Supplementation of Mother’s Own Milk or Pooled Human Milk

No supplement to human milk is usually needed if the infant is more than 1500 g at birth.

The options for supplementing an infant’s own mother’s milk depend on the need for additional volume or for specific nutrients, especially protein, calcium, and phosphorus, based on birth weight and growth rates.65,66
The ideal supplementation is one using human milk nutrients and is referred to as *lacto engineering,* in which nutrient concentration is increased by adding specific nutrients derived from human milk. Techniques involve use of donor milk and separating the cream and protein fractions, reducing the lactose content, and heat-treating the product with a high-temperature, short-time process of pasteurization. This completely human milk product provides higher protein and energy needs so that weight gains and nitrogen retention are similar to intrauterine rates.

Using a feeding prepared from human milk protein and medium-chain triglyceride supplementation of human milk for VLBW infants was reported by Rönnholm et al. Forty-four infants averaging 30 weeks' gestation with birth weights ranging from 710 to 1510 g were nourished by one of four protocols: plain human milk, human milk and protein, human milk and triglycerides, or human milk and protein and triglycerides. The triglycerides did not influence weight and length, but the two groups receiving added protein gained along a curve comparable with the intrauterine growth for their birth weight, gaining faster from 4 to 6 weeks than the unsupplemented infants. The protein-supplemented groups also grew more in length; however, head circumference growth was similar in all groups.

Total protein is usually calculated by determining the total nitrogen content (Kjeldahl method) and multiplying the number by the protein factor (6.25). Total protein corrected for nonprotein nitrogen, which is high in human milk, is true protein. True protein is a heterogeneous mixture of casein and whey proteins. Whey proteins include lactoferrin, immunoglobulin, and lysozyme. True protein minus those more or less indigestible proteins is called *digestible protein.* Analysis of preterm milk by Beijers et al. demonstrated that nonprotein nitrogen was dependent on the degree of prematurity and averaged 20% to 25%, increasing during the time of lactation. Only 30% to 60% of total protein is available for synthesis. However, in absolute amounts over lactation time, it remains stable.

Schanler et al. compared plasma amino acid levels in VLBW infants (mean age 16 days, mean birth weight 1180 g, mean gestation 29 weeks) fed either human milk fortified with human milk or whey-dominant cow milk formula. The infants received continuous enteral infusions of isonitrogenous, isocaloric preparations. Taurine and cystine were significantly higher in the infants fed human milk, and threonine, valine, methionine, and lysine were significantly higher in the infants fed formula.

Mother's own milk shows a wide variability in nutrient components when being pumped for a hospitalized premature infant. Nutrient supplementation is necessary to maintain adequate growth and good nutritional status. According to Herman and Schanler, extraordinary efforts should be made to use mother's own milk because the advantages of nonnutrient components in human milk are significantly diminished by storage and heat processing. The most variable constituent is fat (Box 15-10). Protein does not meet the needs of a small premature. Although levels of minerals (Ca, P) are stable, the needs of VLBW infants require supplementation. Substantial benefits of mother's own milk include reduced infection, enhanced neurodevelopmental outcome, and healthy postnatal growth. The minimum dose of mother's milk when given with various fortifications has been found to be more than 50 mL/kg/day to protect against infection, especially late-onset sepsis. A systemic review looking at multi-nutrient fortification for human milk involved 10 trials and a total of more than 600 infants weighing less than 1800 g. It clearly showed improvement in weight gain increments in length, head circumference, and BMC compared with unsupplemented milk. Neurodevelopmental outcomes were significantly improved with mother's milk. The magnitude of the effect was seen as mother's milk intake increased to 110 mL/kg/day; the developmental scales showed an increase of five points, an important gain for these ELBW infants. Preterm infants have lower energy expenditure when they are fed breast milk than when they are fed preterm infant formula.

### BOX 15-10. Steps to Preserve the Nutrient Value of Mother's Milk

<table>
<thead>
<tr>
<th>I. Most variable component: Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Lost in collection and storage</td>
</tr>
<tr>
<td>B. Settles out on standing</td>
</tr>
<tr>
<td>C. In one report fat content ranged from 2.2 to 4.7 g/dL</td>
</tr>
<tr>
<td>D. Steps to enhance fat</td>
</tr>
<tr>
<td>1. Avoid separation of fat</td>
</tr>
<tr>
<td>2. Avoid continuous feeds</td>
</tr>
<tr>
<td>3. Utilize intermittent bolus feeds</td>
</tr>
<tr>
<td>4. Orient syringe of milk upward</td>
</tr>
<tr>
<td>5. Use short length of tubing</td>
</tr>
<tr>
<td>6. Empty syringe completely at end of infusion</td>
</tr>
<tr>
<td>E. Use hind milk preferentially if volume is adequate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II. Protein content declines from transitional to mature milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Nutrient needs for premature are higher</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>III. Mineral content has increased bioavailability but content is lower than needs of premature infants.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamins A, C, and riboflavin levels decrease with collection, storage, and delivery.</td>
</tr>
</tbody>
</table>
Preterm infants with birth weights from 750 to 1250 g were randomly assigned to a cream or control group. The cream group received a human milk-derived cream supplement if the energy density of the human milk tested below 20 kcal/oz, measured using a near infrared human milk analyzer. The control group received their mother's own milk or donor human milk with donor human milk-derived fortifier. Premature infants who received human milk-derived cream as a fortifier had improved weight and length compared to the control group. Cream can be used as an adjunctive supplement to an exclusive human milk-based diet to improve growth rates (see Figure 15-6 Prolact CR™ Human Milk Caloric Fortifier).

All preterm infants should receive human milk fortified with protein, minerals, and vitamins when birth weight is less than 1500 g according to the American Academy of Pediatrics’ section on breastfeeding.

**Artificial Fortification of Human Milk**

No longer is supplementing an infant’s own mother’s milk with specially prepared formula supplements necessary. Available commercial preparations for such supplementation were intended to complement human milk and not to be used as an exclusive formula. When multicomponent fortified human milk product for promoting growth in preterm infants was examined in a Cochrane Review,74 the authors found short-term increases in weight gain, linear growth, and head circumference. No effect was seen on serum alkaline phosphatase levels, and the effect on BMC was unclear. Nitrogen retention and blood urea levels were increased. Conclusions about long-term neurodevelopmental and growth outcomes were limited by insufficient data after 1 year. The significance of increased blood urea nitrogen and blood pH levels was unclear. Preparations are different and are used differently (Table 15-9). The powdered supplement is intended to add special nutrients to an adequate volume of mother’s own milk (Enfamil human milk fortifier or Similac human milk fortifier), or it can be used to enhance pooled donor human milk. Neither fortifier contains fat. Milk fortification extends the mother’s milk and provides additional nitrogen, calcium, phosphorus, and vitamins for an LBW infant. If an infant is fed the mother’s milk, pooled donor milk, and a fortifier, the sum total should meet the infant’s daily requirements (Table 15-10). Any addition of artificial formula interferes with the infection protection qualities and other benefits of human milk so use of formula-based supplementation should be avoided unless human milk-based formula is not available. Preventing one case of NEC saves $100,000.

Studies comparing fortified mother’s milk with premature infant formulas have shown comparable growth in weight, length, and head circumference. This makes it possible to lose many advantages of a mother’s milk, while providing the additional nutrients for appropriate accretion rates.127

When powdered fortifier was added to a mother’s milk, the supplemented infants had significantly greater weight gain, linear growth, and head circumference growth than those not supplemented. The supplemented infants also had higher blood urea nitrogen levels (Table 15-11).53 The loss of human milk benefits is of significant concern.

When a preterm infant’s own mother’s milk was fortified with protein (0.85 g/dL), calcium (90 mg/dL), and phosphorus (45 mg/dL), the rate of weight gain was greater than that of the unfortified group and comparable with that of the Similac Natural Care formula group.50–52 Bone mineralization improved during the 6 weeks of the study but did not reach the intrauterine accretion rate of 150 mg/kg/day. A relative phosphorus deficiency occurred in the human milk groups, both with and without supplementation. Fortifying preterm mother’s milk permits biochemically adequate growth comparable with that provided by special care formula (Table 15-12).

The effect of calcium supplementation on fatty acid balance studies in LBW infants fed human milk or formula has been shown to be significant. A decrease in total fatty acid absorption both in LBW infants fed their own mother’s milk and in formula-fed infants was seen when calcium was added. Fecal output of fat and fatty acid excretion was higher in the formula-fed infants. In mother’s milk-fed infants, the total fat absorption and the coefficient of absorption were higher.

Preterm milk with routine multivitamin supplementation (providing 4.1 mg of tocopherol) uniformly resulted in vitamin sufficiency in VLBW infants in a control study by Gross and Gabriel.54 This was true when they received iron, as well as when they were not iron supplemented. VLBW infants were fed preterm milk, bank milk, or formula, utilizing 2 mg/day of iron. Vitamin E content of preterm milk does not differ significantly from that of term human milk from days 3 to 36.56

Jocson et al.68 studied the effects of nutrient fortification and varying storage conditions on host-defense properties of human milk. Total bacterial colony counts and immunoglobulin A (IgA) were not affected by the addition of fortifier.

