Nutritional Recommendations for the Late-Preterm Infant and the Preterm Infant after Hospital Discharge

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Early nutritional support of preterm infants is critical to life-long health and well being. Numerous studies have demonstrated that preterm infants are at increased risk of mortality and morbidity, including disturbances in brain development. To date, much attention has focused on enhancing the nutritional support of very low and extremely low birth weight infants to improve survival and quality of life. In most countries, preterm infants are sent home before their expected date of term birth for economic or other reasons. It is debatable whether these newborns require special nutritional regimens or discharge formulas. Furthermore, guidelines that specify how to feed very preterm infants after hospital discharge are scarce and conflicting. On the other hand, the late-preterm infant presents a challenge to health care providers immediately after birth when decisions must be made about how and where to care for these newborns. Considering these infants as well babies may place them at a disadvantage. Late-preterm infants have unique and often-unrecognized medical vulnerabilities and nutritional needs that predispose them to greater rates of morbidity and hospital readmissions. Poor or inadequate feeding during hospitalization may be one of the main reasons why late-preterm infants have difficulty gaining weight right after birth. Providing optimal nutritional support to late premature infants may improve survival and quality of life as it does for very preterm infants. In this work, we present a review of the literature and provide separate recommendations for the care and feeding of late-preterm infants and very preterm infants after discharge. We identify gaps in current knowledge as well as priorities for future research. *(J Pediatr 2013;162:S90-100)*.

Much attention has focused on enhancing the nutritional support of very low birth weight (VLBW) and extremely low birth weight (ELBW) infants to improve survival and quality of life. Significant efforts have been made to provide adequate nutrition to VLBW/ELBW (henceforth VLBW) infants before discharge and for term infants during the first months of life. Nutritional requirements of VLBW infants have been defined to prevent cumulative nutritional deficits soon after birth.[1,2] The goal of these efforts is to improve growth early so that preterm and VLBW infants reach normal weight and length by the expected date of delivery or, at most, by the time they are discharged from the hospital.

In most countries, preterm infants are sent home before their expected date of term birth for economic or other reasons. It is debatable whether these newborns require special nutritional regimens or discharge formulas. Guidelines that specify how to feed VLBW infants after hospital discharge are scarce and conflicting. Furthermore, the nutritional support provided during hospitalization has improved and decreased the incidence of acquired nutritional deficits. Thus, the systematic use of special nutrient-enriched discharge formulas must be considered carefully.

Similarly, the nutritional requirements of term infants during the early months of life may need to be re-evaluated to prevent excess protein and energy intakes and more strictly mimic intakes of breastfed term infants.[3] Feeding regimens designed specifically to meet the nutritional requirements of late-preterm newborn infants have not been established and ought to be considered.

We present a review of the literature and provide recommendations for the care and feeding of late-preterm infants and VLBW infants after discharge, separately. We identify gaps in current knowledge as well as priorities for future research.

Nutritional Requirements for the Late-Preterm Infant

A variety of terms have been used to describe preterm infants born at a number of different intervals between 32 and 36 weeks' gestation (ie, "late preterm," "near term," "marginally preterm," "moderately preterm," "minimally preterm," and "mildly preterm"). Only the terms "moderately preterm" and "late preterm" are defined

AAP	American Academy of Pediatrics
DHA	Docosahexaenoic acid
ELBW	Extremely low birth weight
EUGR	Extrauterine growth retardation
GA	Gestational age
HM	Human milk
LCPUFA	Long-chain polyunsaturated fatty acid
NICU	Neonatal intensive care unit
VLBW	Very low birth weight

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well and should be used. The term "late-preterm infants" describes infants born between 34.0 and <37.0 weeks' gestation, and "moderately preterm" describes infants born between 32.0 and <37.0 weeks' gestation.[4] Late-preterm births comprised 8.8% of all live births in the US in 2008 and close to 10% of all births in developing countries.

Late-preterm infants are at risk for mortality and perinatal morbidity. Although severe illness may be uncommon, late-preterm infants are 2 to 3 times more likely than term infants to experience mild-to-moderate morbidities such as hypothermia, hypoglycemia, respiratory distress and delayed lung fluid clearance, jaundice, infection, feeding intolerance, nutritional compromise in the early neonatal period, and greater rates of readmission after hospital discharge.[5] Presently, long-term neurologic and developmental outcomes of late-preterm infants are a major concern. The brain of the late-preterm infant is less mature than that of the term infant. Given that late-preterm infants comprise 9%-10% of all births, even minor increases in the incidence of neurologic disability and/or school failure in this group can have a huge impact on the effectiveness of educational systems and health care needs.

Current Nutritional Practices

The late-preterm infant presents a challenge to health care providers immediately after birth when decisions must be made about how and where to care for these newborns. Triage of late-preterm infants varies among hospitals. Some institutions admit these infants directly to a newborn nursery, and others admit them to a neonatal intensive care unit (NICU). In many institutions, the limited availability of acute care beds in the NICU and established clinical practices determine that these infants are admitted to the well-baby nursery or to mothers' rooms in accordance with rooming-in practices.

