Chapter 1

Introduction

This book provides a clinical practicum to implement parenteral and enteral feeding guidelines for aggressive nutrition to prevent extrauterine growth failure of the very low birthweight (VLBW), ≤1500 gram infant. These strategies promote the goals of reducing postnatal weight loss, earlier return to birthweight, and improved catch-up growth. The guiding principle for these strategies is that undernutrition is, by definition, non-physiologic and undesirable. It follows that any measure that diminishes undernutrition is inherently good provided that safety is not compromised. Further, this book will review available evidence concerning the controversy of rapid early growth leading to visceral adiposity and metabolic/cardiovascular morbidity in adolescence and adulthood.

Although current guidelines for the growth of preterm infants use intrauterine growth as the reference standard, the growth of most preterm and VLBW infants proceeds at a slower rate than in utero. Although many of the smallest VLBW infants are also born small for gestational age (SGA), both appropriate-for-gestational-age VLBW and SGA infants develop extrauterine growth restriction. Figure 1.1, from the National Institute of Child Health and Human Development

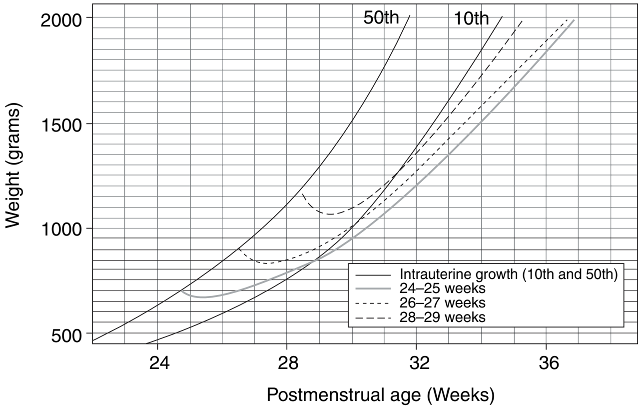

Figure 1.1. Mean body weight versus gestational age in weeks for all study infants who had gestational ages at birth between 24 and 29 weeks. Reference: Ehrenkranz RA, et al. ***Pediatrics*** **1999; 104:280–289. Reproduced with permission.**

(NICHD) Neonatal Research Network, demonstrates the differences between intrauterine growth and the observed rates of postnatal growth in the NICHD study. The postnatal growth curves are shifted to the right of the reference curves in each gestational age category. This "growth deficiency" is common in extremely low birthweight (ELBW) infants (≤1000 gram birthweight).

Figure 1.2 shows three nutritional strategies, in the boxes, superimposed on the NICHD growth observation study. Figure 1.3 is a nutritional "map" for the VLBW infant including a time-line configuration in which the boxes arbitrarily divide nutritional management into three segments beginning at birth and continuing for 9–12 months corrected age.

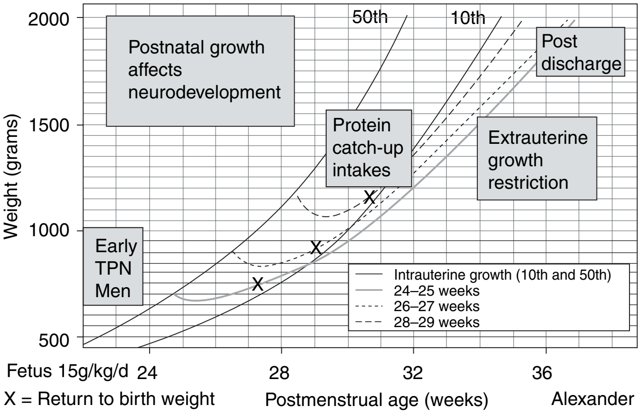

Figure 1.2. NICHD Growth Observational Study. Adapted from Ehrenkranz RA, et al. *Pediatrics* 1999; 104:280–289. Reproduced with permission.

As shown in Figure 1.2, optimizing neurodevelopment is the ultimate goal of promoting growth in the neonatal intensive care unit. Considerable evidence suggests that early growth deficits have long-lasting consequences, including short stature and poor neurodevelopmental outcomes. The most convincing data concerning the neurodevelopmental consequences of inadequate early nutrition are those reported in studies by Lucas and Ehrenkranz. Lucas demonstrated that preterm infants fed a preterm formula containing a higher content of protein and other nutrients over the first postnatal month had higher neurodevelopmental indices at both 18 months and seven to eight years of age compared with preterm infants fed term formula. Ehrenkranz examined (Chapter 23) the relationship between growth in the neonatal intensive