The effect of powdered human milk fortifiers on the antibacterial actions of human milk were
### TABLE 15-9
Composition of Infant Feeding Using Human Milk With and Without Various Supplements

<table>
<thead>
<tr>
<th>Weeks postpartum</th>
<th>Preterm Human Milk</th>
<th>Similac Natural Care</th>
<th>50:50 Mix Similac Natural Care and Preterm Human Milk</th>
<th>Enfamil Human Milk Fortifier (four packets)</th>
<th>Enfamil Human Milk Fortifier (four packets) Added to Preterm Human Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilocalories</td>
<td>67</td>
<td>70</td>
<td>81</td>
<td>72</td>
<td>76</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>2.44</td>
<td>1.81</td>
<td>2.27</td>
<td>1.96</td>
<td>0.7</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>6.05</td>
<td>6.95</td>
<td>7.3</td>
<td>7.8</td>
<td>2.7</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>3.81</td>
<td>4.00</td>
<td>3.6</td>
<td>3.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Vitamin A (IU)†</td>
<td>330</td>
<td>230</td>
<td>550</td>
<td>440</td>
<td>390</td>
</tr>
<tr>
<td>Vitamin E (mg)†</td>
<td>0.9</td>
<td>0.25</td>
<td>3</td>
<td>2.0</td>
<td>1.61</td>
</tr>
<tr>
<td>Vitamin K (mcg)†</td>
<td>NA</td>
<td>1.5</td>
<td>10</td>
<td>NA</td>
<td>5.8</td>
</tr>
<tr>
<td>Vitamin D (IU)†</td>
<td>NA</td>
<td>2.5</td>
<td>120</td>
<td>NA</td>
<td>61</td>
</tr>
<tr>
<td>Thiamin (mcg)</td>
<td>5.4</td>
<td>8.9</td>
<td>200</td>
<td>103</td>
<td>104</td>
</tr>
<tr>
<td>Riboflavin (mcg)</td>
<td>36.0</td>
<td>26.6</td>
<td>500</td>
<td>268</td>
<td>263</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>0.11</td>
<td>0.21</td>
<td>4.0</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Pyridoxine (mcg)</td>
<td>2.6</td>
<td>6.2</td>
<td>200</td>
<td>101</td>
<td>103</td>
</tr>
<tr>
<td>Folate (mcg)</td>
<td>2.1</td>
<td>3.1</td>
<td>30</td>
<td>16.1</td>
<td>16.6</td>
</tr>
<tr>
<td>Vitamin B₁₂ (mcg)</td>
<td>NA</td>
<td>0.1</td>
<td>0.45</td>
<td>NA</td>
<td>0.27</td>
</tr>
<tr>
<td>Vitamin C (mg)†</td>
<td>7</td>
<td>5</td>
<td>30</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>25</td>
<td>22</td>
<td>170</td>
<td>98</td>
<td>96</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>3</td>
<td>2.5</td>
<td>10</td>
<td>6.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Sodium (mEq)</td>
<td>2.2</td>
<td>1.3</td>
<td>1.7</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Chloride (mEq)</td>
<td>1.8</td>
<td>1.7</td>
<td>2.9</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>0.48</td>
<td>0.39</td>
<td>1.2</td>
<td>0.84</td>
<td>0.80</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>0.08</td>
<td>0.06</td>
<td>0.2</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
<td>Manganese (mcg)†</td>
<td>NA</td>
<td>0.4</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Biotin (mcg)</td>
<td>0.15</td>
<td>0.54</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Osmolarity (mOsm/kg H₂O)†</td>
<td>302</td>
<td>305</td>
<td>300</td>
<td>301</td>
<td>303</td>
</tr>
</tbody>
</table>

*Volume 100 mL (1 dL).
†Listed values for 1 and 4 weeks reflect reported values for full-term transitional and mature human milk, respectively. IU, International units; NA, not available.

### TABLE 15-10
Protein, Calcium, and Sodium Requirements by Growing Premature Infants and Composition of Banked Human Milk

<table>
<thead>
<tr>
<th>Protein (g/100 kcal)</th>
<th>Calcium (mg/100 kcal)</th>
<th>Sodium (mEq/100 kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated requirements for hypothetic, growing premature infants*</td>
<td>2.54</td>
<td>132†</td>
</tr>
<tr>
<td>Composition of banked human milk</td>
<td>1.50</td>
<td>43</td>
</tr>
</tbody>
</table>

*Assumed body weight is 1200 g; weight gain, 20 g/day; energy intake, 120 kcal/kg/day. The basis for estimating requirements is described in the text.
†This estimate does not apply to infants fed formulas from which calcium absorption is less than 65% of intake.

### TABLE 15-11
Fortified Versus Unfortified Human Milk

<table>
<thead>
<tr>
<th>Growth</th>
<th>Fortified</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 studies, 596 infants; randomized*</td>
<td>Weight gain +3.7 g/kg/day</td>
</tr>
<tr>
<td>Length +0.13 cm/wk</td>
<td></td>
</tr>
<tr>
<td>Head circumference +0.12 cm/wk</td>
<td></td>
</tr>
<tr>
<td>Bone mineral content +8.3 mg/cm</td>
<td></td>
</tr>
<tr>
<td>Nitrogen balance +66 mg/kg/day</td>
<td></td>
</tr>
<tr>
<td>BUN +5.8 mg/dL</td>
<td></td>
</tr>
<tr>
<td>Necrotizing enterocolitis No significant difference</td>
<td></td>
</tr>
<tr>
<td>Feeding tolerance No significant difference</td>
<td></td>
</tr>
</tbody>
</table>

*Some comparisons with partial supplements.
BUN, Blood urea nitrogen.
explored by Chan. Human milk inhibited the growth of Escherichia coli, Staphylococcus aureus, Enterobacter sakazakii, and group B Streptococcus when Enfamil and Similac human milk fortifiers were mixed with human milk, along with medium-chain triglycerides and 1.09 mg ferrous sulfate (in 25 mL milk). The fortifiers containing iron and the iron alone inhibited the protective effect of human milk against the bacteria. The probable explanation is the interference of iron with the protective action of lactoferrin in human milk. The ferrous iron in the fortifier is changed to a ferric state in human milk, which readily binds with lactoferrin.

Concerns over the nutrient content of supplemented human milk have been expressed by many authors since the early work on premature infants from the Houston group. After noting growth failure in some premature infants, it was discovered that some mother’s milk was lower in calories than 20 kcal/oz. This has been reported by Prolacta Biologicals, which tests the protein and caloric content of all donations. This is a major issue for premature infants who have a restricted fluid intake in the early months of life. Preterm infants fed a commercially prepared, bovine-based human milk fortifier receive less protein than they need, according to Arslanoglu et al. They tested the actual nutrient intakes observed in a previously reported study, with assumed nutrient intakes based on the usual assumptions about the composition of human milk. Actual protein intakes were significantly and consistently lower than the levels assumed based on the standard protein content of human milk. Actual intakes of protein by preterm infants fed bovine-fortified human milk were significantly lower, especially after 3 weeks postpartum when the mother’s milk no longer had the higher protein content of the milk of a mother who delivers prematurely. Calorie content was not significantly lower (Figure 15-7).

The Committee on Nutrition of the AAP has outlined requirements for the premature infant who is less than 27 weeks’ gestation and less than 1000 g at birth, regarding calcium and vitamin D. Bone mineral status should be started by 4 to 5 weeks after birth. Alkaline phosphatase above 800 to 1000 IU/L or clinical evidence of fractures require radiographic evaluation. A persistent serum phosphorus concentration less than 4 mg/dL should be monitored and supplementation with phosphorus considered. Postdischarge monitoring

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**TABLE 15-12** Comparison of Selected Fortifiers for Human Milk (Prepared per 100 mL Milk)

<table>
<thead>
<tr>
<th>Fortifier</th>
<th>PrHM</th>
<th>EHMF</th>
<th>SNC</th>
<th>Eoptin</th>
<th>S-26/SMA HMF</th>
<th>FM85</th>
<th>SHMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ) (kcal)</td>
<td>298</td>
<td>357</td>
<td>319</td>
<td>357</td>
<td>361</td>
<td>374</td>
<td>357</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>3.6</td>
<td>3.6†</td>
<td>4.0</td>
<td>3.6†</td>
<td>3.65</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>7.0</td>
<td>9.7</td>
<td>7.8</td>
<td>9.8</td>
<td>9.4</td>
<td>10.6</td>
<td>8.8</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>1.8</td>
<td>2.5</td>
<td>2.0</td>
<td>2.6</td>
<td>2.8</td>
<td>2.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>22</td>
<td>112</td>
<td>97</td>
<td>72</td>
<td>112</td>
<td>73</td>
<td>139</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>14</td>
<td>59</td>
<td>50</td>
<td>48</td>
<td>59</td>
<td>48</td>
<td>81</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>2.5</td>
<td>3.5</td>
<td>6.3</td>
<td>5.3</td>
<td>4.0</td>
<td>4.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Sodium (mEq)</td>
<td>0.7</td>
<td>1.0</td>
<td>1.1</td>
<td>1.9</td>
<td>1.1</td>
<td>1.9</td>
<td>1.35</td>
</tr>
<tr>
<td>Zinc (mcg)</td>
<td>320</td>
<td>1030</td>
<td>760</td>
<td>320‡</td>
<td>450</td>
<td>320</td>
<td>1320</td>
</tr>
<tr>
<td>Copper (mcg)</td>
<td>60</td>
<td>122</td>
<td>1045</td>
<td>60‡</td>
<td>60‡</td>
<td>60‡</td>
<td>230</td>
</tr>
</tbody>
</table>

*Milupa, Friedrichdorf, Germany.
†Nestle, Vevey, Switzerland.
‡Nutrient not contained in fortifier.
A, D, E, K, B1, B2, B6, niacin, folate, pantothenate, and biotin.
EHMF, Enfamil Human Milk Fortifier (Mead Johnson Nutritional, Evansville, Ind.); HMF, human milk-fed; PrHM, preterm human milk; S-26/SMA HMF, SMA Human Milk Fortifier (Wyeth Nutritional, Philadelphia, Pa.); SHMF, Similac Human Milk Fortifier (Ross Laboratories, Columbus, Ohio); SNC, Similac Natural Care (Ross Laboratories, Columbus, Ohio) mixed 1:1 (vol: vol) with PrHM.


