Pocket Guide to Neonatal Nutrition

Second Edition

Pediatric Nutrition Dietetic Practice Group
Sharon Groh-Wargo, PhD, RD
Melody Thompson, MS, RD
Janice Hovasi Cox, MS, RD, CSP
Editors
ACADEMY OF NUTRITION AND DIETETICS
POCKET GUIDE TO

Neonatal Nutrition
SECOND EDITION

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Academy of Nutrition and Dietetics
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Neonatal Terminology and Abbreviations

TERMINOLOGY

**Neonate**: newborn, birth to 28 days but sometimes used for a longer period of time

**Neonatal**: occurring during the first 28 days of life or very early infancy

**Infancy**: occurring during the first year of life

**Low birth weight (LBW)**: < 2500 grams (5 pounds, 8 ounces)

**Very low birth weight (VLBW)**: < 1500 grams (3 pounds, 5 ounces)

**Extremely low birth weight (ELBW)**: < 1000 grams (2 pounds, 3 ounces)

**Preterm (premature)**: gestational age (GA) < 37 weeks

**Late preterm**: GA ≥ 34 to < 37 weeks

**Term**: GA 37 to 42 weeks

**Postterm**: GA > 42 weeks

**Small for gestational age (SGA)**: < 10th percentile birth weight for GA

**Appropriate for gestational age (AGA)**: 10th to 90th percentile birth weight for GA

**Large for gestational age (LGA)**: > 90th percentile birth weight for GA
ABBREVIATIONS

A/B/D: apnea, bradycardia, desaturations
AGA: appropriate for gestational age
ATN: acute tubular necrosis
BF: breastfeed or breastfeeding
BPD: bronchopulmonary dysplasia
CDH: congenital diaphragmatic hernia
CHD: congenital heart disease
CLD: chronic lung disease
CMV: cytomegalovirus
CPAP: continuous positive airway pressure
DBM/DHM/DM: donor breast milk/donor human milk/donor milk
DIC: disseminated intravascular coagulation
EBM: expressed breast milk
ECMO: extracorporeal membrane oxygenation
ELBW: extremely low birth weight
EN: enteral nutrition
EUGR: extrauterine growth restriction
FAS: fetal alcohol syndrome
FTT: failure to thrive
GA: gestational age
GIR: glucose infusion rate
G_xP_yAb_zLC_w: shorthand for gravida/para/abortion/living children (subscripts represent numbers of each)
HIE: hypoxic ischemic encephalopathy
**HMF:** human milk fortifier  
**IDM:** infant of diabetic mother  
**IFE/IVFE:** intravenous fat emulsion  
**IM:** intramuscular  
**I&O:** intake and output  
**IUGR:** intrauterine growth restriction  
**IV:** intravenous  
**IVH:** intraventricular hemorrhage  
**KUB:** kidneys, ureter, bladder (x-ray view)  
**LBW:** low birth weight  
**LGA:** large for gestational age  
**LOS:** length of stay or late onset sepsis  
**LPI/LPTI:** late preterm infant  
**MBM/MOM:** mother’s/maternal breast milk or own milk  
**MCT:** medium-chain triglycerides  
**MEN:** minimal enteral nutrition (also called priming, trophic and hypocaloric feeding, or gut stimulation)  
**mL/mm:** milliliter/millimeter  
**NAS:** neonatal abstinence syndrome  
**NEC:** necrotizing enterocolitis  
**NG:** nasogastric  
**NICU:** neonatal intensive care unit  
**OFC:** occipital frontal circumference (head circumference)  
**OG:** orogastric  
**PDA:** patent ductus arteriosus
Neonatal Terminology and Abbreviations

**PICC**: percutaneous inserted central catheter  
**PN**: parenteral nutrition  
**PNALD**: parenteral nutrition-associated liver disease  
**PPHN**: persistent pulmonary hypertension  
**PROM**: premature rupture of membranes  
**PT**: preterm  
**PVL**: periventricular leukomalacia  
**RDS**: respiratory distress syndrome  
**ROP**: retinopathy of prematurity  
**RSV**: respiratory syncytial virus  
**SBS**: short bowel syndrome  
**SGA**: small for gestational age  
**SIP**: spontaneous intestinal perforation  
**SVD**: spontaneous vaginal delivery  
**TEF/EA**: tracheoesophageal fistula/esophageal atresia  
**TPN**: total parenteral nutrition  
**TTN**: transient tachypnea of the newborn  
**UAC**: umbilical arterial catheter  
**UVC**: umbilical venous catheter  
**VLBW**: very low birth weight
Chapter 1

Nutrition Assessment

Laura J. Szekely, MS, RD, LD and Melody Thompson, MS, RD, LD

OBJECTIVES

• List the components of infant nutrition assessment.
• Discuss anthropometric assessment and growth expectations.
• Review components of biochemical, clinical, and intake assessments.

INTRODUCTION

Nutrition assessment in infants includes the same components evaluated in other populations:

• Anthropometric assessment
• Biochemical assessment
• Clinical assessment
• Dietary intake assessment (parenteral, enteral, and oral)

Additionally, infant nutrition assessment includes classification of gestational age and size for gestational age.

A nutrition screen—often completed by a neonatal intensive care unit (NICU) nurse or dietetic technician, registered (DTR)—may be used to focus registered
dietitian nutritionist (RDN) resources. Screening should be completed within 24 hours of admission (1,2). See Table 1.1 for an example of screening criteria (3). An RDN then completes an assessment on infants meeting designated criteria.