However, considering these infants as well babies may place them at a disadvantage. For example, mothers of preterm infants who are admitted to a NICU are more likely to initiate and continue breastfeeding than mothers of infants placed in the well-baby nursery.[6] Late-preterm infants have significantly greater medical risks and require specific support more often than term infants.[7] Late-preterm infants can develop hypoglycemia and have difficulty feeding, situations that may require intravenous treatment, which is a relatively labor-intensive treatment for a well-baby nursery.[8] Striking variations in the clinical care of late-preterm infants in 10 NICUs located in California and Massachusetts were reported.[9] Five percent to 66% of infants received "hyperalimentation," and 4%-72% of infants were sent home with recommendations to be fed a postdischarge formula.

Weight gain by moderately premature infants (30-35 weeks' gestational age [GA]) during hospitalization falls well below intrauterine norms.[10] In a study of 15 NICUs, 98% of moderately premature infants (30-35 weeks' GA) failed to gain at least 15 g/kg/d, the recommended intrauterine growth rate.[10] The z-score for weight decreased from birth to discharge by −0.45 to −0.93 (average, −0.67) across all NICUs. The NICUs that reported optimal growth worked to minimize postnatal weight loss so that birth weight was regained more quickly, and better mid-term growth was achieved.[10] The provision of protein and energy supplements increased the growth velocity of moderately preterm infants.[10,11] In one study, shorter duration of gavage feeding correlated with growth velocity, suggesting that terminating gavage feeding may reflect variation in the recognition, rather that true attainment, of mature feeding ability. In fact, gavage often may be discontinued too early to allow for proper growth.[10]

The advantages of breastfeeding for late-preterm infants appear to be even greater than those for term infants. However, establishing breastfeeding in this group frequently is more problematic than in term infants. Late-preterm infants may be sleepier, have less muscle strength, and, thus, have more difficulty with latch, suck, and swallow. Furthermore, they are more likely to be separated from their mothers, who may have medical conditions that interfere with breastfeeding.[12] Any one or a combination of these conditions places the mothers and infants at risk for breastfeeding failure. Breastfeeding initiation in the US is 59%-70% in the late-preterm population, and the likelihood of breastfeeding beyond 4 weeks or the recommended 6 months is significantly less than for term infants, and, possibly, less than for infants born before 34-35 weeks' gestation.[13]

Consequences of Poor Feeding in the Late-Preterm Population

Growth. Poor or inadequate feeding during hospitalization may be one of the main reasons why late-preterm infants have difficulty gaining weight right after birth.[10] When physical growth was measured in a population-based cohort of late-preterm and term infants,[14] late-preterm infants were found to be at increased risk of being underweight and stunted at 12 and 24 months of age (aOR: 2.57 and 2.35, and 3.36 and 2.30, respectively). Wasting was significantly different between the groups in the first year of life, but only a small number of infants were reported to have wasting at 12 and 24 months. Whether or not poor growth of late-preterm infants during the first years of life is linked to inadequate early nutrition remains to be determined.

General Health and Readmission. Late-preterm infants are 2 to 3 times more likely to be readmitted than term infants.[5,13] The main presenting diagnoses are jaundice, suspected sepsis, and feeding difficulties. Feeding may be successful during the birth hospitalization but can become problematic after discharge. Feeding difficulties secondary to poor oral-motor tone, function, and neural maturation predispose the infants to dehydration and hyperbilirubinemia. Late-preterm infants also may be discharged home after successful transition to the extrauterine environment, but before lactation is established and problems with latch and milk transfer are identified and addressed adequately. Parental education and timely outpatient follow-up by a provider knowledgeable in breastfeeding should be included in the proper management of these mother–infant dyads.[15]

Development. The risk of adversely affecting brain development during the last trimester is well known. Although most attention has focused on VLBW infants, moderately preterm infants are also at risk of impaired development. The preterm infant brain weighs approximately two-thirds that of the term infant at 34 weeks' GA, and the relative percentages of gray matter and myelinated white matter to total brain volume increase exponentially between 34 and 40 weeks' gestation.[16] Late-preterm infants can have various neonatal complications, such as poor feeding, that increase the risk of brain injury and abnormal neurodevelopmental outcome.

Long-chain polyunsaturated fatty acids (LCPUFAs) play an important role in early infant development and visual acuity in preterm infants (see article on lipid needs by Lapillonne et al in this Supplement).[17] They may be important in late-preterm infants as well. Supplementation of formula with docosahexaenoic acid (DHA) and arachidonic acid improves visual acuity and cognitive development in moderately preterm infants (ie, 30-37 weeks' GA).[18] Late-preterm infants may require preformed DHA in early life for optimal neurologic development.

Late-preterm infants are at more risk of adverse developmental outcomes and academic difficulties for up to 7 years of age than term infants.[19] Late-preterm infants have a greater risk of cerebral palsy, speech disorders, neurodevelopment handicaps, behavioral abnormalities, and competence issues (behavioral, scholastic, social, and global). Given the known relationship among poor early growth, inadequate nutrition during hospitalization, and long-term development of VLBW infants, it may be speculated that similar risks exist for late-preterm infants. Large population-based studies that evaluate long-term neurodevelopmental and behavioral outcomes in relation to nutritional intake, feeding performances, and early growth are needed to test this hypothesis.