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Figure 15-7. WHO technical report on optimal feeding for LBW infants.
The problem of adding nutrients to mothers’ milk to meet the increased nutrient needs of premature infants, especially ELBW premature infants, has been argued. A minimum of 50 mL/kg/day of the mother’s milk is deemed necessary to maintain the protection provided by the mother’s milk. A number of investigators have explored the possibility of a fortifier made out of human milk, so the feeding would meet needs with entirely human constituents. The antibacterial activity inherent in human milk was inhibited when a bovine-based fortifier containing added iron was mixed with human milk. Chan et al. tested the same antibacterial activity when a newly derived human milk-based product became available (Prolacta Bioscience, Monrovia, Calif.). Human milk samples from 10 fully lactating mothers were utilized to test the effect on the antimicrobial activity of human milk, milk plus bovine fortifier, and milk plus human milk fortifier against Enterobacter sakazakii, Escherichia coli, Clostridium difficile, and Shigella sonnei. Human milk inhibited the growth of all the test organisms. The antibacterial activity was almost completely inhibited by the addition of the bovine-based fortifier. The activity was unaffected by the addition of human milk-based fortifier. Further studies of human milk-based fortifier (H2MF) have been conducted at national and international sites. The fortifier (H2MF) is available from Prolacta Bioscience. Preliminary results from University of Florida, Schneider’s Children’s Hospital, Baylor College of Medicine, and Yale-New Haven Medical Center were reported on 207 extremely premature infants whose mothers intended to provide their milk. The infants were randomized to one of three groups: mother’s milk plus (HUM40) or 100 mL/kg/day (HUM100); the third group received mother’s milk plus 100 mL/kg/day of the bovine-based product (Table 15-13). The groups had similar lengths of stay and rates of growth, chronic lung disease, and sepsis. However, significantly lower rates of NEC, surgical NEC, and combined deaths were observed with the human-based fortifier. Further results are available from other participating centers and all involved patients.

**Fortification of Human Milk with Human Milk**

The problem of adding nutrients to mothers’ milk to meet the increased nutrient needs of premature infants, especially ELBW premature infants, has been argued. A minimum of 50 mL/kg/day of the mother’s milk is deemed necessary to maintain the protection provided by the mother’s milk. A number of investigators have explored the possibility of a fortifier made out of human milk, so the feeding would meet needs with entirely human constituents. The antibacterial activity inherent in human milk was inhibited when a bovine-based fortifier containing added iron was mixed with human milk. Chan et al. tested the same antibacterial activity when a newly derived human milk-based product became available (Prolacta Bioscience, Monrovia, Calif.). Human milk samples from 10 fully lactating mothers were utilized to test the effect on the antimicrobial activity of human milk, milk plus bovine fortifier, and milk plus human milk fortifier against Enterobacter sakazakii, Escherichia coli, Clostridium difficile, and Shigella sonnei. Human milk inhibited the growth of all the test organisms. The antibacterial activity was almost completely inhibited by the addition of the bovine-based fortifier. The activity was unaffected by the addition of human milk-based fortifier. Further studies of human milk-based fortifier (H2MF) have been conducted at national and international sites. The fortifier (H2MF) is available from Prolacta Bioscience. Preliminary results from University of Florida, Schneider’s Children’s Hospital, Baylor College of Medicine, and Yale-New Haven Medical Center were reported on 207 extremely premature infants whose mothers intended to provide their milk. The infants were randomized to one of three groups: mother’s milk plus (HUM40) or 100 mL/kg/day (HUM100); the third group received mother’s milk plus 100 mL/kg/day of the bovine-based product (Table 15-13). The groups had similar lengths of stay and rates of growth, chronic lung disease, and sepsis. However, significantly lower rates of NEC, surgical NEC, and combined deaths were observed with the human-based fortifier. Further results are available from other participating centers and all involved patients.

**Long-Term Follow-Up of Growth Parameters in VLBW Infants**

Weight gain and growth in length and head circumference are similar in VLBW infants who are breastfed or given standard formula after discharge. BMC was also followed at 10, 16, and 25 postnatal
weeks in those graduates from the NICU who had formerly received fortified human milk. At 16 and 25 weeks, the breastfed infants had lower BMC and BMC/bone width ratio, as well as serum phosphorus concentration and higher alkaline phosphatase activity than the formula-fed group. These data suggest a need to carefully monitor this select group of VLBW infants for suboptimal bone accretion while receiving their mother’s milk. However, human milk-based fortifier should solve this problem.57

Reduced bone mineralization is common in preterm infants and has been associated with growth stunting at 18 months of age and dietary insufficiency of calcium and phosphorus. Bishop et al.16 evaluated 54 children at a mean age of 5 years who were born prematurely and had been part of a longitudinal dietary growth study. The diets included were either banked donor milk or preterm formula as a supplement to the mothers’ milk. However, human milk-based fortifier should solve this problem.57

Revised bone mineralization is common in preterm infants and has been associated with growth stunting at 18 months of age and dietary insufficiency of calcium and phosphorus. Bishop et al.16 evaluated 54 children at a mean age of 5 years who were born prematurely and had been part of a longitudinal dietary growth study. The diets included were either banked donor milk or preterm formula as a supplement to the mothers’ own milk. Increased human milk intake was strongly associated with better BMC. Those children who had the greater proportion of human milk had greater BMC than children born at term. That is, supplementing with donor milk produced a better outcome at age 5 years than supplementing with infant formula, even though the nutrient content of formula was greater. The later skeletal growth and mineralization of an infant can be calculated and feeding adjusted to add necessary mineralization with human milk-based supplements.

Iron status has also been studied in LBW infants at 6 months’ chronologic age. The incidence of iron deficiency was 86% in the breastfed group of LBW infants and only 33% in those receiving iron-fortified formula.2 The breastfed group had significantly lower serum ferritin and hemoglobin values at 4 months of age. Abouelfettoh et al.1 recommended that these special breastfed infants should receive iron from 2 months of age, because they were developed.

The AAP recommends that infants less than 1500 g birth weight receive 4 mg/kg/day of iron. There were no studies to test this until Taylor and Kennedy compared the effect of 2 mg/kg/day in a multivitamin on the hematocrit at 36 weeks’ postmenstrual age. It was concluded that this iron therapy for infants under 1500 g at birth, in addition to dietary intake, did not improve the hematocrit or the number of transfusions required compared to the controls who received no additional iron.

The feeding of these special VLBW infants after discharge and for the next 6 to 9 months is an important consideration. Breastfeeding with added supplementation has been studied. Some important results came from a randomized, double-blind trial of the effect of supplementary standard formula feedings.84 Growth and clinical status of infants receiving nutrient-enriched “postdischarge” formula were significantly affected, without vomiting, gas, or stool problems. The group receiving the enriched formula ingested volumes similar to those receiving regular formula.

A large multicenter follow-up study of more than 1000 ELBW infants who had extensive nutritional data collected was reported by Vohr et al.36 Birth weight, gestational age, intraventricular...
hemorrhage status, sepsis, bronchopulmonary dysplasia, and hospital stay were similar between those never receiving human milk and those for whom variables of socioeconomic status, race, ethnicity, educational attainment, and parity were adjusted. Effects of human milk intake on mental and motor development were significantly positive. The impact of receiving 110 mL/kg/day of human milk was correlated with a 5-point increase on the Bayley scales. Human milk feedings affect scores even when donor milk is used, compared with term formula.

Infants fed breast milk were found to have faster brainstem maturation, compared to those infants who received formula. This was determined by an analysis of the rate of maturation of the BAERs (auditory evoked response). Components of human milk improved cognitive and neurological outcomes in a series of studies on VLBW infants. Lack of breastfeeding was a major predictor of poor cognitive outcome in very preterm infants, compared to low social status and cerebral lesions by ultrasound.

The association of human milk feedings with a reduction in retinopathy of prematurity among VLBW infants compared to formula-fed infants, after adjusting for confounding variables, is significant. It can be considered as available intervention.

Box 15-12 lists recommendations modified from the work of Tsang et al. and Schanler and Hurst.

Antimicrobial Properties of Preterm Breast Milk

The infection-protective properties of human milk have been considered to be a key reason to provide human milk to high-risk infants who are prone to devastating infections such as NEC, sepsis, and meningitis and viral infections such as respiratory syncytial virus and rotavirus. The antimicrobial properties of milk produced by mothers who deliver preterm have been studied by several investigators.

The antinfective factors in preterm human colostrum were studied by Mathur et al., who compared the colostrum values of a comparable group of postpartum mothers. The mean concentrations of IgA, lysozyme, and lactoferrin were significantly higher than in full-term colostrum. IgG and IgM were similar in both groups. The absolute counts of total cells, macrophages, lymphocytes, and neutrophils were significantly higher in preterm colostrum. The mean percentage of IgA in the premature colostrum was also significantly higher. The degree of prematurity had no effect, although the study group ranged in gestation from 28 to 36 weeks (mean 33 ± 2.1 weeks), compared with the control infants, who were at 38 to 40 weeks (mean 39.1 ± 0.8 weeks). The colostrum of preterm mothers had an even greater potential for preventing infection than term colostrum and are an additional reason to begin early enteral feeds with human colostrum. Table 15-14 lists the specific antinfective components.