**Table 1.1  Ohio Neonatal Nutritionists Screening Criteria for Identifying Hospitalized Infants at Highest Nutritional Risk**

<table>
<thead>
<tr>
<th>&lt; 1 week of age</th>
<th>a) &gt; 15% weight loss from birth weight</th>
<th>b) &lt; 1 kg at birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2 weeks of age</td>
<td>a) &lt; 70 kcal/kg/d</td>
<td>b) Any continued weight loss</td>
</tr>
<tr>
<td>&gt; 2 weeks of age</td>
<td>a) Intake &lt; 80% expected energy requirement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 70 kcal/kg/d (all IV)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 85 kcal/kg/d (IV/enteral)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 100 kcal/kg/d (all enteral)</td>
<td></td>
</tr>
<tr>
<td>b) &lt; 15 g/kg/d weight gain (&lt; 36 weeks’ gestational age) or</td>
<td>&lt; ½ expected g/d weight gain (&gt; 36 weeks’ gestational age)</td>
<td></td>
</tr>
<tr>
<td>c) Prealbumin(^a) &lt; 8.0 mg/dL, or albumin &lt; 2.5 g/dL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BUN &lt; 7 mg/dL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct bilirubin &gt; 2.0 mg/dL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Serum phosphorus &lt; 4 mg/dL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alkaline phosphatase &gt; 600 U/L</td>
<td></td>
</tr>
<tr>
<td>&gt; 2 months of age</td>
<td>Any of the above for &gt; 2 weeks of age plus:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) No source of dietary iron</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Continued total parenteral nutrition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any infant with newly diagnosed NEC, BPD, cholestasis, osteo-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>penia, cardiac disorders, neurologic problems, GI surgical anoma-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lies, or metabolic aberrations</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
Table 1.1  (continued)

Any infant with birth weight < 1.5 kg (and current weight < 2 kg) on full feedings but not receiving fortified human milk or preterm formula Abbreviations: BUN, blood urea nitrogen; NEC, necrotizing enterocolitis; BPD, bronchopulmonary dysplasia; GI, gastrointestinal.

*aInclude as criteria only if screening can be done in some time-efficient manner for entire unit; use values only as guide—compare to institutional normal ranges; while not reliable during inflammatory states, may indicate the infant with increased nutritional needs.


NEWBORN CLASSIFICATION OF GESTATIONAL AGE AND BIRTH WEIGHT

Newborn infant maturity and intrauterine growth are classified by gestational age, birth weight, and weight-for-gestational age.

• Gestational age can be estimated by maternal dates and by early (first/early second trimester) ultrasound exam (if available). The gestational age is also determined in the NICU by examining the infant’s physical and neurological development on a reliable standardized instrument called the New Ballard score (available at www.ballardscore.com/files/ballardscore_scoresheet.pdf) (4). The gestational age classifies the infant as preterm, term, or postterm.
• The infant’s birth weight is used to categorize the infant as (a) normal weight, (b) low birth weight (LBW), (c) very low birth weight (VLBW), or
(d) extremely low birth weight (ELBW). For specific definitions of LBW, VLBW, and ELBW, refer to Terms and Abbreviations.

- The infant’s weight is plotted on an intrauterine growth chart to determine size for length of gestation—defined as (a) small for gestational age (SGA), (b) appropriate for gestational age (AGA), or (c) large for gestational age (LGA). For specific definitions of SGA, AGA, and LGA, refer to Terms and Abbreviations. In addition, infants may also be classified as intrauterine growth restricted (IUGR). Of note, although SGA and IUGR appear interchangeable, there is in fact a distinct difference. IUGR refers to the failure of the fetus to achieve normal predicted growth in utero (estimated fetal weight below the 10th percentile). SGA refers to a newborn with actual birth weight below the 10th percentile for gestational age (5). Finally, the term extrauterine growth restriction (EUGR) is a classification used to apply to infants who, although born with adequate intrauterine growth, fall below population norms during their hospitalization (weight < 10th percentile for corrected gestational age at the time of hospital discharge) (6).

- These classifications can help to guide or anticipate clinical care needs. For example, babies who are postterm and/or SGA or LGA are more likely to have hypoglycemia, polycythemia, birth asphyxia, and specific syndromes/anomalies than are term AGA babies. Prematurity is also associated with a host of potential morbidities—many of which are discussed in this pocket guide.
ANTHROPOMETRIC ASSESSMENT

Postnatal growth—with consistent and comprehensive monitoring—is an important health care outcome measure for high-risk infants (7). Anthropometric measurements are rapid, inexpensive, and noninvasive to obtain.

Measurement of body weight, length, and head circumference is the predominant method used to monitor infant growth, detect growth abnormalities, and assess nutritional status in infants. Measurements are plotted on percentile growth curves for comparison against established reference data. Serial measures of growth are compulsory in assessing response to nutrition support in hospitalized infants. Satisfactory postnatal growth is associated with shortened lengths of hospitalization and improved cognitive development (8–11).

Weight

Method

The nude infant is weighed on a regularly calibrated digital gram scale.

Uses and Interpretation

• Body weight comprises the total mass of the infant’s lean tissue, fat, and extracellular and intracellular fluid compartments.

• As gestational age increases, extracellular fluid volume decreases and lean tissue and fat mass increase.