Changes in Nutritional Needs in Late Gestation

Nutritional requirements for late-preterm infants can be evaluated in the same manner applied to VLBW infants and with a similar goal.[20] Specific data about late-preterm infants are scarce. However, extrapolation from data for VLBW and term infants can be made with a reasonable degree of confidence. In general, nutritional recommendations for preterm infants need to: (1) consider fetal growth as appropriate for a particular GA; (2) focus on lean body mass deposition; (3) consider age-appropriate accretion rates of protein, minerals, and various essential constituents; (4) incorporate an understanding of gastrointestinal tract development; (5) consider the cumulative nutrient deficit that may accrue during the early days or weeks of life; and (6) adapt recommendations relative to postconceptional age.

Growth velocity decreases dramatically from 18-20 g/kg/d at 28 weeks' GA to 10 g/kg/d at term.[21,22] Protein accretion and, therefore, requirements related to body weight decrease in proportion during this time. Resting energy expenditure is 45 kcal/kg/d in VLBW infants and 50 kcal/kg/d in larger preterm infants. The additional energy requirements needed for heat generation and physical activity (eg, movement, crying) are slightly less in VLBW infants (15 kcal/kg/d) than in larger preterm infants (20 kcal/kg/d). Fat accumulation increases as a proportion of the weight gain from 12% at 28 weeks' GA to 20% at term and 40% in breast-fed term infants.[22] Fetal energy deposition per gram of weight gain also increases from 1.8 kcal/g at 28 weeks' GA to 2.3 kcal/g at term and 3.8 kcal/g in breast-fed term infants. Therefore, energy requirements vary across all preterm groups.

Mineral requirements are controversial. On one hand, mineral requirements for bone development can be estimated exclusively from placental transport. Accordingly, the American Academy of Pediatrics (AAP) and other groups[23] recommend that preterm infants receive relatively large amounts of mineral supplements. On the other hand, smaller amounts of highly bioavailable calcium and phosphorous are recommended if adaptation to extrauterine life is taken into account.[2] After birth, bone turnover is stimulated, and calcium and phosphorous are released to the mineral pool. Thus, activation of bone turnover reduces the need for exogenous calcium and phosphorus and, therefore, on that basis the European Society of Pediatric Gastroenterology, Hepatology, and Nutrition Committee on Nutrition recommended recently smaller amounts of highly bioavailable calcium and phosphorus. Mineral requirements are relatively high in late-preterm infants because bone mineralization lags bone growth in all preterm infants, and their bones contain smaller mineral stores than those of similar GA newborn infants.

Nutritional stores of essential nutrients in newborn infants (ie, LCPUFAs, iron, trace elements) are derived from transplacental transfer and related to GA. To date, no data justify providing late-preterm infants with different amounts of these nutrients than those recommended for other preterm infants. Therefore, similar intakes are recommended.

The nutritional requirements of late-preterm and early-term infants are shown to be greater than those of full-term infants. The values do not take into account the nutrient supply needed to compensate for any nutritional deficit and, therefore, may not apply to the very preterm infant at time of or after hospital discharge.

Recommendations, Gaps in the Literature, and Research Priorities

The nutritional needs of late-preterm infants differ from those of term infants, especially with regard to energy, protein, calcium, and phosphorous requirements. Late-preterm infants have unique and often-unrecognized medical vulnerabilities and nutritional needs that predispose them to greater rates of morbidity and hospital readmissions.

Breastfeeding is the preferred way to feed late-preterm infants. However, donor or mother's milk often does not meet the theoretical nutritional needs of the late-preterm infant. When late-preterm infants have a significant comorbidity and/or when the gap between actual and recommended nutrient intakes is significant, fortifiers and supplements may be necessary to meet a particular infant's needs.

Presently, clinical judgment is applied to balance the benefits (improved nutrition) with the risks (interruption of breastfeeding and transient undernutrition) associated with providing nutrient-enriched supplements or formula to late-preterm infants. Studies designed to determine the best way to provide optimal nutrition to late-preterm infants, the largest subgroup of preterm infants, are needed.

Late-preterm infants appear to have poorer rates of breastfeeding initiation and duration than term and, possibly, earlier preterm infants. Health care providers should monitor breast milk supply, nutrient transfer, and problems related to poor intake. Individualized feeding plans should be promoted and include special considerations to compensate for immature feeding skills and inadequate breast milk production, including the need to stimulate lactation. Mothers of late-preterm infants should receive qualified, extended lactation support, frequent follow-up, and due consideration of delayed hospital discharge.

Current nutritional practices are likely to induce transient undernutrition in late-preterm infants, the magnitude and consequences of which are unknown. The possible link between early nutrition and long-term neurologic and developmental outcomes in late-preterm, moderately preterm, and early-term infants needs to be defined.