The cells of preterm milk were compared with those of term milk and found to be similar in number and in capacity to phagocytose and kill staphylococci. The ability of the preterm cells to produce interferon on stimulation with mitogens was marginally better than that of term cells. The cells survived 24 hours refrigerated at 4°C (39.2°F),

<table>
<thead>
<tr>
<th>BOX 15-12. Feeding Schedule for Human Milk in Low-Birth-Weight Infants</th>
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<tbody>
<tr>
<td>1. Use refrigerated milk from the preterm infant's mother when it is available and has been collected within 48 hours of feeding.</td>
</tr>
<tr>
<td>2. When fresh milk is not available, use frozen human milk from the infant's mother. This milk should be provided in the sequence that it was collected to provide the greatest nutritional benefit.</td>
</tr>
<tr>
<td>3. When the preterm infant is tolerating human milk at greater than 100 mL/kg/day, supplementation using a human milk fortifier is started.</td>
</tr>
<tr>
<td>a. If it requires more than 1 week to reach 100 mL/kg/day intake, fortifier is added even though volume tolerance has not been achieved.</td>
</tr>
<tr>
<td>b. Milk volumes should increase to 150 but not exceed 200 mL/kg/day. Weight gain is optimally 15 g/kg/day and length increment 1 cm/wk. Urinary excretion of calcium should be less than 6 mg/kg/day and phosphorus greater than 4 mg/kg/day.</td>
</tr>
<tr>
<td>c. If weight gain is less than 15 g/kg/day, hind milk is used if mother's milk production exceeds the infant's requirements by 30%.</td>
</tr>
<tr>
<td>4. If the mother's milk supply is inadequate to meet her infant's feeding needs, an infant formula designed for preterm feeding is used as described.</td>
</tr>
<tr>
<td>5. Fortification of human milk is recommended until the infant is taking all feedings from the breast directly or weighs 1800 to 2000 g, depending on nursery policy on infant discharge weight. During the transition from feeding human milk by gavage or bottle and nipple to feeding at the breast, only those feedings given by gavage or bottle require fortification.</td>
</tr>
<tr>
<td>6. Multivitamin supplementation is started once feeding tolerance has been established. This supplementation varies depending on the composition of human milk fortifier.</td>
</tr>
<tr>
<td>7. Iron supplementation providing 2 mg/kg/day is started by the time the infant has doubled birth weight.</td>
</tr>
</tbody>
</table>
at 48 hours, cell number, but not function, was reduced. Passing the milk through a feeding tube did not diminish the number or function of the cells. The levels of lactoferrin and lysozyme were greater in preterm milk than in term milk from the 2nd to 12th weeks postpartum.49

Secretory IgA is the predominant form of IgA, and values increased from the 6th to 12th weeks in preterm milk. The increase in IgA is not dependent on method of collection, rate of flow, or time of day, but the concentration varied inversely with the milk volume. Thus some investigators think that total production of IgA in 24 hours is comparable for the two groups.26 Preterm infants (31 to 36 weeks’ gestation) were fed human milk and compared with a matched group of premature infants fed infant formula. The serum levels of IgA at 9 to 13 weeks were higher in the human milk-fed infants.121 Those infants who received at least 60% of their own mother’s milk had higher IgA levels at 3 weeks of age than those receiving less than 30% of the feedings from their mother’s milk.

Serum IgG levels were higher in the breast milk group, and serum IgM levels were similar in the two feeding groups. Samples of precolostrum collected from undelivered mothers were assayed and found to contain equal or greater amounts of IgA, IgG, IgM, lactoferrin, and lysozyme as mature colostrum.79

When the impact on actual prevention of infection among premature infants is reviewed, significantly less infection is found in infants receiving human milk compared with those receiving formula (9 of 32 receiving breast milk, 28.1%; 24 of 38 receiving formula, 63.3%). In a prospective evaluation of the antiinfective property of varying quantities of expressed human milk for high-risk LBW infants, infections were found to be significantly less frequent in the groups that received human milk.128 This has been documented for decades.

NEC is a major cause of morbidity and death in preterm and other high-risk infants. The absolute cause has eluded neonatologists, although many theories have been put forth and associations suggested86 (Box 15-13). When researchers investigate its prevention, the role of human milk is prominent. In a large prospective multicenter study of 926 infants, 51 infants (5.5%) developed NEC. The mortality rate was 26% (Figure 15-8). In exclusively formula-fed infants, the incidence was 6 to 10

### TABLE 15-14
Comparison of Antiinfective Properties in Colostrum of Preterm Versus Term Mothers

<table>
<thead>
<tr>
<th></th>
<th>Preterm Colostrum</th>
<th>Term Colostrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total protein (g/L)</td>
<td>0.43 ± 1.3</td>
<td>0.31 ± 0.05</td>
</tr>
<tr>
<td>IgA (mg/g protein)</td>
<td>310.5 ± 70</td>
<td>168.2 ± 21</td>
</tr>
<tr>
<td>IgG (mg/g protein)</td>
<td>7.6 ± 3.9</td>
<td>8.4 ± 1</td>
</tr>
<tr>
<td>IgM (mg/g protein)</td>
<td>39.6 ± 23</td>
<td>36.1 ± 16</td>
</tr>
<tr>
<td>Lysozyme (mg/g protein)</td>
<td>1.5 ± 0.5</td>
<td>1.1 ± 0.3</td>
</tr>
<tr>
<td>Lactoferrin (mg/g protein)</td>
<td>165 ± 37</td>
<td>102 ± 25</td>
</tr>
<tr>
<td>Total cells (mL(^{-3}))</td>
<td>6794 ± 1946</td>
<td>3064 ± 424</td>
</tr>
<tr>
<td>Macrophages</td>
<td>4041 ± 1420</td>
<td>1597 ± 303</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>1850 ± 543</td>
<td>954 ± 143</td>
</tr>
<tr>
<td>Neutrophils</td>
<td>842 ± 404</td>
<td>512 ± 178</td>
</tr>
</tbody>
</table>


### BOX 15-13. Issues and Risk Factors Associated with Enteral (Oral) Intake and the Causation of NEC

- Initiation of oral fluids too early
- Excessively rapid increases in volume or concentration of oral fluids
- Nutritional and nonnutritive sucking
- Hyperosmolar fluids
- Formula compared with human breast milk
- Feeding intolerance (cannot advance, residuals)
- Transpyloric compared with gastric gavage
- Bolus compared with continuous gavage
- Malabsorption of carbohydrates (lactose)—low luminal pH and ischemia
- Malabsorption of protein—low luminal pH
- Differences in gut bacterial or viral flora (epidemic NEC)
- Labile or inadequate gut blood flow (e.g., diving reflex, apnea, asphyxia)
- Increased work of gut muscle (increased oxygen consumption) because of gut motility

NEC, necrotizing enterocolitis.

![Figure 15-8. Effect of gestational age and human milk versus formula feeding on necrotizing enterocolitis (NEC). In infants fed formula, incidence of NEC decreases after 27 weeks and then remains the same. In infants fed human milk, incidence of NEC continues to decline. (From Lucas A, Cole Tj: Breast milk and neonatal necrotising enterocolitis, Lancet 336:1519, 1990.)](image-url)
times more common than in those who received human milk exclusively. In those who received human milk and formula, it was three times more common than in the exclusively breastfed group. Pasteurization did not diminish the effect of human milk in these studies.\(^8\)\(^6\),\(^1\)\(^2\)\(^8\) The comparison was more dramatic at more than 30 weeks' gestation, when formula-fed infants were 20 times more apt to develop NEC than human milk-fed infants. Early enteral feeding did not change the risk in those receiving breast milk, whereas delaying feedings of formula did lower the rate of NEC.\(^7\)\(^7\) In a study of the prevention of NEC in LBW infants, with feedings higher in IgA and IgG, none of the infants in the study group or the breastfeeding comparison group developed NEC. Six cases developed among the 91 infants in the untreated group.\(^3\)\(^7\)

It is notable that human milk also affects the incidence of other infections in the premature infant, including upper respiratory infections (Figure 15-9).

When stool colonization and incidence of sepsis in human milk-fed and formula-fed infants were studied in an intensive care nursery, a protective effect was seen against nosocomial sepsis, which was unrelated to GI flora. It was concluded that human milk feeding is associated with a significantly decreased incidence of nosocomially acquired sepsis that cannot be explained by the effect of human milk feeding on the GI flora. In a retrospective review of a group of premature infants fed fortified human milk, a 26% incidence of infection was seen. Those fed all formula had an infection rate of 49%.\(^8\)\(^7\) Infants fed predominantly human milk (i.e., more than 50 mL/kg/day) had significantly less late-onset sepsis and NEC and shorter hospital stays compared with those receiving preterm formula. This dose of at least 50 mL/kg/day as protective was confirmed in another study.\(^4\)\(^7\) The greater the dose of human milk, the greater the effect was.\(^1\)\(^0\)\(^2\) A large multicenter study in Norway reported that early feeding of extremely premature infants with human milk and subsequent fortified human milk was associated with significantly less late-onset sepsis and improved survival. Probiotics for the prevention of NEC in preterm infants were subjected to a Cochrane Review. Milk feeding and bacterial growth play a role. Dietary supplements containing potentially beneficial bacteria reduce the occurrence of NEC and death in premature infants under 1500 g. However, this review did not find support for probiotics in infants under 1000 g at birth.

The impact of postnatal antibiotics on the preterm intestinal microbiome was studied in a group of premature infants between 24 and 31 weeks' gestation. They received at least 50% or more of breast milk per day and had received only 2 days of antibiotics or 7 days of antibiotics. The results showed that antibiotics disturbed the acquisition of bacteria in the gut.

Dysbiosis in the first week of life is related to later onset of NEC. Neuregulin-4 (NRG4) is an ErbB4-specific ligand that has been shown to help epithelial cells survive. Epithelial cell death is a major pathologic feature of NEC. Studies of ErbB4, which is found in the developing human intestine, as well as NRG4 (its receptor), which is found in human milk, suggest that NRG4-ErbB4 signaling may be a special pathway for therapeutic intervention to prevent NEC. Perhaps this explains the role of human milk.

