate family about obesity; family attitudes about nutrition affect complementary foods offered; include entire family in meal plans

Practices of concern: substantial formula supplementation without need; consider frequent weight checks for reassurance; early introduction of solid foods; cereal no longer recommended to help babies sleep through night; babies sleep through night when birth weight doubles (≈4 mo of age); transition to formula feeds at same frequency as breastfeeding (inappropriately increases energy intake); late introduction of meats (median age ≈8 mo); consider introduction at 4 to 6 mo of age; shellfish does not promote allergy; rather, allergy promoted by feeding solids too soon; feeding delayed by introducing solids too late; feeding high-sugar and high-fat foods

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Suggested Reading


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<td>5 minutes</td>
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<td>Take pretest</td>
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<td>Review written summary and suggested readings</td>
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Audio Digest Foundation is approved as a provider of nurse practitioner continuing education by the American Academy of Nurse Practitioners (AANP).
1. The most common cause of rickets in preterm infants is:
   (A) Hypophosphatemia  (C) Insufficient vitamin D
   (B) Hypocalcemia       (D) Hyperphosphatemia

2. What is the most common feeding mistake in preterm infants?
   (A) Excess calories  (C) Insufficient protein relative to energy
   (B) Insufficient energy relative to protein (D) Insufficient iron

3. For preterm infants, what is the goal for weight gain after hospital discharge?
   (A) ≥5 g/kg/day         (C) ≥15 g/kg/day
   (B) ≥10 g/kg/day        (D) ≥20 g/kg/day

4. A study showed that preterm infants fed fortified human milk (HM) had ________, compared with those fed unfortified HM.
   1. Better weight
   2. Better length
   3. Larger head circumference
   4. Better bone mineral content
      (A) 1,2,3  (B) 1,4  (C) 2,3  (D) 1,2,3,4

5. Supplementation of docosahexaenoic acid is:
   (A) Recommended for infant formulas and breastfeeding mothers
   (B) Recommended for infant formula, but unnecessary for breastfed babies
   (C) Recommended for mothers of breastfeeding babies only
   (D) Completely unnecessary

6. Which of the following influences the risk of developing adverse health effects in adulthood?
   1. Birth weight
   2. Maternal obesity
   3. Infant undernutrition
   4. Maternal undernutrition
      (A) 1,2  (B) 2,3  (C) 1,2,3  (D) 1,2,3,4

7. Low maternal body mass index is associated with decreased risk for insulin resistance and coronary artery disease in offspring.
   (A) True  (B) False

8. Formula-fed infants have been shown to have a lower risk for obesity than breastfed infants.
   (A) True  (B) False

9. According to current recommendations, cow’s milk should be introduced into the diet at:
   (A) 6 mo of age        (C) 1.5 yr of age
   (B) 1 yr of age       (D) 2 yr of age

10. Identify the incorrect statement about introducing solid foods to infants.
    (A) Allergy is promoted by feeding solids too soon
     (B) Feeding is delayed by introducing solids too late
     (C) Early introduction of cereal has been shown to improve nighttime sleep
     (D) Introduction of meat should occur between 4 and 6 mo of age

Answers to Audio Digest Pediatrics Volume 60, Issue 38: 1-A, 2-A, 3-C, 4-B, 5-A, 6-B, 7-A, 8-D, 9-D, 10-B