• Initial postnatal weight loss is attributed to contraction of body water compartments and catabolism of endogenous stores before energy and nutrient needs are met (8).
Chapter 1

- Expected initial postnatal weight loss ranges between 8% and 15%, with greater loss found in the smallest, most immature infants (12).
- Initial weight loss reaches its nadir by approximately 4 to 6 days of life (8).
- Birth weight is optimally regained by 2 weeks with the extremely premature infant; the very ill infant sometimes requires 3 weeks (8,9,13).
- Daily body weights allow assessment of fluid status.
- Expected incremental weight gain in LBW infants changes over time, with advancing gestational age. In general, a growth velocity (GV) goal of 15 to 20 g/kg/d is often used for LBW infants. If desired, specific GV goals can be calculated from intrauterine growth charts over various time intervals at specific percentiles. A multicenter cohort study of ELBW infants showed that, once birth weight was regained, weight gain of >18 g/kg/d was associated with better neurodevelopmental and growth outcomes than those seen with lower growth velocities (10).
- Actual GV over time can be calculated for an individual infant. Calculating GV using an exponential method is the most accurate of five methods tested and has been validated in ELBW infants (14,15). A limitation of this method is that it requires computerized calculations. A method that is close in accuracy to the exponential method can be calculated using the following equation (14):

\[
GV (g/kg/d) = \frac{[1000 \times (W_n - W_1)]}{(D_n - D_1) \times [(W_n + W_1)/2]}
\]

Where \(W\) = weight in grams, \(D\) = day, \(1\) = beginning of time interval chosen and \(n\) = the end of that time interval in days.
For example, here is how to calculate GV for an infant who weighs 1,100 g on day 12 and 1,400 g on day 26:

\[
GV = \frac{[1000 \times (1440 - 1100)]}{(26 - 12) \times [(1440 + 1100)/2]}
\]

\[
GV = \frac{[1000 \times 340]}{14 \times 1270}
\]

\[
GV = \frac{340,000}{17,780}
\]

\[
GV = 19.1 \text{ g/kg/d}
\]

This equation, which uses average weight in the denominator, is more accurate than methods using birth weight or other weights in the denominator (14).

Limitations

Weight gain does not accurately reflect lean body mass changes, especially when edema or dehydration is present (8,9).

Length

Method

Ideally, two people are required to obtain an accurate linear measurement using an infant length board. One person holds the infant’s head against the fixed headboard; the other measurer gently flattens the infant’s knees and guides the footboard toward the infant’s flat feet. In some clinical settings, however, infant length is estimated using a tape measure, sacrificing accuracy for expediency.
Uses and Interpretation

- Weekly length measurements have the following advantages over the measurement of weight (16):
  - Length more accurately reflects lean tissue mass.
  - Length is not influenced by fluid status.
  - Length is a better indicator of long-term growth.
- Expected incremental gain in crown-heel length in LBW infants is ≥ 0.9 cm/week (8,9,17).

Limitations

Length is often more difficult to accurately determine—requiring a length board and two measurers—than either weight or head circumference (8,9).

*Head Circumference*

Method

The largest occipital frontal circumference (OFC), commonly referred to as head circumference (HC) is measured with a flexible tape measure.

Uses and Interpretation

- During the first postnatal week, HC may decrease by approximately 0.5 cm due to extracellular fluid space contraction (8).
- Head circumference is monitored weekly; mean weekly gain in LBW infants is ≥ 0.9 cm/week (8,9,17).
- More frequent assessment may be indicated for infants with micro- or macrocephaly or with suspected abnormal increases in head circumference (> 1.25 cm/week) (8).
Limitations
Cerebral edema, hydrocephalus, compression due to the administration device for nasal continuous positive airway pressure (NCPAP), or the addition or removal of external apparatus may interfere with accuracy of head circumference measurements.

Weight-for-Length
Method
Using the growth chart, ideal weight-for-length is identified by finding the weight that is approximately on the same percentile as the infant’s length measurement percentile.

Uses and Interpretation
• Determining ideal weight-for-length is helpful in assessing symmetry of growth.
• Current weight expressed as a percentage of ideal weight-for-length can be used to identify infants at risk for under- or overnutrition (8). This measurement should be used with caution and optimally when the length measurement is known to be accurate.

Regional Anthropometry
Regional anthropometry is not routinely assessed. (It is used primarily in research settings.)

Uses and Interpretation
• Triceps skinfold (TSF) and midarm circumference, or the ratios and formulas derived from these measurements, are reported to be good predictors of
infant body composition, growth, and metabolic complications for infants who are overgrown or undergrown during gestation (16).

- Standards are available for infants between 24 and 41 weeks’ gestation and can be used to compare measurements of an individual infant to reference values or to assess individual changes over time (8). Of note, this measurement may be most helpful in patients with compromised conditions such as ascites, conjoined twins, and chronic ventilator dependency.

Limitations

- Examiner measurement technique variability, as well as critical illness, hydration status, and positioning of infants, can make these measurements invalid or unreliable (8).
- The use of calipers to measure TSF may not be feasible in extremely immature infants who have delicate, easily punctured skin.
- Weight, length, and head circumference have been found to be the most reliable measurements and are highly predictive of both fat and lean mass (8).

Growth Charts

Growth charts provide the basis for growth and nutrition assessment of high-risk infants by presenting a comparison of an infant’s actual size and growth trajectory to reference data (8,9).
Two types of charts are presently available for growth assessment:

- Charts developed using intrauterine growth data
- Charts developed using postnatal growth data

In most NICUs, the infant’s measurements are plotted sequentially and electronically and may be accessed utilizing both intrauterine and postnatal growth charts via the electronic health record as available.