Nutritional Requirements for the Preterm Infant after Discharge

Nutritional Status at Discharge from the Hospital

Growth and Quality of Growth. Extrauterine growth retardation (EUGR) describes postnatal growth of preterm infants that is less than the expected growth of a fetus at the same postconceptional age. It is a major problem that occurs in 60%-100% of preterm births globally.[24-28] EUGR has been defined at discharge as growth values <10th percentile or <−2 SD from the mean of intrauterine growth expectation. It has also been defined as a change in z-score of >−1 SD or >−2 SD from birth to discharge.[29] The latter definition was a better predictor of neurodevelopmental outcomes than the former definition.[30]

Body composition and bone mineral content at discharge can be measured reliably in research settings.[31-35] There is no standard for these measures in preterm infants because neonatal disease and undernutrition occur commonly and influence body composition strongly. Indeed, most studies show that body composition is abnormal at discharge and marked by a reduction in fat-free mass[32] and increased total[31-33] and intra-abdominal adiposity.[32,35] This predominant fat mass deposition among preterm infants is believed to be due to imbalances in protein/energy nutrition during hospitalization and recovery from early malnutrition, especially in the ELBW groups.[20]

It is important to assess lean-to-fat mass or lean-to-total body mass routinely. Monitoring only weight-for-age may

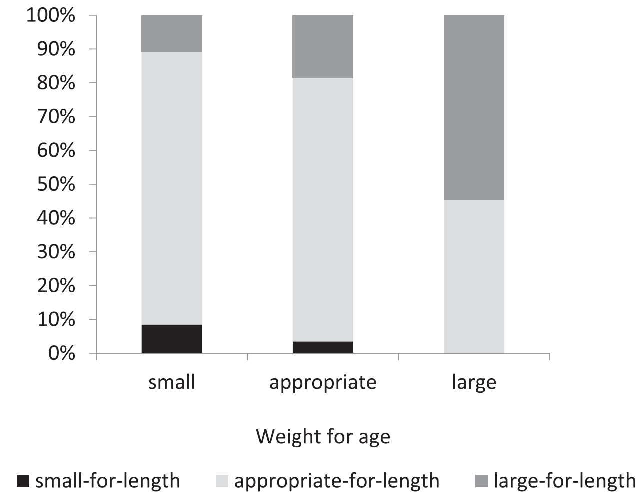

Figure 1. Weight growth status categorization (ie, weight-for-age vs weight-for-length) at discharge from hospital of preterm infants born at 26 to 29 weeks' GA (n = 1214). The discordance at discharge between the weight-for-age and weight-for-length methods of weight growth status assessment is primarily caused by the small-for-age infants being mostly appropriate-for-length (adapted from Olsen et al[36]).

result in an inappropriate classification of nutritional adequacy (Figure 1).[36] Therefore, the assessment of growth status of preterm infants in the NICU and at the time of discharge should include weekly measurements of length and recordings of weight-for-length or other measures of body proportion. It remains to be determined how type of growth and body proportion are associated with optimal outcomes.

Finally, poor growth of head circumference postnatally is associated with poor brain development, cerebral palsy, Mental Development Index score <70, and Psychomotor Index <70 at 18 months' corrected age,[37] motor and cognitive impairment at 3 and 7 years,[38,39] and a detriment of 4.1 IQ points in adults.[40] Accordingly, assessments of growth should include measurements of head circumference.

Effects of the Nutrition Strategies during Hospitalization. The goal of providing nutrition to the preterm infant is to ensure that the rate of growth and body composition equal those of a fetus at the same GA. This goal also can apply to the growing preterm infant after discharge through the first year of life. EUGR is attributed to an early nutritional deficit and poor growth during the stable growing period. "Aggressive" enteral and parenteral nutrition for very preterm infants reduces cumulative energy and protein deficits, promotes postnatal growth, optimizes body composition,[21,41-45] and may, improve neurodevelopmental outcomes.[37,42,45-49] When infants are fed human milk (HM), they should also receive fortifiers.[50] There is considerable interest in individualizing the nutrient fortification of HM to address each preterm infant's unique nutritional requirements and differences in milk composition.[51,52] The variability in the protein and/or fat content of HM may be responsible for slow growth in some HM-fed infants when fortifiers are provided in a consistent manner, regardless of differences in milk composition.[51-54] When infants are fed formula, it is necessary to stress that the use of hydrolyzed protein and/or bottled or canned sterilized preterm formula has a reduced nutrient bioavailability that needs to be compensated.

A prospective study of preterm infants with birth weights <1250 g demonstrated that initiating aggressive nutritional support early (ie, energy and protein intakes of 50 kcal/kg/d and 2.5 g/kg/d at day 1; increased to 120 kcal/kg/d and 4 g/kg/d at day 6; and to 120-130 kcal/kg/d and 4-4.5 g/kg/d during the stable growing period) significantly reduced growth restriction at the time of discharge. The incidence of infants with a weight <2 SD did not change between birth and discharge, and postnatal growth restriction was observed in only 9% of infants.[55]

Effect of Postdischarge Nutrition on Development and Growth

Few published studies have tested the hypothesis that a proactive approach to feeding VLBW infants after hospital discharge (eg, feeding VLBW infants differently than term infants) improves growth and development better than a reactive approach (eg, intervening when growth failure has occurred). This gap in our knowledge is particularly pronounced for VLBW infants fed HM predominantly after hospital discharge and for VLBW infants with persistent morbidities.