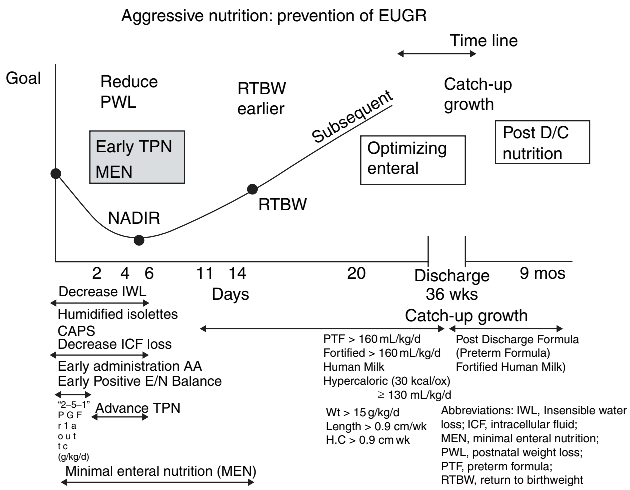

Figure 1.3. Aggressive nutrition: Prevention of EUGR. Adamkin DH. Feeding the preterm infant. In: J Bhatia, ed. *Perinatal Nutrition Optimizing Infant Health and Development.* **New York, NY: Marcel Dekker; 2004: 165–190. Reproduced with permission.**

care unit and later neurodevelopment and growth outcomes. The study demonstrated improved developmental and growth outcomes at 18 to 22 months of age for ELBW infants who had higher growth velocities for weight and head circumference during the neonatal intensive care unit hospitalization. As elusive as is the goal for VLBW infants that nutrition should support "postnatal growth" approximating in utero fetal growth, the fetal model is sound and there is no alternative model or "gold standard."

The goal of nutritional management in VLBW infants, which is supported by the American Academy of Pediatrics

Committee on Nutrition, is the achievement of postnatal growth at a rate that approximates the intrauterine growth of a normal fetus at the same postconceptional age. In reality, however, the growth of VLBW infants lags considerably after birth. Such infants, especially those weighing less than 1000 g at birth (ELBW), typically do not regain birthweight until two to three weeks of age.

Nutrient intakes of VLBW infants are much lower than the nutrient intake that the fetus receives in utero. This intake deficit often persists throughout much of the infants' hospital stay. Although non-nutritional factors (morbidities) are involved in the slow growth of VLBW infants, nutrient deficiencies are critical in explaining delayed growth.

Neu and colleagues have recently suggested goals that are more meaningful than just somatic growth. These include:

- Maintenance of lean body mass and bone density
- Prevention of complications (e.g. chronic lung disease, necrotizing enterocolitis, and infection)
- Optimization of neurodevelopment
- Adult health

We address nutritional practices in this book and try to examine not only nutrient balance and growth but also the impact on neurodevelopment and health outcomes.

Evidence and experience often dictates the neonatologist's approach to patient care. Ehrenkranz recently reviewed the strength of the evidence for common nutritional practices for VLBW infants. Table 1.1, adapted from an AAP steering committee in a policy statement, weighs the quality of the

Table 1.1. Evidence-based early nutritional practice for VLBW infants: recommendations and evidence quality

Practice	Strength of recommendation[a]	Evidence quality[b]
Prompt provision of energy: Glucose infusion providing about 6 mg/kg/min Increase to about 10 mg/kg/d by 7 days of life Maintain blood sugar 50–120 mg/dL	Recommended	B
Prompt provision of parenteral amino acids: Initiate 3.0 g/kg/d within hours of birth Advance to 4.0 g/kg/d by 0.5–1.0 g/kg/d steps	Recommended	B
Initiate lipid emulsion within the first 24–30 hrs of birth: Start 0.5–1.0 g/kg/d Advance to 3.0–3.5 g/kg/d by 0.5–1.0g/kg/d steps	Recommended	B
Initiate trophic feedings by 5 days of age: Provide about 10 mL/kg/d (human milk if possible) Begin advancing to ~150 mL/kg/d by 10–20 mL/kg/d steps within the next several days	Recommended	B

Adapted with permission from the AAP Steering Committee on Quality Improvement and Management: Marcuse EK, Shiffman RN. Classifying recommendations for clinical practice guidelines. *Pediatrics* 2004; 114: 874–877.

[a] Strength of recommendation: strongly recommended; recommended; option; not recommended

[b] Evidence quality: A, well-designed, RCTs performed on appropriate populations;
B, RCTs with minor limitations, overwhelmingly consistent evidence from observational studies;
C, observational studies (case-control and cohort design);
D, expert opinion (case reports, reasoning from first principles).

evidence for practices and strategies utilized in clinical neonatology.

We have followed this evidence-based information in writing this monograph.