**Intrauterine Growth Charts**

Intrauterine growth charts are based on a compilation of cross-sectional measurements of birth weight, length, and head circumference from infants of varying gestational ages at birth (8,9). They represent fetal growth and are presented as the goal for preterm infant growth (8,9). The infant’s weight, length, and head circumference can be plotted weekly on these curves.

Gender-specific intrauterine growth charts based on precise measurements of gestational age have been developed and revised to reflect recommended growth goals for preterm infants (the fetus, followed by the term infant) and support an improved transition of preterm infant growth to the World Health Organization (WHO) growth charts (see Figures 1.1 and 1.2) (17). A free copy of the development article for the 2013 Fenton growth charts can be found online at www.biomedcentral.com/1471-2431/13/59.
Figure 1.1 2013 Preterm Growth Chart for Girls

Figure 1.2  2013 Preterm Growth Chart for Boys

In addition, some NICUs may choose to utilize an alternate intrauterine curve that Olsen created and validated with a contemporary, large, racially diverse US-specific sample population (18). This growth curve provides clinicians in US NICUs with an updated tool for growth assessment. Note that Olsen’s data are included in the Fenton charts mentioned above and in Figures 1.1 and 1.2.

If a desired growth curve is unavailable, access to the information may be obtained through web-based software that computes size-for-gestational age, or via smartphone applications called PediTools (19). These tools provide the clinician with a variety of approaches to assess growth comparatively.

The following are limitations to the use of intrauterine growth charts:

- Intrauterine growth charts do not allow for the initial postnatal weight loss seen in newborn infants; body weight and head circumference at 1 week of age will often be less than the birth percentiles (8).
- Variability among the intrauterine charts limits the generalizability of these data. Charts vary in terms of the following: the years data were collected, geographic location of the infants as related to elevation, ethnicity, estimation of gestational age, and sample size (8,9).
- Typically, the preterm infant’s growth will parallel and not exceed the intrauterine growth curve of a fetus of similar gestational age (8,9).

Postnatal Growth Charts

Postnatal growth charts based on a large sample of infants (from a broad geographic area in the United States) receiving current neonatal care have been published (20). These
charts provide a reference for expected weight, length, and head circumference changes starting at various birth weights. Because they were developed from postnatal growth data, they reflect the initial weight loss that occurs in infants during the first week of life (8,9).

The following are limitations to the use of postnatal growth charts:

- Postnatal growth charts do not show an infant’s GV or “catch-up” growth relative to the fetus (8).
- Postnatal growth charts were likely influenced by the medical and nutritional support practices used for the sample infants (8).

The preterm infant’s ideal growth pattern remains undefined. Studies are in process to determine prescriptive standards for fetal and preterm growth and may be available following the completion of the INTERGROWTH-21st Project (17,21).

_Growth Assessment_

Weight gain is used to identify infants with mean weight gains that are less than desired growth (≤ 15g/kg/d) or more than desired growth (> 35 g/d) during a week’s period of time (9).

Infants at high risk of poor weight gain include those with extreme prematurity, chronic lung disease, severe intraventricular hemorrhage, necrotizing enterocolitis (NEC), and late-onset sepsis (8,9). Factors that may contribute to poor weight gain include the following (8,9):

- Insufficient fluid, energy, or nutrient intake
- Improper preparation of feeding
- Feeding intolerance
- Acidosis
• Hypoxia
• Anemia
• Chronic diuretic administration
• Temperature instability/cold stress

Factors that may contribute to excessive weight gain include the following (8,9):

• Excessive fluid, energy, or nutrient intake
• Improper preparation of feeding
• Chronic systemic steroid administration (in addition to excessive weight gain, this treatment may contribute to the loss of lean mass and decreased linear growth)

**BIOCHEMICAL ASSESSMENT**

Biochemical (laboratory) data can be useful markers of nutritional status. Specific laboratory tests may help detect nutritional deficiency or toxicity prior to the appearance of clinical symptoms.

Many factors, however, can alter serum levels and must be considered when interpreting laboratory results (8). These factors include:

• Storage and processing of the specimen
• Laboratory method used
• Technician accuracy
• Disease state or medical treatment, including blood transfusions
• Infant’s state of hydration

It is important to note trends in laboratory results as well as the speed and direction of changes. Laboratory tests are interpreted with caution and used to complement other nutrition assessment data (8).
Parenteral Nutrition

Regular assessment of laboratory data is necessary for infants receiving parenteral nutrition (PN). Early detection of metabolic complications of PN is facilitated by analysis of electrolytes, blood urea nitrogen, creatinine, calcium, magnesium, phosphorus, glucose, liver enzymes, visceral proteins, and triglycerides.

Frequent monitoring may be required as PN solutions are initiated and adjusted to meet the specific energy and nutrient needs of individual infants. Once stable, laboratory monitoring every 7 to 14 days is sufficient (8). See Table 1.2 (8).