It is difficult to establish universal postdischarge feeding guidelines because growth and nutritional status of preterm infants vary considerably. Furthermore, the volume of feeds consumed at discharge varies greatly and may reach 200 mL/kg/day or more if the infants are fed ad libitum. It is important to consider caloric density because infants on less calorie-dense formulas ingest 22%-23% more formula than those on more calorie-dense formulas.[56] Therefore, the caloric density of feeds will determine the intake not only of energy but also of micronutrients and proteins, which are important for physical growth.

Current Practices for Feeding after Hospital Discharge. Postdischarge practices regarding breastfeeding and nutrient enrichment of feedings vary widely by country, NICU, and caregiver. Infants are sent home on HM alone, partially or fully nutrient-fortified HM, nutrient-enriched formula, or conventional term formula. Although there is a lack of evidence to suggest a prescriptive approach to feeding all VLBW infants after discharge, there is general consensus that HM should be fed in preference to infant formula and that certain subgroups of infants will be at risk for poor nutritional status after discharge.

Many organizations recommend that mother's own milk be the exclusive source of nutrition for the first 6 months of life.[57-59] These endorsements are based on abundant data that demonstrate many advantages of HM.[60-62] Despite awareness of these advantages, rates of HM feeding among preterm infants fall significantly below those of term infants for a variety of reasons such as maternal illness, stress, lack of adequate staff support, and other factors related to preterm birth.[63] Premature infants are at greater risk for morbidity, malnutrition, and likelihood that not all nutrient deficits will be resolved before discharge. Therefore, VLBW preterm infants, and particularly those born ELBW, have the greatest nutrient needs, especially if they: (1) are discharged well before their expected delivery date; fed predominantly HM; (2) have fallen below the 3rd or 5th percentile in growth indices; or (3) have persistent morbidities that elevate nutritional requirements or limit the volume of feeds consumed.

The goals for VLBW preterm infants should be to promote HM feeding, minimize nutrient deficits, promptly address deficits when identified, and avoid overnourishing or promoting postnatal growth acceleration beyond normal for postconceptional age. Because the nutritional status of preterm infants varies widely, creating individualized feeding plans is the best approach. Ideally, the pre- and postdischarge nutritional concerns should be closely coupled, although it generally is not achieved. VLBW infants are discharged at younger ages and lower body weights than ever before. Once home, they are cared for by health care providers who had not been involved with their inpatient care. Close nutritional monitoring of infants after hospital discharge frequently is not accomplished because high-risk neonatal follow-up clinics are concerned more with neurodevelopmental than nutritional status. Therefore, it is important to establish postdischarge feeding guidelines to care for these infants.

Evidence in Support of the Need for Nutrient-Enriched Formula after Hospital Discharge. Infants who weigh less than expected for their postconceptional ages are at increased risk of long-term growth failure and require particular attention.[64] Breastfeeding and providing fortified HM should be promoted. If an infant is formula-fed, a preterm formula or a special postdischarge formula that contains more protein, minerals, trace elements, and LCPUFAs than standard term formula should be provided until the preterm infant reaches 40 weeks' postconceptional age and, possibly, until the infant reaches 52 weeks' postconceptional age.[64,65]

Henderson et al[66] identified 7 good-quality controlled trials (N = 631 infants) in which the authors compared the effects of feeding preterm infants either a nutrient-enriched formula or standard term formula after hospital discharge. The authors found little evidence that nutrient-enriched formula affected the growth or development of preterm infants up to 18 months' corrected age. However, this analysis was limited because preterm infants at most nutritional risk were either excluded or underrepresented. For example, in all but 1 of the 6 trials (n = 20 infants), a significant proportion of infants weighed >1500 g. In one trial, preterm infants (n = 103) were included only if they were growing well at discharge (25 g/kg/d). In another, infants with an abnormal suck and swallow were not included (n = 89). In yet another, infants with chronic lung disease were not included (n = 125). Thus, future research efforts should study subgroups of preterm infants who are not able to feed ad libitum after hospital discharge or who have extra metabolic demands secondary to growth restriction or chronic lung disease.[66] Another limitation is that the growth could not be evaluated until 6 months postterm because of lack of data. It is important to evaluate growth before 6 months because most preterm infants are at greatest nutritional risk soon after hospital discharge.

Recent studies indicate that nutrient-enriched discharge formulas can provide advantages to preterm infants. Growth at 4 and 12 months and mineralization at 4 months after discharge are better in VLBW infants fed preterm formula during the first 2 months after discharge than in those fed term formula.[67] Nutrient-enriched formula provided after term does not change the quantity of growth but improves the quality of growth in preterm infants. Infants fed nutrient-enriched formula have lower fat mass, corrected for body size at 6 months' corrected age, than infants fed standard formula or HM.[68] Preterm infants fed nutrient-enriched formula after discharge exhibit an increase in fat-free and peripheral fat mass but not central adiposity compared with infants fed term formula.[69] These data indicate that nutrient-enriched formulas do not promote central adiposity in preterm infants, a feature that is associated with metabolic syndrome later in life.