An exclusively human milk-based diet is associated with a lower rate of NEC than a diet of human milk and bovine milk-based product. This was demonstrated by a multicenter study involving 207 infants.\(^1\)\(^3\)\(^0\) A human milk diet with human milk-based fortification allows the neonatologist to feed premature infants on totally human milk, meeting nutritional needs and preventing NEC.

NEC has historically had a variable rate in nurseries but the etiology has remained elusive. Patel et al. developed an NEC QI initiative when their NEC rates went from 4% in 2005 to 2006 to

![Figure 15-9. Effect of human milk on upper respiratory infection symptoms in premature infants during their first year. BW, Birth weight; DC, discharge; GA, gestational age. (From Blaymore Bier J-A, Oliver T, Ferguson A, et al.: Human milk reduces outpatient upper respiratory symptoms in premature infants during their first year of life, J Perinatol 22:354, 2002.)](attachment:Figure15.9.png)
10% in 2007 to 2008. A change in feeding protocol had no effect. However, NEC rates did change significantly when nasogastric tube management was redesigned to include more frequent NG tube changes, as well as reeducation of parents about pump cleaning and storage. This project demonstrated the need for ongoing evaluation of routines and protocols.

Changing to an exclusively human milk diet for infants under 33 weeks' gestational age was tested to reduce the incidence of NEC. The diet was limited to the mother's milk and human milk-based fortifier and excluded any trace of bovine protein. It was compared to the incidence of NEC during the years that formula was used, and human milk was fortified with bovine-based supplements. It reduced the incidence of NEC from 3.4% down to 1%.59

When donor milk was compared to the mother's own milk, it provided no short-term advantage in infection rates over premature formula. The mother's own milk appears to protect the premature infant from infectious morbidity (Table 15-15). Further investigation into pasteurization techniques is important. High-temperature short-time techniques appear to protect more infectious protection properties than the Holter technique.

In South Africa, where mothers remain with and help care for their premature babies, a study compared feeding an infant its own mother's milk with feeding pooled pasteurized breast milk. Birth weights were between 1000 and 1500 g. Babies who were not on ventilators began feedings by 96 hours of age. Weight gain was significantly greater using untreated mother's milk, both for regaining birth weight and reaching 1800 g sooner. Both SGA and AGA infants did better on their own mothers' milk. This diet decreased hospital stays and decreased hospital-acquired infection. The authors attribute the advantages to the milk being fed fresh, with early initiation of feeding at the breast, compared to the pasteurization of the bank milk.127

### Kangaroo Care and Skin-to-Skin Care

Kangaroo care and skin-to-skin care are important constituents of the support program for milk production by mothers who are pumping to produce milk, without the benefit of the infant suckling at the breast. The conduction of heat from parent to infant is sufficiently high to compensate for the increase in evaporative and conductive heat loss.

Extensive studies have been carried out to substantiate not only the safety, but also the benefits of the skin-to-skin contact for fragile premature infants, including micropreterm, at 24 weeks gestation. All the reports recommend initiation directly after birth, even when the infant requires ventilator care. Stability of heart rate, respirations, and oxygen saturation during skin-to-skin care is remarkably calm.42 This technique was started initially in resource-poor countries but has been so effective in calming stabilizing infants that it has become universal. It is particularly effective when the mother is initiating breastfeeding and pumping to start milk production. The Kangaroo Mother Care (KMC) method is a standardized, protocol-based system for preterm and/or LBW infants. The cardiorespiratory instability seen in separated infants during the first hours is consistent with the mammalian "protest-despair" biology and with a hyperarousal and dissociation response.11 The aim is to empower the mother (and father, if possible) by gradually transferring the skills and responsibility for becoming the child's primary caregiver. It has been formally organized internationally.18,112

Skin to skin has been evaluated by utilizing a number of measurements to demonstrate the physiologic benefits of this close contact with a parent for premature infants. Measurements of salivary cortisol showed that the infant's cortisol reactivity decreased in response to handling. In addition, skin to skin improves the symmetry between the mother's and infant's salivary cortisol levels.103 It also helps

<table>
<thead>
<tr>
<th>TABLE 15-15</th>
<th>Effects of Refrigeration Versus Freezing on Pasturized STHT Milk</th>
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</thead>
<tbody>
<tr>
<td>Component</td>
<td>Refrigerated</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>40%</td>
</tr>
<tr>
<td>Lysozyme</td>
<td>40%</td>
</tr>
<tr>
<td>Lactoferrin</td>
<td>30%</td>
</tr>
<tr>
<td>Lipase</td>
<td>25%</td>
</tr>
<tr>
<td>Secretory IgA</td>
<td>40%</td>
</tr>
<tr>
<td>Specific IgH</td>
<td>Variable</td>
</tr>
</tbody>
</table>

STHT, Short time high temperature.

allay the father’s fears of spousal relationship problems, as he feels abandoned when the mother is totally consumed by the infant’s needs. Breastfeeding was more common and more exclusive in the skin-to-skin group than in the control group at 1 and 4 months (all 18 dyads vs. 16 of 19).103

KANGAROO CARE

Kangaroo care was first introduced in 1979 in a hospital in Bogota, Colombia, because of a shortage of incubators, high death rate from infection, and abandonment of premature infants by their mothers. Since that time, many investigators have carefully evaluated kangaroo care and found it to be beneficial to mother and infant.71 Dressed only in a diaper, an infant is held skin to skin against the mother’s chest between her breasts, snug inside the mother’s clothing, often for hours. The father can do the same. Many advantages have been noted, including more stable respirations, heart rates, and temperatures. The infants spend less time crying and more time in a quiet, alert state and deep sleep.82 Some studies suggest better weight gain and earlier discharge. Hurst et al.61 also reported an increase in milk volume during pumping (Figure 15-10).

Mothers who give kangaroo care breastfeed longer and more frequently. They also report greater confidence in caring for their fragile infant than those who experience traditional care.6 NICU nurseries should encourage kangaroo care. All parents should be assisted in providing it whenever they are in the nursery to benefit both the mother and the infant. This skin-to-skin contact enhances milk production, especially when the infant is too immature to suckle.

Milk Production by Mothers of Premature Infants

The Committee on Nutrition at the AAP28 published a handbook in 2014 that included a section on nutritional needs of LBW infants. They suggest...
that the mother’s own milk and new special formulas for those babies who need breast milk substitutes are promising alternatives.

A joint effort of the AAP Committee on the Fetus and Newborn and the American College of Obstetricians and Gynecologists Committee on Obstetric Practice states that “human milk has a number of special features that make its use desirable in feeding preterm babies.”

The production of milk by a mother who is not actively nursing her infant, as is frequently the case in LBW infants and other neonates in NICUs, is a challenge to the resources of the NICU and the postpartum staff. Insufficient milk production is a common problem that becomes more critical as time passes. As production continues to drop, an infant’s needs increase. Evaluation of various protocols has been undertaken by investigators who looked at onset of pumping postpartum, frequency of pumping, and duration in total minutes per day and length of time when no pumping occurred.

Hopkinson et al. enrolled 32 healthy mothers, 19 of whom had no previous breastfeeding experience, into a study protocol. Their infants were 28 to 30 weeks’ gestation. All of the mothers initiated pumping between days 2 and 6. The day of initiation was correlated with the volume of milk at 2 weeks, but not at 4 weeks, with mothers who had nursed previously and initiated pumping sooner. Parity, gravidity, age, and previous nursing experience were not correlated with volumes at 2 weeks. Parity and previous nursing experience were associated with milk volume at 4 weeks, with multiparas producing 60% greater volumes. The investigators found no significant relationship between 24-hour milk volume and frequency, duration, or maximal night interval. The change in milk volume from 2 to 4 weeks was correlated with frequency of pumping but not to maximal night intervals. The range in number of pumpings per day was four to nine. The authors concluded that optimal milk production occurs with at least five expressions per day and pumping durations that exceed 100 min/day.

The frequency of milk expression was evaluated by de Carvalho et al. in a crossover design study of 25 mothers who delivered at 28 to 37 weeks’ gestation. Frequent expression of milk was significantly associated with greater milk production (342 ± 229 mL) than with infrequent expression (221 ± 141 mL). They compared three or fewer pumpings per day to four or more. The mean numbers were 2.4 versus 5.7, neither equaling the frequency that a mother would usually feed her infant in the first few weeks.

Minimum frequency and duration figures have been provided. However, it is advisable to increase the frequency of pumping as the need for production increases and as the time for discharge and feeding the infant exclusivity at the breast approaches. Consideration for increasing nighttime pumpings is also important as discharge approaches. Some mothers experience a dread of the pump when demands are increased for “more milk production.” The management of the mother producing milk for her hospitalized infant should be coordinated by a neonatologist and a primary care physician. She should be assisted by a primary care nurse and the unit’s lactation coordinator and lactation consultants to maximize support and minimize stress.

Peer counselors have become important members of the lactation support teams in the NICU, as they have been in birth centers and in the community. Peer support was originated by the LaLeche League. Anthropologist Dana Raphael coined the expression “a friend from across the street.” Health departments and WIC programs have developed peer counselor programs, where women (peers) with breastfeeding experience are trained to provide support and counsel but not practice medicine. Very successful programs have been developed in NICUs. A combination of a lactation consultant and a peer counselor provides the most effective breastfeeding support in the NICU (see Figure 15-11 and Chapter 22).