Table 1.2  Suggested Monitoring Schedule for Infants Receiving Parenteral Nutrition Support

<table>
<thead>
<tr>
<th></th>
<th>Initial Phase(^a)</th>
<th>Stable Phase(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Weight</td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td>• Length</td>
<td>Baseline</td>
<td>Weekly</td>
</tr>
<tr>
<td>• Head circumference</td>
<td>Baseline</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Intake and output</strong></td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td><strong>Glucose:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Serum</td>
<td>As indicated</td>
<td>As indicated</td>
</tr>
<tr>
<td>• Urine</td>
<td>As indicated</td>
<td>As indicated</td>
</tr>
<tr>
<td><strong>Electrolytes</strong></td>
<td>2–3 times/wk</td>
<td>Every 1–2 wks</td>
</tr>
<tr>
<td><strong>Calcium, magnesium, phosphorus</strong></td>
<td>2–3 times/wk</td>
<td>Every 1–2 wks</td>
</tr>
<tr>
<td><strong>Triglycerides</strong></td>
<td>Daily during dose increase</td>
<td>Every 1–2 wks</td>
</tr>
<tr>
<td><strong>BUN/creatinine</strong></td>
<td>2–3 times/wk</td>
<td>Every 1–2 wks</td>
</tr>
<tr>
<td><strong>Serum proteins</strong></td>
<td>Baseline</td>
<td>Every 2–3 wks</td>
</tr>
</tbody>
</table>

(continued)
Table 1.2  Suggested Monitoring Schedule for Infants Receiving Parenteral Nutrition Support (continued)

<table>
<thead>
<tr>
<th>Test</th>
<th>Baseline</th>
<th>Every 2–3 wks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver enzymes—including direct bilirubin</td>
<td>Baseline</td>
<td>Every 2–3 wks</td>
</tr>
<tr>
<td>Alkaline phosphatase</td>
<td>Baseline</td>
<td>Every 2–3 wks</td>
</tr>
<tr>
<td>Blood cell count</td>
<td>Baseline</td>
<td>Every 2–3 wks</td>
</tr>
<tr>
<td>Vitamin and trace mineral status or other specific tests</td>
<td>As indicated</td>
<td>As indicated</td>
</tr>
</tbody>
</table>

Abbreviations: BUN, blood urea nitrogen.

*In the initial phase, parenteral nutrition solutions are adjusted to meet the specific energy and nutrient needs of individual infants. This period generally lasts for < 1 week for parenteral support.

*In the stable phase, the infant is in a metabolically steady state. For clinically stable infants receiving an adequate nutrient intake with desired growth, the interval between laboratory measurements may be increased beyond the above recommendations.

Source: Data are from reference 8.

**Enteral Nutrition**

Biochemical assessment of the infant receiving enteral nutrition (EN) is not well delineated. In medically unstable infants, it may be desirable to follow serial indicators of hematologic, protein, mineral, and electrolyte status. Routine laboratory monitoring, however, is not indicated for medically stable infants receiving enteral nutrition at advised levels and achieving adequate growth (8). See Table 1.3 (8).
Table 1.3  Suggested Monitoring for Infants Receiving Enteral Nutrition Support

<table>
<thead>
<tr>
<th>Interval</th>
<th>Growth:</th>
<th>Intake and output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Weight</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>• Length</td>
<td>Weekly Week daily</td>
</tr>
<tr>
<td></td>
<td>• Head circumference</td>
<td>Weekly Week daily</td>
</tr>
<tr>
<td>Indication</td>
<td>Electrolytes</td>
<td>Diuretics; renal disease</td>
</tr>
<tr>
<td></td>
<td>BUN and creatinine</td>
<td>Renal disease</td>
</tr>
<tr>
<td></td>
<td>BUN alone</td>
<td>Protein intake adjustment</td>
</tr>
<tr>
<td></td>
<td>Phosphorus, alkaline phosphatase, 25 (OH) vitamin D</td>
<td>Osteopenia screen</td>
</tr>
<tr>
<td></td>
<td>Albumin, prealbumin</td>
<td>Poor nutrition history, slow growth, edema</td>
</tr>
<tr>
<td></td>
<td>Liver enzymes including direct bilirubin</td>
<td>Cholestasis</td>
</tr>
<tr>
<td></td>
<td>Blood cell count</td>
<td>Anemia</td>
</tr>
<tr>
<td></td>
<td>Vitamin and trace mineral status or other specific tests</td>
<td>As indicated</td>
</tr>
</tbody>
</table>

Abbreviations: BUN, blood urea nitrogen. 
Source: Data are from reference 8.

Limitations of Biochemical Assessment

High-risk infants cannot afford to lose much blood volume for biochemical tests. The laboratory performing the tests for small preterm infants must be capable of using techniques that require only microliters of blood (8).

The cost, relative usefulness, and turnaround time of a complex laboratory test should be considered before the test is done (8). Proposed laboratory monitoring
protocols for infants receiving PN or enterally fed infants with chronic illness, such as chronic lung disease, or poor growth are provided in Tables 1.2 and 1.3 (8).

Although it is best to use the individual laboratory’s reference ranges, Table 1.4 gives rounded average ranges of normal laboratory values for infants beyond the first week of life (22–24).

<table>
<thead>
<tr>
<th>Test</th>
<th>Normal Rangea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>50–100 mg/dL</td>
</tr>
<tr>
<td>Electrolytes</td>
<td></td>
</tr>
<tr>
<td>• Sodium</td>
<td>130–145 mEq/L</td>
</tr>
<tr>
<td>• Potassium</td>
<td>3.5–6 mEq/L</td>
</tr>
<tr>
<td>• Chloride</td>
<td>100–110 mEq/L</td>
</tr>
<tr>
<td>Calcium</td>
<td>6–12 mg/dL</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.5–2.5 mg/dL</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>5–9 mg/dL</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>&lt; 200 mg/dL</td>
</tr>
<tr>
<td>BUN</td>
<td>7–20 mg/dL</td>
</tr>
<tr>
<td>Creatinine</td>
<td>0.2–1 mg/dL</td>
</tr>
<tr>
<td>Albumin</td>
<td>3–5 g/dL</td>
</tr>
<tr>
<td>Prealbumin</td>
<td>10–25 mg/dL</td>
</tr>
<tr>
<td>Direct bilirubin</td>
<td>&lt; 0.2 mg/dL</td>
</tr>
<tr>
<td>Alkaline phosphatase</td>
<td>100–500 U/L</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>10–15 g/dL</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>30%–45%</td>
</tr>
</tbody>
</table>

Abbreviation: BUN, blood urea nitrogen.

aRounded average ranges to use beyond the first week of life.