Evidence in Support of the Need for Nutrient-Enriched HM after Hospital Discharge. Although HM is purported to be superior to formula, HM-fed infants often accrue the greatest nutritional deficits before hospital discharge.[64] To determine whether the provision of nutrient supplements after discharge is beneficial, VLBW (750-1800 g) preterm infants fed predominantly HM were randomly assigned at discharge (38 weeks postconceptional age) to a control group (unfortified HM) or an intervention group (half of HM feeds nutrient-enriched).[70,71] Both groups received intensive lactation support. The infants fed nutrient-enriched HM grew more rapidly during the 12-week study period than infants fed HM alone. The observed differences in absolute weight and length, and, among smaller babies, head circumference were sustained for the first year.[71] In addition, the duration of HM feeding for both groups was significantly longer than had been reported previously for preterm infants.[63]

A larger, randomized controlled trial studied HM-fed preterm infants (535-2255 g, n = 207) randomized to receive 20-50 mL of expressed breast milk containing a multinutrient fortifier (17.5 kcal and 1.4 g of protein) each day from the time of discharge to 4 months corrected age or HM alone.[72] In this study, the breast milk supplement did not influence breastfeeding, nor did it have a significant impact on growth. It is not clear why the results of the 2 studies differ, but it is possible that differences in the incremental increase in the nutrition and the rate of breastfeeding may play a role.

Nutritional Deficiencies Other than Protein/Energy. Considerable attention has focused on the macronutrient content of feedings that contribute to caloric intake such as protein, which has a direct effect on growth. Less attention has focused on other nutrients, particularly minerals, iron, LCPUFAs, and vitamin A.

Feeding postdischarge preterm infants formulas or HM with greater concentrations of calcium and phosphorus than those contained in term formula improves bone mineralization, particularly if the special formulas used during hospitalization are continued after hospital discharge.[65,73] Provision of large amounts of calcium and phosphorous for long periods may not be necessary. Relative osteopenia of preterm infants resolves spontaneously during the first months after discharge in a manner similar to that induced by the acceleration of growth at the first stage of adolescence. Bone mineral content improves spontaneously in most infants, and rapid catch-up mineralization is observed after discharge in VLBW infants. At 3 to 6 months' corrected age, spine and total bone mineral density, corrected for anthropometric values, are found to be in the range of normal term newborn infants.[74,75]

Nevertheless, potential long-term effects of supplementation after discharge on peak bone mass are not known. Bone mass may be reduced at adulthood, but this is mainly the result of a persistent growth restriction because it is appropriate for the body size achieved. Furthermore, early diet or HM feeding does not affect bone mass during childhood.[75,76] Therefore, on the basis of the limited data available, it is likely that mineral intake after discharge should exceed that of term infants when catch-up growth occurs and is supported by enriched feeds, but it is unlikely that extra mineral supplementation is necessary when a mineral-rich postdischarge or preterm formula or enriched HM is used. With regard to vitamin D intake, there is no evidence that preterm infants after discharge should receive greater doses that term infants to maintain a normal plasma *25*-hydroxy vitamin D concentration.

Body iron stores are highly variable at discharge, so it is important to screen for iron deficiency at discharge and during the first year of life. The AAP and European Society of Pediatric Gastroenterology, Hepatology, and Nutrition recommend that preterm infants receive iron supplements for up to 1 year after discharge.[2,77] The AAP recommends at least 2 mg/kg/day, which is the amount of iron provided by iron-fortified formulas. Preterm infants fed HM should receive an iron supplement of 2 mg/kg/day by 1 month of age, and this should be continued at least until the infant is weaned to iron-fortified formula or begins eating complementary foods that supply 2 mg/kg of iron per day. Infants who receive iron loads from multiple transfusions of packed red blood cells do not require supplements.

Lapillonne et al discuss providing LCPUFAs to preterm infants (see article on lipid needs by Lapillonne et al in this issue) and recommend that DHA and arachidonic acid be provided until the expected due date in amounts greater than had been previously recommended. After the due date, preterm infants should receive the same quantity of LCPUFAs as term infants until more data become available.

Vitamin A status may be suboptimal in formula-fed VLBW infants for many months after discharge.[78] It has been shown that preterm infants who ingest 3000 IU of vitamin A per day for 90 days fail to exhibit plasma vitamin A concentrations at levels characteristic of repletion status.[79] This observation is in contrast to previous studies of term infants, in which a similar supplementation protocol was sufficient to maintain plasma vitamin A concentrations.[80] The failure to achieve optimal vitamin A concentrations may be due to immaturity of fat digestion mechanisms in premature infants. Additional studies are needed to determine the dose and duration of vitamin A supplementation that allows infants to reach full repletion values.

