

Enteral Feeding

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I. Introduction

A. Nutritional Goals for the Premature:

1. Stimulate intrauterine growth
 - a. Weight 1-2% of body weight/day
 - b. OFC 0.5-1.0 cm/week
 - c. Length 1-1.5 cm/week
2. Stimulate fetal intestinal function
 - a. Fetal gut absorbs 500 mL of amniotic fluid/day near term
 - b. Have a direct trophic effect on its development and integrity
3. Avoid complications of TPN

B. When to start? As soon as there are no contra-indications, such as:

1. Hemodynamically instability:
 - a. Volume resuscitation
 - b. Dopamine >5 mics/kg/min
 - c. Initiation of HydroCortisone (can feed if stable on weaning doses)
 - d. Significant PDA or ≤ 48 hours after closure with Indomethacin
 - e. Surgery within ≤ 48 hours
2. Abnormal abdomen, e.g.:
 - a. Distention, discoloration, “surgical” abdomen
 - b. Suspected GI anomaly
 - c. Large volume, bloody, or bilious gastric residuals
3. Perinatal Depression (e.g., low Apgars, metabolic acidosis, HIE) requires individualized clinical evaluation
4. Pulmonary instability e.g.:
 - a. Impending ECMO;
 - b. Significant hypoxemic episodes;
 - c. Mechanical ventilation and/or UAC are not *per se* contra-indications
5. Fluid and electrolyte instability needs to be assessed individually, e.g.:
 - a. Hypoglycemia
 - b. Hyponatremia or
 - c. Hypocalcemia

II. What to Feed

A. Maternal Milk: **Every effort should be made before and after delivery to encourage maternal pumping (unless there is a documented medical contraindication).**

1. The volume of expressed milk at two weeks post-partum usually is predictive of successful lactation – this should be ≥ 500 mL/day.
2. Lactation Services are available to consult and assist our mothers. Early intervention is best.

- B. Donor Milk:** For VLBW infants at risk for NEC, Donor Human Milk from the Milk Bank is available to supplement the maternal supply. Milk donors are screened like blood donors, but additionally may not smoke nor be on medications. Banked Milk is Holder Pasteurized, which destroys bacteria and known viruses such as CMV and HIV.
- C. Advantages (immunological):**
1. Lactoferrin limits availability of iron to pathogenic bacteria.
 2. Secretory IgA - mucosal antibodies against specific pathogens.
 3. Lysosome – a nonspecific protective factor in breast milk thought to influence flora of intestinal tract through cell wall lysis.
 4. Breast milk contains a specific factor encouraging the growth of other potentially pathogenic organisms.
 5. Presence of numerous hormones and growth factors including epidermal growth factor.
 6. Pasteurization does kill the white cells in Donor Milk, and thus it is not as good as fresh Maternal Milk. However, many other factors are preserved (see Table 1), and freeze/thawing damages Maternal Milk, too. Both sources of human milk are superior to formula in preventing NEC and nosocomial infections, and enhancing immunity.
- D. Limitations:**
1. Additional calcium and phosphorus are necessary to meet premature infant’s needs.
 2. Very low birthweight infants will also require protein and sodium supplementation.
 3. Human milk has a range of caloric content and it is occasionally inadequate to support adequate weight gain by itself. Of note, Donor Milk from the Milk Bank is pooled so that the caloric content is fairly constant, and no recipient is at risk of getting low-caloric milk from an “outlier” donor.
 4. Maternal milk can be a source of infection if not collected carefully. Maternal milk may transmit viruses such as CMV even after freezing.
- E. “Fortifying” Breast Milk:** Human Milk Fortifiers or Formula powder can be added to breast milk to increase caloric density, protein, and electrolyte content. These should not be added until the baby has demonstrated both tolerance of full-volume feeds and the need for fortification, either by slow weight gain, hypoalbuminemia, or evidence of inadequate mineral intake (e.g., very high Alkaline Phosphatase). For stable premies who can tolerate the volume, increasing the feedings to 180 mL/kg/day or more may be adequate. HMF provides more Calcium and Phosphorus, but may not be available after discharge, thus we usually switch to powdered formula before discharge when fortification is still needed.
1. Human Milk Fortifier
 - a. 1 packet/1 oz of breast milk \approx 24 kcal/oz (full strength)
 - b. 1 packet/2 oz of breast milk \approx 22 kcal/oz (half strength)
 2. Formula Powder with MBM/BBM - presumed to be 20 cal/oz (Neosure, Enfamil, Enfacare, Similac, Portagen, Pregestimil)
 - a. 1/4 tsp/2 oz breast milk \approx 22 kcal/oz
 - b. 1/4 tsp/1 oz breast milk \approx 24 kcal/oz
 - c. 1/2 tsp/1 oz breast milk \approx 27 kcal/oz
 - d. 3/4 tsp/1 oz breast milk \approx 28 kcal/oz
 - e. 1 tsp/1 oz breast milk \approx 30 kcal/oz
 3. Protein – BeneProtein [protein powder] 1.5 gm per 1 teaspoon.