Source: Data are from references 22–24. Table is used by permission of Melody Thompson.
CLINICAL ASSESSMENT

Clinical assessment includes observation of the infant’s general condition, bedside nursing documentation, feeding tolerance, and medical status. Of note, the Nutrition Focused Physical Assessment is an additional tool utilized in assessing nutritional status, but is an evolving practice and not yet refined in the neonatal population (25).

Apgar Scores

Apgar scores are recorded in the medical record. These scores are an assessment of a newborn’s heart rate, respiratory effort, muscle tone, reflex irritability, and color. Scores are tallied at 1 and 5 minutes after birth and may be repeated every 5 minutes until the infant’s condition stabilizes.

- Scores range from 0 to 10.
- Total scores of 0 to 3 indicate profound distress.
- Scores of 4 to 6 show moderate difficulty.
- Scores of 7 to 10 represent normal adaptation to extrauterine life.
- Low Apgar scores with no improvement may warrant a cautious approach to enteral feeding initiation and advancement.

Skin

Carefully observe the infant’s skin (see Table 1.5) (22,26). Skin color is an important indicator of cardiorespiratory function. Additionally, notice any devices for respiratory, feeding, or excretory assistance that may influence feeding (such as ventilator tubing, nasal prongs, feeding tube, pacifier, urinary catheter, or ostomy).
<table>
<thead>
<tr>
<th>Observation</th>
<th>Possible Clinical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color</strong></td>
<td></td>
</tr>
<tr>
<td>Pallor (washed-out, whitish)</td>
<td>• Birth asphyxia</td>
</tr>
<tr>
<td></td>
<td>• Shock (altered perfusion)</td>
</tr>
<tr>
<td></td>
<td>• Anemia (iron and/or vitamin deficiency)</td>
</tr>
<tr>
<td></td>
<td>• Chronic disease</td>
</tr>
<tr>
<td></td>
<td>• Patent ductus arteriosus</td>
</tr>
<tr>
<td>Plethora (deep, rosy red)</td>
<td>• Polycythemia</td>
</tr>
<tr>
<td></td>
<td>• Overoxygenated</td>
</tr>
<tr>
<td></td>
<td>• Overheated</td>
</tr>
<tr>
<td>Jaundice</td>
<td>• Yellowish: indirect hyperbilirubinemia</td>
</tr>
<tr>
<td></td>
<td>• Greenish: direct hyperbilirubinemia</td>
</tr>
<tr>
<td>Central cyanosis (bluish skin, tongue, lips)</td>
<td>• Low O$_2$ saturation, may be congenital heart disease or lung disease (concern about gut perfusion)</td>
</tr>
<tr>
<td>Acrocyanosis (bluish hands and feet only)</td>
<td>• Cold stress</td>
</tr>
<tr>
<td></td>
<td>• Hypovolemia</td>
</tr>
<tr>
<td>Mottling (lacy red pattern)</td>
<td>• Normal variation</td>
</tr>
<tr>
<td></td>
<td>• Cold stress</td>
</tr>
<tr>
<td></td>
<td>• Hypovolemia</td>
</tr>
<tr>
<td></td>
<td>• Sepsis</td>
</tr>
<tr>
<td><strong>Fluid status</strong></td>
<td></td>
</tr>
<tr>
<td>Periorbital or generalized edema; bulging fontanel</td>
<td>• Overhydration</td>
</tr>
<tr>
<td></td>
<td>• Protein deficiency</td>
</tr>
<tr>
<td>Dry mucous membranes; sunken fontanel; lack of tears; poor skin turgor</td>
<td>• Dehydration</td>
</tr>
</tbody>
</table>

(continued)
Table 1.5 Infant Clinical Assessment: Skin (continued)

<table>
<thead>
<tr>
<th>Integrity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermatitis</td>
<td>• EFA, B vitamin, or zinc deficiency</td>
</tr>
<tr>
<td>Flaky paint dermatitis</td>
<td>• Protein deficiency</td>
</tr>
<tr>
<td>Poor wound healing</td>
<td>• Zinc, vitamin C, calorie, or protein deficiency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Texture</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaly, dry</td>
<td>• EFA, vitamin A, or zinc deficiency</td>
</tr>
<tr>
<td>Excessive initial peeling</td>
<td>• Postterm: normal variant</td>
</tr>
</tbody>
</table>

Abbreviations: O₂, oxygen; EFA, essential fatty acid.
Source: Data are from references 22 and 26. Table is used by permission of Melody Thompson.

Vital Signs, Urine and Stool Output, and Feeding Tolerance

Review the infant’s vital signs and urine and stool output (see Tables 1.6, 1.7, and 1.8) (22,24,26). An infant’s first urine output is within 24 hours of birth; first stool is within 24 to 48 hours of birth (24). Also note signs of feeding tolerance or intolerance (see bulleted list of feeding intolerance signs in Chapter 3 on page 107).