How to Monitor the Postdischarge Infant

Accurate serial measurements of weight, length, and head circumference plotted precisely on validated growth charts facilitate early identification of potential nutritional or health problems after hospital discharge. To ensure accuracy, measurements should be made by trained personnel who use standardized techniques. Expensive equipment is not necessary.[81]

Selection of a Growth Chart

Two types of growth charts can be used to monitor the growth of preterm infants after hospital discharge. One is based on fetal growth until term and growth of preterm infants thereafter; the other tracks growth of term infants. Most growth charts describe how infants actually grow, rather than how they should grow to promote optimal neurodevelopment and achieve the best long-term health outcomes. For a detailed discussion of growth charts, see the article on growth curves by Bhatia, in this Supplement[82]; for the effects of early growth on optimal neurodevelopment and long-term health outcomes, see the article on metabolic and cardiovascular outcomes by Lapillonne and Griffin, in this Supplement.[83]

A single chart cannot be used to monitor and plot the growth of infants during their initial hospital course and through the early discharge period when the risk of nutrient deficits is greatest. To address these issues, the Fenton charts[84] were designed to commence monitoring infants at 22 weeks' postconceptional age and continue for 10 weeks postterm. However, intrauterine and postnatal growth in term infants are sex-related. The use of sex-related intrauterine growth charts such as those of Olsen et al[85] reduces the false detection of intra-uterin growth retardation, especially in girls. Therefore, we have created new sex-related fetal-infant growth charts from 22 wks GA to 66 or 92 weeks' postconceptional age to evaluate the growth adequacy during the first year of life in preterm infants according to sex (Figure 2).

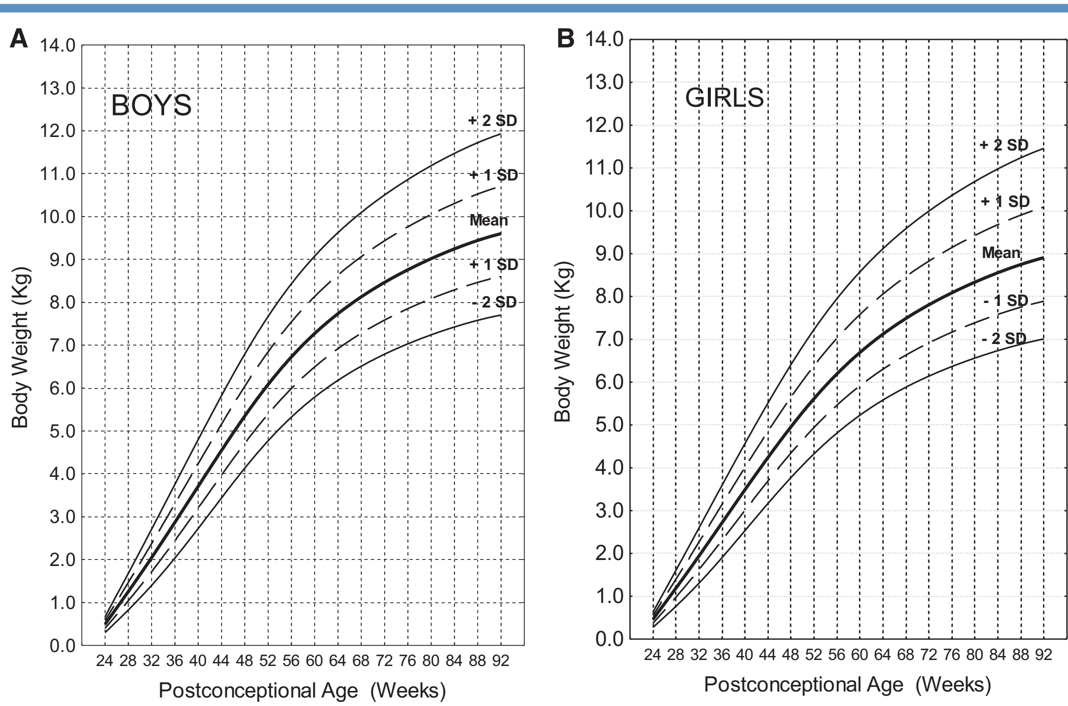

Figure 2. Examples of sex-related fetal–infant growth charts from 22 weeks' GA to 92 weeks' postconceptional age by combining the Olsen et al[85] and the World Health Organization growth curves.[86] Body weight versus GA for **A,** boys and **B,** girls.

Monitoring During the First Weeks after Discharge. As a general rule, infants should be transitioned to the feed that they will go home consuming several days before discharge to assess tolerance and growth. Close monitoring of feeding and growth is recommended after hospital discharge, especially for infants at risk for nutritional deficit (ie, those who have an uncoordinated suck swallow, have persistent comorbidities, or are predominantly breast fed). Parents should be reminded that breastfeeding is the optimal way to feed their infants. Breast-fed infants should be fed every 1.5-3 hours and allowed no more than one period of prolonged sleep (5 hours) to maintain mother's milk supply. Ad libitum feeding is encouraged to optimize infant growth. Infants should be weighed within 48 hours of discharge to assess intake and provide reassurance to families. This is particularly important for families that had been transitioned from nasogastric or enriched feedings to breastfeeding just before discharge. A complete feeding assessment should be conducted within the first week of discharge. Parents should be made aware how to contact a dietitian and/or lactation consultant, ideally one who has experience working with mothers of preterm infants.