The NICU at Rush University Medical Center developed a lactation support program that included peer counselors who were former NICU parents. They work directly with NICU mothers and babies, in collaboration with the NICU nurses, to promote successful breastfeeding. The health care providers in a study of 17 university NICUs thought the peer counselors improved the care of the infants by empowering the mothers to provide milk and modeling good infant care for the mothers.

When the physiology of lactation is applied to the practical management of inducing milk supply without the benefit of an infant’s participation, it is apparent that mimicking natural breastfeeding is more effective. The breast can be prepared with massage and manual expression. Although some women succeed with manual expression alone, it is rare, and a good pump should be recommended. None of the hand pumps can truly duplicate the milking action of the infant, and all are essentially vacuum extractors. They should be used only as a stopgap measure when the electric pump is unavailable (see Chapter 21). A pump that can be used on both breasts simultaneously saves time and generates higher levels of prolactin. These pumps also generate a greater total milk volume than pumping each breast separately for the same length of
time. Subsequent studies have produced variable observations. Groh-Wargo et al. studied 32 women who were randomly assigned to single or double pumping for 6 weeks. No difference was found in prolactin levels or total volume of milk produced by these investigations, although the time-saving effect was considered important.

Jones et al. reported a randomized, controlled trial that was designed to compare methods of milk expression after preterm delivery. It involved 36 women: 19 used simultaneous pumping and 17 used sequential pumping by random assignment. A crossover design was used to evaluate the effect of breast massage on milk volume and fat content (estimated by creamatocrit). The authors reported that the results were unequivocal, showing that pumping both breasts simultaneously produced more milk—125.1 g with massage and 87.7 g without. This was compared with sequential volumes of 78.7 g with massage and 51.3 g without.

Pumping should be initiated as soon as a mother’s condition permits. Offering this opportunity to the mother should be part of the supportive care offered by postpartum staff. All the points of preparation for pumping should be included: comfortable position, tranquil atmosphere, preparation of the breast with gentle stroking and warmth, massage during pumping, confidence, and reassurance from the staff. The obstetrician is in an important position to initiate the offer to pump, because he or she should know whether or not the mother intends to breastfeed from conversations during the mother’s prenatal care. The mother may not know it is appropriate to ask for a pump. Providing knowledgeable, accurate, consistent, and sensitive support should be the rule in every perinatal center, especially for mothers of high-risk infants who choose to breastfeed. The opportunity to pump should be offered to all women, regardless of previous feeding choice. Often a mother changes her mind when her infant is high risk and would receive many additional benefits from her milk.

Providing an appropriate room for pumping after the mother has been discharged is critical to individual success and is an expression of commitment to

Figure 15-11. Breastfeeding outcomes during hospital stay by lactation staff type. χ² tests for overall differences within each outcome were significant at p < 0.001. Breastfeeding outcomes were classified as any maternal breast milk (infant receiving any maternal breast milk via direct breastfeeding and/or pumping regardless of supplementation with formula), exclusive breast milk (infant receiving exclusive maternal milk via direct breastfeeding and/or pumping without any formula supplementation), and any direct breastfeeding during NICU admission and at discharge (infant fed directly at the breast for at least one feeding with or without subsequent formula supplementation) during NICU admission and at discharge. Estimates do not include exclusive donor milk. (From Oza-Frank R, Bhatia A, Smith C: Combined peer counselor and lactation consultant support increases breastfeeding in the NICU, Breastfeed Med 8:509, 2013.)
breastfeeding by the NICU. This room should be clean, bright, and cheerful and accommodate more than one mother and companion at a time, unless several rooms are available. It should have a sink for washing hands and storage for equipment and supplies. A nurse call button or other alarm system is also essential. Additional features are soft music, a telephone, and reading material. The hospital should have a supply of approved electric pumps and individual disposable attachment packets for each mother. A place should be available to store her properly labeled and dated milk in a freezer or refrigerator. Sterile storage containers should be readily available.

A mother should be encouraged to rent a pump for home use and around-the-clock pumping. These are available from medical supply stores, pharmacies, home care services, hospitals, and some lactation consultants. Insurance companies reimburse for the cost of the rental when the milk is prescribed for a high-risk infant. A neonatologist can provide an appropriate letter of support. The hospital support staff who are coordinating the mother’s care or the NICU staff should be sure that the mother understands how to use the equipment effectively. Ideally, NICUs have at least one staff member who is a licensed, certified lactation consultant who will coordinate this effort under the direction of the obstetrician, pediatrician, and neonatologist. One lactation consultant per 15 infants in the NICU is ideal. The mother should not be subjected to pressures of pump equipment entrepreneurs and unsolicited advice. The best remedy is for the NICU to provide on-staff, up-to-date experience and support to the mother in her efforts to provide milk and breastfeed her high-risk infant. Box 15-16 outlines key strategies for successful pumping when an infant is unable to suckle the breast. All neonatal nurses should be familiar with the available pumps and their use and be supportive of mothers who are pumping.

Who Produces Milk for LBW or SGA Infants?

Nationwide, mothers who give birth to infants who are admitted to special care nurseries are less likely to initiate lactation than mothers of healthy term infants, according to Meier. The profile of mothers who give birth to these high-risk infants includes a higher percentage of low-income, low-education, young mothers, who do not breastfeed in great numbers. Postpartum and NICU staff should work to encourage these women to initiate lactation.

Maternal choice to breastfeed or provide milk for an LBW infant is influenced by many factors beyond those that affect most feeding decisions of normal full-term infants. Lucas et al. sought to answer two major questions in a study of 925 mother-infant pairs in five hospitals. Do health care professionals in neonatal units exert a major influence on a mother’s feeding preference and availability of her milk for her infant? Are there population differences between mothers who do and do not provide their milk? In this study of five centers, the demographic characteristics of the mother were important, not those of the staff. This study did not look at success rates, however.

Mothers in a study by Verronen had delivered infants at a mean of 31 weeks gestation; the infants weighed less than 1850 g with a mean of 1370 g. More educated mothers provided their milk (98%) than uneducated (40%). Factors of higher socioeconomic class, lower parity or fewer living children, being married, and being older than 20 years of age were associated with providing milk. Boys were more apt to receive mother’s milk, as shown in other studies. Birth weight and extreme immaturity were not a determinant, nor was transfer of the infant to another center. The Rush Mother’s Milk Club, which is a breastfeeding intervention for mothers of VLBW infants in Chicago, was developed and directed by Meier and colleagues. In the 52-bed urban NICU, the staff provided facilitated learning. Transportation was provided for mothers from home, as well as a weekly interactive social luncheon. They employ five peer counselors and provide a 24-hour, toll-free pager information line. The peer counselors also contact mothers at home. Low milk supply is aggressively managed with record keeping, encouragement, and counseling. The lactation initiation rate among these predominately low-income African-American women was

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<td>1. Begin as soon after delivery as maternal condition permits.</td>
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<td>2. Initiate use of electric pump while in hospital.</td>
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<td>3. Begin slowly, increasing time over first week.</td>
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<td>4. Pump on more regular basis as soon as engorgement is evident.</td>
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<td>5. Pump at least five times in 24 hours.</td>
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<td>6. Allow a rest period for uninterrupted sleep of at least 6 hours.</td>
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<td>7. Pump a total of at least 100 min/day.</td>
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<td>8. Use “double” pump to pump both breasts simultaneously, which can cut total time proportionately.</td>
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<td>9. Prepare breast with warm soaks, gentle stroking, and light massage to maximize production of milk.</td>
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<td>10. Encourage skin-to-skin care (kangaroo care).</td>
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72.9%. Exclusive mother’s milk was attained by 57.2% and some mother’s milk by 72.5%. Skinto-skin and kangaroo care are important features of this program and many others.

Feeding the Near-Term Infant (35 to 37 Weeks’ Gestation) at the Breast

Near-term infants (i.e., 35 0/7 weeks to 36 6/7 weeks) may be nursed at the breast if otherwise stable. Breastfeeding should be initiated by one hour of age if mother and infant are stable. Health care professionals should monitor to ensure that frequent ongoing feedings are occurring “on demand” at least 10-12 times a day. Communication among staff and with the parents is key to success. Involvement of lactation-trained staff who are also skilled neonatal nurses mitigates confusion and conflicting messages to the family. Particular care should be given to assist a mother in getting the infant to suckle, especially if the breast and nipples are large or engorged. Weight should be followed closely to prevent excessive weight loss. Infants who receive sugar water and formula supplements lose more weight than those who are nursed frequently at the breast without supplementation. If breastfeeding is going well, the infant could be discharged with the mother from the hospital as soon as the infant begins to gain substantially, with close follow-up at home. Poor weight gain, less than 20 g/day, is usually the result of inadequate intake. Average weight gain should be 26 to 31 g/day (see Appendix J). A mother may need to pump between feedings if the infant does not stimulate the breasts adequately. The milk can be provided by cup or lactation aide device (see Appendix J and Figure 14-10). Difficulties with latch should be investigated with a careful examination of the infant’s mouth and the mother’s breast and nipples. Before discharge, the physician, as well as the nurse, should observe the dyad. If a mother is a low producer, galactagogues can be considered. (See Chapter 11 and Protocol #9 in Appendix J.) Follow-up should include frequent weighings and growth measurements (length and head circumference should increase approximately 0.5 cm/wk). Home visits or office checks are crucial to monitor progress. An extensive review of practice guidelines for the care of the late preterm infant has been prepared by the National Perinatal Association.

Premature Infants of 28 6/7 Weeks to 32 6/7 Weeks

Infants of gestational age more than 28 weeks but less than 35 weeks are frequently breastfed in NICUs, because the value of human milk has been recognized by most neonatologists.