Table 1.6 Infant Clinical Assessment: Vital Signs

<table>
<thead>
<tr>
<th>Temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal range: 36.5–37.5°C (97.7–99.5°F)</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
Table 1.6  Infant Clinical Assessment: Vital Signs (continued)

**Respiratory rate**
- Normal range: 30–60 breaths/min<sup>a</sup>
- Tachypnea (> 60 breaths/min) is a contraindication for nipple feeding
- Apnea (absence of breathing for > 20 seconds) and/or bradycardia (see below) suggest cardiorespiratory instability: feed cautiously

**Heart rate**
- Normal range: 100–180 beats/min<sup>a</sup>
- Tachycardia (> 180 beats/min) associated with increased energy consumption
- Bradycardia (< 100 beats/min) (see apnea above)

Abbreviations: BMR, basal metabolic rate; O₂, oxygen.
<sup>a</sup>Respiratory rate and heart rate may be lower when sleeping; higher when crying.

*Source:* Data are from references 22 and 26. Table is used by permission of Melody Thompson.

Table 1.7  Infant Clinical Assessment: Urine Output

**Urine volume**
- Normal range: 1–3 mL/kg/h or 5–7 mL/kg/h with diuresis
- < 1 mL/kg/h = oliguria
- No urine output = anuria
- If the infant is oliguric or anuric, consider reducing volume and PRSL of feeding for conservative treatment of ARF

**Urine-specific gravity**
- Normal range: 1.001–1.020
- > 1.020 may be associated with dehydration, increased feeding concentration, increased PRSL, or decreased fluid intake

**Urine-reducing substances**
- Normal finding: negative
- Glucosuria associated with IV glucose load above renal threshold; or rule out galactosemia

Abbreviations: PRSL, potential renal solute load; ARF, acute renal failure.
*Source:* Data are from reference 22. Table is used by permission of Melody Thompson.
### Table 1.8 Infant Clinical Assessment: Stool Output

#### Timing of first stool
- Normal range: Within 48 hours of birth
- No stool: consider bowel obstruction, imperforate anus, aganglionosis, Hirschsprung’s disease

#### Frequency (when enteral feedings are established)
- Normal range: From every feeding to every 3 days
- Excessive watery stools: evaluate hydration status
- Infrequent stools: consider strictures

#### Color
- Normal range: Initially: tarry, dark (meconium); later: yellow to green to brown
- Black stools: may be associated with occult blood
- Clay-colored stools: may indicate cholestasis or decreased bile flow

#### Blood
- Normal: None present
- Blood present: early, consider swallowed maternal blood; later, consider anal fissure, enteral tube trauma, gastritis/stress ulcer, feeding intolerance (protein allergy), colitis, or necrotizing enterocolitis

#### pH
- Normal range: 5–7
- < 5 suggestive of carbohydrate malabsorption (colonic bacterial fermentation produces short-chain fatty acids, which lower stool pH)

#### Reducing substances
- Normal: None after first week of life
- Unabsorbed sugars (> ¼%) suggest carbohydrate malabsorption

*Source: Data are from references 22, 24, and 26. Table is used by permission of Melody Thompson.*
Medical Records

A review of interdisciplinary care could include reviewing the medical record, as well as participating and listening on rounds for the following:

- Potential drug-nutrient interactions
- Radiology reports— noting studies relevant to gastrointestinal (GI) anatomy and function (e.g., upper gastrointestinal [UGI], barium enema, abdominal ultrasound, etc) and noting any evidence of osteopenia (See Chapter 15.)
- Neurology reports— noting any evidence of neurologic problems (See Chapter 13.)
- Maternal history of relevance: intent to breastfeed, weight gain during pregnancy, illnesses (including gestational diabetes; surgeries [breast implants/reduction, gastric bypass]; deficiencies [vitamin D]; family history of food allergies; and use of alcohol or drugs)

Dietary Intake Assessment

Data Collection

To assess dietary intake, review the medical record or nursing flow sheets to determine nutrient sources—PN, IV solutions, human milk, human milk fortifier (HMF), infant formula, and vitamin, mineral, or other modular supplements.
Data Analysis

The dietary intake assessment should include both qualitative and quantitative analyses:

- In the qualitative analysis, consider whether current nutrient solutions are appropriate for the patient’s gestational age, size, tolerance issues (if any), and diagnoses.
- In the quantitative analysis, calculate nutrient intakes (at least mL/kg/d, kcal/kg/d, and protein g/kg/d).
  - PN calculations (including dextrose, crystalline amino acids, and IV fat g/kg/d) are done in the same way for infants as they are for other populations.
  - Additionally, fluid, dextrose, and/or electrolytes in IV drip medications often contribute substantially to an infant’s nutrient intake and are calculated.
  - Occasionally, even medication flushes influence the small infant’s glucose or electrolyte status.
  - A more detailed targeted nutrient intake analysis may be done on intakes of infants with certain diagnoses or conditions (e.g., assessing calcium, phosphorus, and vitamin D intakes for infants with osteopenia).