4. Fat – very concentrated caloric source, though not optimum nutrition and large doses can cause loose stools.
 - a. MCT Oil (Medium Chain Triglycerides) – 7.6 kcal/mL readily absorbed
 - b. MicroLipid – 4.5 kcal/mL includes essential Long-Chain Fatty Acids
- F. Formula Feedings:** On (hopefully rare) occasions, mothers may not provide their own milk and refuse Donor Milk. In this situation, premature infants should be started on a 20 kcal/oz premature formula (e.g., Premature Enfamil²⁰, Similac Special Care²⁰). There is no need to dilute these formulas. Once full-feeds are tolerated, these can be advanced to the 24 kcal/oz version.

III. Fluid Volume

- A.** Most preterm infants <2 kg and <35 weeks gestation will require IV fluid initially because of suck/swallow discoordination and the risk of hypoglycemia. However, they do not require sodium and water initially. Fluids initially are held to 60 - 80 mL/kg/day of D10W to provide adequate glucose, and then slowly advanced as indicated.
 1. Term and near term babies can start on *ad lib* feeds with IV fluids reserved for those with specific risk factors for hypoglycemia (e.g., IDM, SGA) or who can't feed.
 2. Late preterm babies (35-36) weeks and 2000-2500 grams are at risk to develop hypoglycemia if mother attempts to breast feed only (inadequate supply immediately after birth and decreased ability to suck vigorously) and may often avoid IV fluids if started on bottle feeds (discontinued as soon as breast feeding is well established).
- B.** Our rough goals for enteral feeds would be to provide calories for growth and to meet all of the other nutritional needs of the patients.
 1. Usually your target is 100-120 kcal/kg/day. This will require 150 ml/kg/day of 24 calorie formula/fortified human milk as the feeding target for most preemies, although many without heart or lung problems will tolerate 175-180 ml/kg/day or more.
 2. Ill preemies with chronic lung disease or heart disease may require 120-150 kcal/kg/day with decreased tolerance for fluid, dictating higher than 24 calorie formula or additional nutrient supplements.
- C.** Parenteral Nutrition will be needed usually for VLBW infants until feedings can be advanced to a significant volume (see “Management of IV Fluids and TPN,” Part 3A – Nutrition). This is necessary to prevent a protein and caloric deficit from accruing during the initial period of restricted enteral intake. However, once the preemie can tolerate a substantial amount of enteral nutrition, fluid supplementation can be with just D10W and electrolytes. Generally, supplemental Hyperalimentation is stopped when approximately 75% of intake is enteral.

IV. Feeding Guidelines

- A. Route:**
 1. Asymptomatic infants who can suck/swallow (usually >34 weeks EGA) can be started on nipple feeds.
 2. Most preemies <34 weeks are fed via gavage. Gavage feeding provides an easy way of checking tolerance by aspirating back and determining residual feeding material prior to introduction of additional feeds.
 3. Preemies who don't tolerate NG feeding due to poor gastric emptying, or small preemies <1 kg who require nasal CPAP are often managed with transpyloric Nasojejunal (NJ) feeding. With small infants on CPAP, swallowed air can collect in the stomach leading to distention and feeding intolerance. By feeding transpylorically and using standard orogas-

tric (OG) tube left open to air for venting, gastric distention is minimized and feeding can be accomplished safely.

- a. NJ tubes require an X-ray to verify placement.
- b. Transpyloric feeds must be “continuous drip” using a pump.