Feeding at the breast when an infant is less than 1500 g is considered too strenuous by many neonatologists, even though it has been proved that it takes less energy and less impact on vital signs to breastfeed than bottle feed. When the feeding of infants of less than 1500 g was examined, however, the growth of those fed at the breast was comparable with that of matched control infants fed expressed human milk by bottle. Breastfeeding was started when sucking movements were observed. Initially, they received supplementary human milk by tube plus 800 units of vitamin D and 60 mg of vitamin C daily. Unrestricted visiting of parents to the neonatal unit, an optimistic and knowledgeable attitude of the nursing staff toward breastfeeding, and the avoidance of a bottle for the infants are important to success. Encouraging the expression of milk by the mothers early in the postpartum period is essential. The main deterrent to successful breastfeeding was lack of maternal interest and commitment.

Blaymore Bier et al. undertook a clinical study of breast feeding and bottle feedings in ELBW infants (birth weight 800 g or less) when they were considered ready to bottle feed. This was at a mean age of 35 weeks since conception (corrected gestational age). One breastfeeding and one bottle feeding were monitored each day for 10 days. Prefeeding and postfeeding weights, oxygen saturation, respiratory and heart rates, and axillary temperature were recorded. Higher oxygen saturation and higher temperatures during breastfeeding and less likelihood of desaturation below 90% were noted in the breastfed infants. The weights reflecting intake were higher in the bottle-fed infants. The authors concluded that it was physiologically safe and less stressful for infants to breastfeed. The lower intake requires monitoring, however.

The ontogenic and temporal organization of nonnutritive sucking during active sleep was studied by Hack et al. in preterm infants. One of the six infants studied had recognizable rhythmic sucking bursts at 28 weeks, and all had bursts by 31 to 32 weeks. The number of bursts increased and the interval between bursts decreased as the infants matured, with the earliest indications of intrinsic rhythm beginning at 30 weeks.

Nonnutritive sucking has become a subject of controversy in NICUs. Allowing premature infants to suck on a pacifier during gavage feedings was initially reported to be associated with increased weight gain and shorter hospitalization. When nutrient intake and other parameters were controlled, however, no advantages to nonnutritive sucking were observed in somatic growth, serum proteins, energy absorption, or feeding tolerance, nor was any increase in trophic hormones or growth
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Promoters seen. Infants have been observed to have transcutaneous oxygen saturation measurements increase by 3% to 4% during nonnutritive sucking. Nonnutritive sucking does not appear to carry risk for infants destined for further bottle feeding. However, it should be avoided for infants destined to breastfeed, in order to avoid interference with normal sucking. Unfortunately, most studies have been done with bottles.

Of greater significance is the value of having these infants placed at the “emptied” breast during gavage tube feedings. When Narayanan et al. studied this practice, they found no change in weight gain or length of hospital stay. The practice did, however, result in more successful and longer duration of breastfeeding after discharge. This technique was originally designed in our nursery to improve the mother’s milk production and encourage mothers who were becoming discouraged. As the infant matures and begins swallowing with sucking, it becomes unnecessary to pump the breast “empty” before presenting it to the infant. This is because any milk provided could be suckled and swallowed. Suckling at the breast initiates a peristaltic action that also triggers swallowing and the physiologic response of the entire GI tract (see Chapter 8). Suckling the breast also improves the mother’s success when pumping. Readiness to wean from tube feedings to oral feeding is poorly defined and based on observations utilizing a bottle and/or a pacifier. Stable cardiopulmonary status at 33 to 34 weeks is associated with sucking patterns that resemble term infants (i.e., rhythmic alteration of suction and expression and the positive pressure generated by compression). Mature sucking pattern is not necessary for safe, successful feeding at the breast. Infants can feed orally without suction. The undulating motion of the tongue does trigger let-down and the swallowing of fluid. An infant’s behavioral state and organization during feeding, as well as the nursery environment (especially light and sound), and a caretaker’s approach to oral feeding all affect an infant’s performance. This is another point supportive of early breastfeeding. Avoidance of bottles during the establishment of breastfeeding in premature infants has been evaluated in a Cochrane Review. Small premature infants begin with tube feedings of their mother’s milk. As they mature, they have breastfeedings added. But in many nurseries, the bottle with the mother’s milk is introduced. Its impact on successful breastfeeding is challenged. Five studies of 543 infants were included in a Cochrane Review by Collins et al. Four of the studies substituted cup feeding when mother was not available to breastfeed. The cup feedings increased the probability of successful breastfeeding and continuation of breastfeeding. Cup feedings, however, prolonged hospitalizations by 10 days. Noncompliance was an issue as well. A study in Egypt, after this review, reported 30 cup-fed premature infants compared with 30 bottle-fed infants who were breastfed on discharge because mothers did not provide their milk or breastfeed before discharge. The cup-fed infants breastfed for longer durations and in greater numbers. The crucial role of adequate nutrition to brain growth, especially in the premature infant, is generally acknowledged. Although nutrition may not overcome all the problems of extreme prematurity and its impact on the immature brain, it does reduce infections and NEC and has immunomodulatory properties when it includes over 50% human milk. The impact of human milk constituents on the white matter and its development is remarkable. This is being attributed to the gut-immune brain axis. The nutritional adjustments to use human milk and human milk supplements are considered safe, inexpensive, cause few side effects, and are easily implemented.

Breastfeeding the Extremely Premature Infant

Evaluations of feeding strategies are rarely conducted or published, in spite of rigid protocols in some nurseries. Early initiation of feedings has been thought valuable and safe. In a study of 171 premature infants between 26 and 30 weeks’ gestation, Schanler et al. tested the validity of GI priming and continuous infusion, versus intermittent bolus tube feeding with human milk or preterm formula. Infants were randomized to four treatment combinations in a balanced two-way design. Investigators compared the presence or absence of GI priming for 10 days and continuous infusion versus intermittent bolus tube feeding. Time to full feeding was similar in all groups. GI priming had no adverse effects and improved calcium/phosphorus retention and shorter intentional transient times. Bolus feeding was associated with less feeding intolerance and greater weight gain than the continuous method. The more human milk fed, the lower the morbidity rate was. The authors concluded that early GI priming with human milk and bolus feedings provided the best advantage for premature infants. Very preterm infants, born at 26 to 31 weeks’ gestation, have the capacity for the early development of oral motor competence that is sufficient for establishment of full breastfeeding at a low postmenstrual age, according to Nyqvist. Using the Preterm Infant Breastfeeding Behavior Scale (Table 15-16), designed for use by mothers and professionals to observe levels of competence in oral motor behavior during breastfeeding, the author studied 15 infants born at 26 to 31 weeks’
gestational age. The author made daily assessments. Semidemand feeding was utilized with a prescribed total daily income volume. Breastfeeding was initiated at 29 weeks. Rooting, efficient areolar grasp, and repeated short sucking bursts were noted at 29 weeks. At 31 weeks, long sucking bursts and repeated swallowing were observed. Sucking rates ranged from 5 to 24 with a median of 17. Full breastfeeding was reached between 32 and 38 weeks with a median of 35 weeks. Weight gain was described as adequate. Alternative techniques were described in a report from a nursery in Brazil, where they placed infants in groups trying techniques of relactation, translactation, and breast-orogastric tubes. They described 432 infants who, at discharge, were breastfeeding 85%, 100%, and 100% in each group, respectively. All attained good weight gain, with only 1.6% feeding-related problems. The definition of relactation and translactation resembles other nurseries’ use of lactation aide devices for additional nutrition.

Transpyloric tube feeding in VLBW infants with suspected gastroesophageal reflux has been used successfully by Malcolm et al. They described 72 VLBW infants with a median birth weight of 870 g (a range of 365 to 1435 g) and a gestational age of 26 weeks (range 23 to 31 weeks) who received transpyloric feedings. They observed a reduction in apneic episodes and a decrease in bradycardia. Five infants developed NEC, none of whom were receiving human milk. The authors concluded that transpyloric feedings, when limited to human milk, may safely reduce episodes of apnea and bradycardia in preterm infants suspected of gastroesophageal reflux. They suggest confirmation of this work in other NICUs, with the potential of changing hospital procedures.

**SGA Infants**

Infants who are below the 10th percentile (or 2 SDs) in weight for their gestational age are termed SGA. These infants may also be shorter in length and have smaller heads, depending on when in gestational life the insult to their growth occurred. The more general the growth failure is, the earlier the intrauterine effect appears. For example, rubella in the first trimester causes total growth retardation, whereas hypertension in the mother in the third trimester predominantly affects weight. The more profound the growth retardation is, the more difficult the nutritional problems are.

SGA infants are prone to be hypocalcemic; however, if they can be provided with adequate breast milk early, this complication may be avoided. This is because the calcium/phosphorus ratio is more physiologic in human milk than formula. Other problems, including hypothermia and hypoglycemia, which lead to a vicious circle of acidosis and associated problems, can be triggered by...
unmonitored exposure of an infant to thermal stress in the first hours of life and failure to identify the hypoglycemia early. Hypoglycemia in an SGA infant cannot be ignored. The potential exists for significant stress to the nervous system, which can result in seizures that require aggressive therapy and a detailed diagnostic workup. SGA infants lack glycogen stores, so they cannot raise their own blood sugar level by mobilizing stores.

Using human α-lactalbumin as a marker protein, Schanler et al. demonstrated that SGA infants with intrauterine growth restriction have delayed postnatal decrease in macromolecular absorption and delayed intestinal maturation, even compared with premature infants of the same weight. Their management demands special care. The enzymes in human milk can facilitate catch-up maturation of the intestinal tract.