SUGGESTED READING

Adamkin DH. Feeding the preterm infant. In: J Bhatia, ed. *Perinatal Nutrition Optimizing Infant Health and Development*. New York: Marcel Dekker; 2004:165–190.

Ehrenkranz RA. Early, aggressive nutritional management for very low birth weight infants: what is the evidence? *Semin Perinatol* 2007; **31**:48–55.

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Kleinman RE (ed). Nutritional needs of the preterm infant. In: *Pediatric Nutrition Handbook*, 5th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2004:23–54.

Lucas A, Morley R, Cole TJ. Randomised trial of early diet in preterm babies and later intelligence quotient. *BMJ* 1998; **317**:1481–148.

The AAP Steering Committee on Quality Improvement and Management: Marcuse EK, Shiffman RN. Classifying recommendations for clinical practice guidelines. Policy statement. *Pediatrics* 2004; **114**:874–877.

Cambridge University Press
978-0-521-73246-8 - Nutritional Strategies for the Very Low Birthweight Infant
David H. Adamkin
Excerpt
More information

Chapter 2

Fluid and electrolyte management (Na, Cl and K)

The 24-week fetus is composed of 90% total body water (TBW). Cell membranes separate intracellular water and extracellular water spaces. Sixty-five percent of TBW is in the extracellular (ECW) compartment and 25% is intracellular (ICW). As gestation proceeds towards term, TBW decreases to 74% of total body weight and the extracellular and intracellular volumes are 40% and 35%, respectively. Potassium (K^+) is the major ion of the ICW and potassium's intracellular concentration is impaired by insufficient supplies of oxygen and energy. The major ion of ECW is sodium (Na^+) and the major anion is chloride (Cl^-).

The preterm infant is in a state of relative extracellular fluid volume with an excess of TBW compared with the full-term infant. VLBW infants are vulnerable to imbalances between intra- and extracellular compartments. The dilute urine and negative sodium balance the first few days after birth in the preterm infant is an appropriate adaptive response to extrauterine life. Therefore, the initial diuresis is physiologic, reflecting changes in interstitial fluid volume. This diuresis should be considered in the estimation of daily fluid needs. As a result, a gradual weight loss of 10–15% in a VLBW infant during the first week of life is expected without adversely affecting urine output, urine osmolality, or clinical status. Provision of large volumes of fluid to provide increased nutrition, for example, 160 to 180 mL/kg/d, does not prevent this weight loss and appears to increase the risk of the development of patent ductus arteriosus, intraventricular hemorrhage, bronchopulmonary dysplasia (BPD), and necrotizing enterocolitis (NEC). Therefore, a careful and conservative approach to fluid and nutritional management is appropriate. It appears that the preterm infant can adjust water excretion within a relatively broad range of fluid intake (65–70 mL/kg/d to 140 mL/kg/d) without disturbing renal concentrating abilities or electrolyte balance.

Estimation of daily fluid requirements includes insensible water losses (IWL) from the respiratory tract and skin, gastrointestinal losses (emesis, ostomy output, diarrhea), urinary losses, and losses from drainage catheters (chest tubes). IWL is a passive process and is not regulated by the infant. However, the environmental conditions in which the infant is nursed should be controlled to minimize losses (Table 2.1).

The transepithelial losses are dependent on gestational age, the thickness of the skin and stratum corneum, and blood flow to the skin. The preterm infant has a large body surface area to body weight ratio, with thinner, highly vascularized, more permeable skin. These factors increase heat and fluid losses, and placing a cap on the infant's head will help decrease these losses. In addition, the use of open bed platforms with radiant warmers as well as phototherapy

Table 2.1 Factors affecting insensible water loss (IWL) in preterm neonates

Factors that increase IWL
Prematurity
Radiant warmer heat
Phototherapy
Skin defects
Tachypnea
Non-humidified oxygen
Factors that decrease IWL
Mature skin
Heat shields
Plastic wrap blanket
Rigid plastic body hood
Topical skin agents
Paraffin
Aquaphor
Covering skin defects
Humidified oxygen

Parish A and Bhatia J. Nutritional considerations in the intensive care unit: neonatal issues. In: SA Shikora, RG Martindale and SD Schwaitzberg, eds. *Nutritional Considerations in the Intensive Care Unit, Science, Rationale and Practice*. Iowa: American Society for Parenteral and Enteral Nutrition, Kendall/Hunt Publishing. Reproduced with permission.

lights increases the IWL by more than 50%. This excessive IWL may be reduced with the use of humidified incubators to care for the infant. The measurement of urine specific gravity has been used to predict urine osmolality. While this is a reliable means of predicting hyperosmolality (urine osmolality of greater than 290 mOsm/kg water with a urine specific gravity 1.012 or greater), it is less helpful