Recommendations for Preterm Infants after Hospital Discharge

Guidelines for all preterm newborn infants should be similar because postconceptional nutritional needs are very similar. Therefore, the recommendations below are appropriate for all groups of preterm infants, except where indicated otherwise.

Prevention

We strongly emphasize the importance of proactive nutritional support during hospitalization to prevent nutritional deficits and reduce the incidence and the degree of growth failure. Proactive support limits the need for specialized feeding after discharge. Nutrient intake and growth should be monitored in all groups of preterm infants (ELBW, VLBW, moderately preterm) after birth to reduce the risk of nutritional deficits occurring during the early days or weeks of life.

A paucity of data exists on the effects of a poor nutrition supply at different stages of gestation, and we stress the need for future research in this area. At the present time, good clinical judgment is required to balance the benefits (improved nutrition) versus risks (interruption of breastfeeding and transient undernutrition) and provide appropriate, nutrient-enriched feeds to all preterm infants including the moderately preterm infants.

Monitoring

Close monitoring of growth (weight-, length-, and head circumference-for-age, indexes of body proportionality) and feed intake should be performed at discharge, at expected term, and every 2 to 4 weeks after discharge until indexes of growth are >-2 SD on an appropriate growth curve (ie, World Health Organization growth standard).

Predominantly breast-fed infants, infants with persistent morbidities, and infants who were recently transitioned to a different type/mode of feeding should be monitored closely immediately after discharge and during the first week after discharge.

Selective biological indexes (ie, blood urea nitrogen, ferritin, retinol binding protein, alkaline phosphatase, 25[OH] vitamin D) may be useful in assessing selective nutrient deficiencies but should be determined on an individual risk basis.

Nutritional Counseling

Because of the heterogeneity in nutritional status, postnatal age, and corrected age of preterm infants at the time of hospital discharge, an individualized approach is highly recommended over the use of general guidelines. Individualized nutritional plans should be based on growth, quality of growth, and selective nutrient deficiencies. As a rule of thumb, however, infants who weigh <1000 g at birth and those who weigh <2000 g at discharge require detailed instructions at discharge, close monitoring and, potentially, nutritional intervention.

Table. Nutritional needs by GA (weeks)

	GA, weeks					
Variables (per kg/d)	**<28**	**28-31**	**32-33**	**34-36**	**37-38**	**39-41**
Fetal growth						
Weight gain, g	20	17.5	15	13	11	10
Lean body mass gain, g	17.8	14.4	12.1	10.5	7.2	6.6
Protein gain, g	2.1	2	1.9	1.6	1.3	1.2
Requirements						
Energy, kcal	125	125	130	127	115	110
Proteins, g	4	3.9	3.5	3.1	2.5	2
Calcium, mg	120-140	120-140	120-140	120-140	70-120	70-120
Phosphorus, mg	60-90	60-90	60-90	60-90	35-75	35-75

Weight gain, lean body mass, and protein gain during the last trimester of pregnancy and theoretical energy and protein requirements for enteral nutrition are indicated by GA group. Before 39 weeks' GA, requirements are based on fetal growth, fetal accretion rate, and intestinal absorption; after 40 weeks' GA, requirements are based on the composition of HM (adapted from Rigo[20] and Ziegler [21]). The values indicated in this table are theoretical values per GA groups. They show that both the late-preterm infant (ie, 34-36 weeks' GA) and the early-term infant (ie, 37-38 weeks' GA) have nutritional requirements that are different than the full-term infant (ie, 39-41 weeks' GA). The values indicated do not take into account the nutrient supply needed to compensate for any nutritional deficit and therefore are not applicable as such for the very preterm infant at time of, or after, hospital discharge.

To avoid creating nutritional deficits after discharge, preterm infants should at least receive the nutrient intake of their respective corrected age (Table) until they reach full term (ie, 39-41 weeks). This strategy does not take into account the nutrient supply needed to compensate for any nutritional deficit.

We strongly endorse HM feeding as the preferred method of nourishing preterm infants after discharge and recognize that providing mothers with lactation support is an important component of care for the preterm infant.

Nutrient deficits should be identified, promptly corrected, and afterwards, nutrition should be normalized as soon as possible to avoid overnourishing or promoting growth acceleration. Close monitoring of growth as outlined here and select follow-up of biochemical deficiencies should accomplish these objectives.

HM fortifiers and enriched formulas are effective nutrition adjuvants and are an effective strategy in addressing early discharge nutrient deficits and poor growth. However, the strategy should be limited to the period of poor feeding or poor growth and should be discontinued as soon as possible after expected term to avoid overfeeding.

The recommendations for DHA, and arachidonic acid, supply for preterm infants should be continued until full term. Thereafter, recommendations for term infants should be applied. We recommend that iron status be measured. Iron supplementation should be continued after discharge from the hospital, at least until 6-12 months of age, depending on diet. ■

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