Thus perinatal nursery staff may appear to be obstructive to breastfeeding when they hover over this infant or even insist on transfer to the nursery. Initial breastfeeding at delivery is permissible; however, adequate external heat must be provided. Testing the blood sugar should be performed in the delivery room recovery area. The infant should be sent to the nursery if hypoglycemia or hypothermia cannot be controlled. Frequent breastfeeding can be initiated unless the blood sugar level is too low (less than 30 mg/dL) or unresponsive to oral treatment. It may not be possible for even an actively lactating multipara to sustain an SGA infant initially, but the infant should be put to breast at least every 3 hours and given intravenous glucose as well.

Term SGA infants often have a poor suck and poor coordination with the swallow reflex. They may have considerable mucus, with gagging and spitting. A simple lavage of the stomach with a No. 8 feeding tube (or No. 5, if the infant weighs less than 2600 g) and warmed glucose water usually relieves the gagging. Once this SGA infant begins to eat, he or she will do well and will require sufficient kilocalories to meet the needs of an AGA infant. The mother should be instructed to continue pumping until the infants are exclusively breastfed and gaining weight adequately. Pumping three to four times per day to completely empty the breasts at home is critical. Preterm infants usually do not completely empty the breasts at first. They lack the suction strength and sustainable effective organization of sucking until they approach 40 weeks’ corrected gestational age, according to Meier. To guarantee adequate production and intake, these preterm infants need scheduling to ensure feeding every 3 hours, although feeding on cue is more effective in the long run.

The authors suggested that SGA infants clearly benefited from being breastfed.

**Transitioning from Hospital to Home**

The transition from hospital to home is a stressful time for all families, but when an infant is premature and has been in the NICU for days, weeks, or months, transition can be extremely difficult. The stress can be reduced by discharge planning. The mother should spend as much time as possible with her infant, breastfeeding when present. A lactation consultant or trained staff member should observe these interactions. The presence of sucking and swallowing should be documented. If mothers have received adequate assistance in the days and weeks before discharge, then positioning and latch should be perfected by discharge.

The Committee on Fetus and Newborn of the AAP has delineated three physiologic competencies that are recognized as essential before hospital discharge of the preterm infant:

- The ability to maintain body temperature in a home environment
- Sufficiently mature respiratory control
- Oral feeding sufficient to support appropriate growth

Hospitals that have facilities to accommodate care-by-parent overnight are helpful in the transition. At minimum, parents should be given all the medications and treatments before discharge and be breastfeeding. If a mother’s supply is not adequate yet, she should be instructed in the use of the lactation supplementer before discharge, with a plan for the amount and substance to be placed in the supplementer. If she has stored milk available, it can be used. If not, the neonatologist will have to order donor milk, preferably from a milk bank. If not, a special care formula or special human milk supplementer, which is designed to be used separately from mixing with mother’s milk as a feed, can be utilized. Mothers should be instructed to continue pumping until the infants are exclusively breastfed and gaining weight adequately. Pumping three to four times per day to completely empty the breasts at home is critical. Preterm infants usually do not completely empty the breasts at first. They lack the suction strength and sustainable effective organization of sucking until they approach 40 weeks’ corrected gestational age, according to Meier. To guarantee adequate production and intake, these preterm infants need scheduling to ensure feeding every 3 hours, although feeding on cue is more effective in the long run.
In Sweden, preterm infants who are less than 32 weeks’ gestation are fed their mother’s milk or, if that is not available, donor milk. Twenty-seven of 36 NICUs in Sweden that responded to a questionnaire on breast milk handling had their own milk bank. The authors have established national guidelines for the hospital use of human milk. In North America, the Human Milk Banking Association of North America oversees volunteer milk banking (see Chapter 21). Milk banks are listed in Appendix H.

Follow-up after discharge from the NICU is essential and should be involved as the dyad is prepared for discharge. Independent predictors of human milk receipt at NICU discharge were determined by Brownell et al. from analysis of the Vermont Oxford Network clinical data at a Level IV NICU in the inner city. They concluded that a strong NICU lactation program, in combination with a community-based peer counselor program, may increase rates of human milk consumption among VLBW infants of black/Hispanic mothers, as well as those with more complicated courses.

Community-based peer support programs are very helpful in supporting postdischarge mothers to continue to provide their own milk.

Early discharge with tube feeding of preterm infants under close supervision by pediatric nurse practitioners in the Netherlands was done. The effect was an increase in the duration of breastfeeding. The finding continued for 6 months postdischarge. This approach needs confirmation but is important.

Not all premature infants will need supplementation at home. Before and after weighings can be done while an infant is still in the hospital to measure the infant’s intake at each feeding. Digital scales, accurate to 2 g, are available in hospitals, and home models can be rented. When an infant is first discharged, it is helpful to both the physician and the parents to know what intake actually is. Some mothers produce large volumes of milk, but the infants do not gain weight. Pumping first to remove the foremilk (and freeze it) and having the infant suckle the hind milk can help this problem. A pediatrician plays a critical role in the success of feeding after discharge. Monitoring of progress and knowledge of the unique concerns in breastfeeding premature infants are key. The Academy of Breastfeeding Medicine Protocol #12 in Appendix J details the steps to follow.

**Improving Milk Production**

1. Begin pumping as soon postpartum as possible.
2. Use hospital-grade double (two-breast) pumps.
3. Pump 10 to 15 minutes every 3 hours until more than a few drops are produced (72 hours).
4. When the amount increases, continue to pump for 2 minutes after the last drop is produced (total 20 to 30 minutes).
5. Keep a record of times pumped and volumes produced.
6. Pump at babies’ bedside when possible.
7. Start with kangaroo care.
8. Stroke and massage breast during pumping.
9. As soon as infant is able, place at emptied breast to suckle or during gavage feedings.

Pump-dependent mothers are at risk for diminishing milk supply. Mothers of preterm infants can attain and sustain high production levels by combining the use of electrical pumps with manual techniques, including hand expression taught by an experienced nurse. This includes mothers of normal term babies. It is essential for mothers of infants in the NICU. Dr. Morton has developed several videotapes demonstrating these techniques that are excellent for mothers and staff alike. Chapter 8 discusses pharmacologic stimulation of milk volume.

**Concluding Recommendations**

Infants who weigh less than 1800 g at birth and have to be gavage fed and infants of any weight who are acutely ill present complex problems. A mother should be instructed to express her milk initially and contribute any colostrum she produces. This can be given by gastric tube spoon or cup. A hospital-grade electric pump is effective in helping a mother increase the volume produced. When an infant is born at 1000 g, requires ventilator support for days, and is not discharged for 8 weeks (Figure 15-12), it is difficult to maintain

Figure 15-12. 1100-g infant shown at 4 hours of life in a busy NICU. Infants in these situations require early intervention to ensure successful breastfeeding.
a large volume of milk by pumping. It can be done, however, with supportive counseling by staff and the initiation of kangaroo care. Milk volumes usually increase when an infant begins to actually breastfeed, not unlike relactation (see Chapter 19) or increasing milk volume in other situations (see Chapter 8).

When nipple feeding is possible, an infant can be put to the breast. It requires less energy to suckle at the breast than to feed from a bottle. The peristaltic motion of the tongue, which is the normal innate suckling mode, initiates the peristaltic motion of the GI tract and triggers the swallow. If no pacifiers or rubber nipples have been given, an infant may be able to suckle at the breast well before he reaches 1500 g. Figure 19-3 illustrates an infant who first nursed at 1100 g. If little or no breastfeeding has been done in the hospital and the mother has been unable to pump enough to sustain the daily needs, then an infant may be frustrated at the breast when sent home from the hospital unless intervention is provided.

One can see that the reserves of premature infants are limited if one studies the absolute and relative body compositions of infants at birth (Figure 15-13). If one considers how little time it takes to starve a premature infant compared with a full-term infant, the risks of starving a premature infant while the infant adapts to nursing at the breast are real (Figure 15-14). The solution to the problem is to provide nourishment while the infant stimulates maternal milk production by suckling at the breast. A piece of equipment called a nursing supplementer provides this setup very effectively (see Figure 19-4). It was developed to provide nourishment for an adopted infant who is being nursed by a mother who has not been pregnant or has never lactated. It sustains the infant while the mother’s milk supply develops (see Chapter 19). The same effect can be provided for premature or sick infants who have not nursed at the breast since birth and need nourishment while the mothers’ supply develops, even though she has been pumping.

The infant can continue to gain weight while stimulating the breast if a supplementer is used. The volume required from the nursing supplementer drops continually in a week or so. Occasional infants require the supplementer for a month. The mother should continue to pump after breastfeedings until her volume increases.

The nursing supplementer provides a simple means of ensuring adequate nourishment while adapting to the breast. It is preferable to using
supplemental bottles because the infant is not confused by the rubber nipple, which requires a different mechanism of sucking than the human nipple. Furthermore, the sucking of the breast provides the continued stimulus necessary for increasing milk production. Cup feeding is an alternative to the bottle if the infant needs additional nourishment.

The parameters that are to be met before discharge home from the hospital include sustained weight gain, growth in length and head circumference, and stable biochemical parameters19 (Table 15-17). After discharge from the hospital, these same parameters should be met. If faltering is persistent, fortifying breastfeeding may be indicated. This can be accomplished without interfering with the breastfeeding process again by using a lactation supplementer containing enriched breast milk that had been previously pumped or donor milk, which is preferable to formula.

Posthospitalization breastfeeding patterns of moderately preterm infants (30 to 35 weeks) were studied by Wooldridge and Hall138 using daily feeding diaries in 55 women for the first month after discharge. Those women who were able to exclusively breastfeed before the end of the first week at home were able to maintain their supply. In general, those women who did not have an adequate supply during the first week were unlikely to achieve it by week 4. The proportion of breastfeeds increased during the 4 weeks of observation, but only 56% achieved exclusive breastfeeds by 4 weeks in this study. Proper preparation prior to discharge and adequate support at home assures success.

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