B. Trophic Feeds: Early enteral nutrition has been demonstrated to have a beneficial effect on maturing the intestinal tract of the very low birth weight and sick infant. The prolonged withholding of enteral feeds delays the capability of the intestines to adapt to the extra-uterine environment and may actually enhance the potential of pathogenic organisms to translocate from the intestine to cause generalized infection. Several investigators have demonstrated that the early initiation of minimal enteral feedings has improved pre-term sick neonates' ability to tolerate enteral feedings, decrease the need for TPN, decrease the incidence and severity of cholestasis and hepatic dysfunction, and decrease the incidence of nosocomial infections. Small volume trophic feeds can be given with UAC in place.

C. Colostrum: Colostrum, the initial milk produced in the first several days of lactation, is very important immunologically and trophically. Even if the volume is small, it provides great benefit to our preemies, and every effort should be made to collect and utilize it.

1. If the infant is ready to begin feeds, colostrum should be used according to the appropriate pathway described below.
2. If feeds are still contra-indicated as above, colostrum should be delivered to the buccal pouch in small volumes (± 1 mL each side) via syringe or cotton swab until the patient is ready to begin following the appropriate pathway.

D. For all neonates less than or equal to 1000 gm or less than 27 + 0/7 weeks meeting criteria for initiation of feeds above:

Feeding Day 1-4:	2-3 mL/kg q 6 hr	10 mL/kg ·day
Feeding Day 5-8:	2-3 mL/kg q 3 hr	20 mL/kg ·day
Feeding Day 9:	4-5 mL/kg q 3 hr	40 mL/kg ·day
Feeding Day 10:	6-8 mL/kg q 3 hr	60 mL/kg ·day
Feeding Day 11:	9-10 mL/kg q 3 hr	80 mL/kg ·day
Feeding Day 12:	11-13 mL/kg q 3 hr	100 mL/kg ·day
Feeding Day 13:	14-16 mL/kg q 3 hr	120 mL/kg ·day
Feeding Day 14:	17-19 mL/kg q 3 hr	140 mL/kg ·day
Feeding Day 15:	20 mL/kg q 3 hr	160 mL/kg ·day

1. Feedings should be rounded to nearest mL (i.e. 2 mL not 2.2 mL).
2. Feeding days are NOT day of life, but count from day feeds initiated.
3. For infants ≤ 14 days old, use birth weight. Thereafter, you will need to individualize for small weight changes during the protocol.

- E.** For all Neonates 1001-1500 gm or between 27 + 0/7 and 31 + 0/7 weeks meeting criteria for initiation of feeds above:

Feeding Day 1-6:	2-3 mL/kg q 3 hr	20 mL/kg ·day
Feeding Day 7:	4-5 mL/kg q 3 hr	40 mL/kg ·day
Feeding Day 8:	6-8 mL/kg q 3 hr	60 mL/kg ·day
Feeding Day 9:	9-10 mL/kg q 3 hr	80 mL/kg ·day
Feeding Day 10:	11-13 mL/kg q 3 hr	100 mL/kg ·day
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1. Feedings should be rounded to nearest mL (i.e. 2 mL not 2.2 mL).
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 3. For infants ≤ 14 days old, use birth weight. Thereafter, you will need to individualize the choice of calculation weight. You do not need to correct the calculations for small weight changes during the protocol.
- F. Monitoring:** Tolerance to feeds must be monitored continuously. Babies must be evaluated with chart documentation, and feedings reduced or withheld for:
1. Abdominal distention, visible loops, or abdominal discoloration.
 2. Worsening clinical status, e.g.:
 - a. hemodynamic/respiratory instability
 - b. hypo- or hyperglycemia
 3. Bloody stools NOT related to anal fissure.
 4. Bloody or bilious gastric residual or emesis.
 5. Large volume residual, defined as $> \frac{1}{2}$ the volume fed once feeds are at > 75 mL/kg ·daily. (See NICU Feeding Orders)
- G. Constipation:** Many preemies may go more than 24 hours without a stool, but constipation may result in feeding intolerance. If otherwise benign, an order for occasional Glycerin Suppository PR may be needed to prevent feeding problems.
- H. Vitamins:** Multivitamins are an important dietary adjunct for very low birth weight infants. Once the infant is on full enteral feeds, a multivitamin preparation such as Poly-Vi-Sol should be started. For infants weighing less than 1500 grams, the dose is 0.5 mL PO BID. For infants greater than 1500 grams, the dose is 1 mL PO daily. Although the formulas for preterm infants contain supplemental vitamins, as do the human milk fortifiers, the premature infant may benefit from the multivitamin preparations. If, however, the infant's serum phosphorus level is found to be increasing (greater than 8 mg/dL) the vitamins may need to be decreased or discontinued as the infant may be receiving too much vitamin D. One should first be sure that the elevation is not due to a low Ca:PO₄ ratio in the diet, or renal abnormalities.