Calculations of nutrient intakes are compared with recommended intakes (see Chapters 2 and 3 for PN and EN recommendations) and interpreted in light of the infant’s medical condition and growth. See Box 1.1 for an example of how to calculate nutrient intake.
Box 1.1  Sample Nutrient Intake Calculation for 1,500-g Preterm Infant

<table>
<thead>
<tr>
<th>Intake</th>
<th>Maternal milk fortified to 24 kcal/fl oz with human milk fortifier; taking 28 mL every 3 hours</th>
</tr>
</thead>
</table>
| Calculations | 28 mL × 8 feedings/d = 224 mL/d ÷ 1.5 kg = 149 mL/kg/d  
149 mL/kg/d × 0.8 kcal/mL<sup>a</sup> = 119 kcal/kg/d  
149 mL/kg/d × 0.028 g protein/mL<sup>a</sup> = 4.2 g protein/kg/d |

<sup>a</sup>For most precise calculations, consult the specific manufacturer’s literature.

**SUMMARY**

Screening should be completed within 24 hours of NICU admission (see Table 1.1). An RDN then completes an assessment on designated infants. This assessment should include all of the following:

- **Anthropometric assessment:** Obtain accurate measurements of weight, length, and head circumference. Plot on appropriate growth curves. Consider infant’s classification (ie, gestational age, birth weight, and weight for gestational age). Interpret/analyze growth pattern or trend.
- **Biochemical assessment:** Review appropriate biochemical data. Interpret in light of patient’s condition.
- **Clinical assessment:** Look at the patient and medical record; make clinical observations.
- **Dietary intake assessment:** Evaluate intake to assess what and how much is administered. Calculate intake—at least fluids, energy, and protein, all per kilogram per day.
All components of nutrition assessment (anthropometric, biochemical, clinical, and dietary intake assessments with infant classification) are used to develop the infant’s nutrition care plan and form the basis for documentation in the medical record.

REFERENCES


Appendix A

Nutrition Care Process

Janice Hovasi Cox, MS, RD, CSP

The Academy of Nutrition and Dietetics has developed a system for documenting nutrition care using standardized language to describe assessment, identify specific nutrition diagnoses, describe intervention, and identify measures to monitor and evaluate progress toward meeting the goals of intervention. This Nutrition Care Process (NCP) system supports and promotes individualized nutrition care by providing a framework for standardizing the process and the way in which this process is communicated. This process encourages critical thinking and supports the efficient and equitable provision of safe and effective nutrition care (1–4).

STEP 1: NUTRITION ASSESSMENT

For neonates, nutrition assessment begins with determining gestational age and z score or percentile ranking for anthropometric measurement, then comparing subsequent growth against established standards and obtaining relevant data from intake records, including parenteral, enteral, and oral nutrient intake. Other factors considered in nutrition assessment include biochemical data, medical tests, and procedures; physical examination findings, including feeding tolerance descriptions, presence and
appearance of emesis, and description of stool characteristics; and client history information, such as family history of food allergy, intent to breastfeed, parental height, financial eligibility for supplemental food programs, and reading ability of parents or other caregivers. Accurate interpretations of these data yield assessments that lead to nutrition diagnoses and effective interventions.

STEP 2: NUTRITION DIAGNOSIS

Nutrition diagnosis is not a restatement of the medical diagnosis but the identification and specific labeling of the nutrition problem that the neonatal dietitian is responsible for treating. The nutrition diagnosis is defined by a statement that includes the following:

• Problem (P) or label that describes an alteration in nutritional status
• Etiology of the problem (E) or the cause or contributing factors that sustain the problem, and
• Signs and symptoms (S) that identify, characterize, or define the nutrition problem

For example, the medical diagnosis may be osteopenia of prematurity, but the nutrition diagnosis may be: “Inadequate vitamin intake, specifically vitamin D, and inadequate mineral intake, specifically calcium and phosphorus (P), related to increased nutrient needs and feeding intolerance associated with cow’s milk protein–based human milk fortifier (E), as evidenced by serum phosphorus level less than 5.6 mg/dL and alkaline phosphatase level more than 900 U/L (S).”
STEP 3: NUTRITION INTERVENTION

Nutrition intervention involves specific actions to treat or resolve the nutrition problem. Intervention requires a change in one or more of the following:

- Food and nutrient delivery
- Nutrition education
- Nutrition counseling
- Coordination of nutrition care

The intervention is usually aimed at the etiology of the problem. For example, the nutrition intervention for a preterm infant with the nutrition diagnosis of inadequate vitamin D, calcium, and phosphorus intake might be to change nutrient delivery by the following nutrition prescription: “Provide standard dose of extensively hydrolyzed cow’s milk protein–based human milk fortifier.”

STEP 4: NUTRITION MONITORING AND EVALUATION

In the fourth NCP step, the success of the nutrition intervention may be measured as a change in the signs and symptoms of the problem, or by comparing specific indicators with established standards. For example, the patient with low serum phosphorus levels and elevated alkaline phosphatase may be monitored for changes in serum phosphorus levels. Serum alkaline phosphatase levels may remain elevated with increased osteoblastic activity, but serum phosphorus levels should become normal with adequate nutrient intake. By selecting the appropriate measure(s) of outcome, the neonatal dietitian can compare findings with the previous state, specific identified goals, and/or reference standards. The use of such standards to
monitor and evaluate achievement of nutrition goals and resolution of the nutrition problem facilitates the assessment and comparability of outcomes and increases the validity and reliability of treatment modalities.

Standardized language has been developed for many of the parameters of nutrition assessment, diagnosis, intervention, monitoring, and evaluation. Publications that address the NCP and provide detailed lists and explanations of the standardized Nutrition Care Process Terminology are available through the Academy of Nutrition and Dietetics, and are included in the reference list (1–4).

Note: An online tool kit for the Nutrition Care Process as it is applied in the neonatal patient population is also available for purchase through the Academy of Nutrition and Dietetics (5).

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