- I. Iron:** After the infant has been on full feeds and has tolerated the enteral multivitamin preparation, Fer-In-Sol (elemental Fe 25 mg/mL) can be started at 0.1 mL/day and increased slowly to 0.2, 0.3 and even 0.6 mL/day for infants over 2.5 kg. The goal is 2-3 mg/kg (~0.1 mL/kg) daily maintenance, 5-6 mg/kg (~0.2 mL/kg) daily if there is evidence of iron deficiency.
- J. Minerals:** Supplementation with Calcium and/or Phosphorus are occasionally needed to prevent or treat nutritional rickets. Usually the doses will be calculated with the help of the Dietitian to provide about a 1.7:1 Ca:Phos ratio for the entire intake including the milk or formula. The commonly used supplements include:
1. Calcium Glubionate (NeoCalGlucon) \approx 23 mg elemental Calcium/mL;
 2. Calcium Carbonate (Tums) \approx 100 mg elemental Calcium/mL
 3. Na/K Phosphate (Neutra-Phos) \approx 0.32 mM or 10 mg elemental Phosphorus/mL.
- K. Routine Laboratories:** Growth parameters over the preceding 1-2 weeks are the best judge of nutritional adequacy. In general, preemies should gain weight by about ~10% per week, and the OFC should increase about 1 cm/wk. We routinely check labs weekly on “feeding and growing preemies” for signs of Vitamin/Mineral, Iron, or Protein deficiency.
1. HCT q week, if low then twice a week and check a reticulocyte count.
 2. Electrolytes for patients on chronic diuretics once or twice a week.
 3. Preemie Nutritional Panel (PNP) every week. This contains:
 - a. **BUN:** assesses protein utilization and renal function. A high BUN in the presence of normal renal function implies protein overload. Conversely, one can “push” protein intake as long as the BUN stays low.
 - b. **Ca/Phos:** assesses bone mineralization & Vitamin D status.
 - c. **Alkaline phosphatase (AlkP):** normally increased with the bone formation in preemies, but if significantly elevated (>800 IU) it may be due to sub-optimal calcium/phosphorous or Vitamin D intake. AlkP also is elevated in patients with hepatocellular damage and/or cholestasis, and it may be difficult to ascertain which factor is causing the elevation. Furthermore, AlkP increases during bone healing with resolving nutritional rickets. Radiograph of the bones are not often helpful and we do not perform densitometry.
 - d. **Albumin:** non-specific nutritional status assessment. Pre-albumin may be a more specific test, but is not readily available.

Table 1. Selected Components of Human Milk After Freezing and Pasteurization

	<i>Function</i>	<i>Percentage Activity</i>
IgA and sIgA*	Binds microbes in the baby's digestive tract to prevent their passage into other tissues	67-100
IgM*	Antibodies specifically targeted against pathogens to which the mother has been exposed	0
IgG*	Antibodies specifically targeted against pathogens to which the mother has been exposed	66-70
Lactoferrin (iron-binding capacity)*	Binds iron required by many bacteria and thus retards bacterial growth	27-43
Lysozyme*	Attacks bacterial cell walls and thus destroys many bacteria	75
Lipoprotein lipase*	Partly responsible for lipolysis of milk triglycerides to release monoglycerides and free fatty acids	0
Bile salt activated lipase*	Partly responsible for lipolysis of milk triglycerides to release monoglycerides and free fatty acids	0
Monoglycerides produced by lipolysis of milk triglycerides*	Disrupts the membrane coating of many viruses and protozoans, destroying them	100
Free fatty acids produced by lipolysis of milk triglycerides**	Disrupts the membrane coating of many viruses and protozoans, destroying them	100
Linoleic acid (18:2n6)**	Essential fatty acid; metabolic precursor for prostaglandins and leukotrienes	100
α -linolenic acid (18:3n3)**	Essential fatty acid; metabolic precursor for docosahexaenoic acid; important for eye and brain development	100

* These biologically active components do not occur in commercial formula.

** Some manufacturers are now adding docosahexaenoic acid and other supplemental fats to selected infant formula preparations.

From: Tully DB, et al. *J Hum Lact* 2001; 17:152-5.