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“Breastfeeding” by Feeding Expressed Mother’s Milk

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Milk Expression

Milk expression, defined as the removal of breast milk from a mother’s breast without an infant’s mouth at her nipple, is a normal component of breastfeeding for many mothers. Survey data indicate that 85% of breastfeeding mothers express milk at some point before 4 months of age.¹ Mothers practice expression for a variety of reasons, including enabling another person to feed their infant, storing milk for unexpected maternal-infant separation, relieving engorgement and/or nipple pain, maintaining milk supply, and obtaining breast milk to mix with cereal or other foods.^{1, 2} Milk expression is more common for employed mothers and for those with higher income and education.

Methods of milk expression

Mothers have several options for milk expression. Review of these options also requires some clarification of the terminology used for milk expression. (Table 1) Hand expression may also be called manual expression, and differs from hand-powered pumping, which may also be called hand pumping or manual pumping. The most commonly used form of milk expression in developed countries is electric-powered pumping. In addition, mothers may use “hands-on pumping,” which combines hand expression with electric powered pumping. In resource-constrained areas, hand expression may be the only available approach, and may often be adequate to address maternal needs.^{3–5}

Hand expression

Hand expression is an easily taught technique for which a mother uses her hand or hands to exert gentle pressure on her breast in such a way that milk is expressed. Manual hand expression with proper hygiene is no different in terms of infection risk than expression using sterile pumping equipment.⁶ Several approaches to hand expression may be used, and a mother who hand expresses regularly will refine her technique until she finds the approach that is most effective for her. When teaching hand expression, a provider can suggest that the

mother form a “C-shape” with her ipsilateral hand, placing her thumb 2–3 cm above her areola and her fingers 2–3 cm below her areola. To initiate expression, the mother may press gently back towards her chest wall, exerting continuous pressure without eliciting any pain. The thumb and fingers are pressed toward the chest wall, and then brought together and pressed gently forward, so that they push on the ducts beneath the areola. Milk is often expressed at this point. Using a cycle of pressing and releasing and rotating her fingers around the areola, a mother can aim to capture all of the ducts until a maximum volume of milk has been expressed.

Breast pumping

Breast pumping simulates infant suck by generating a vacuum similar to that generated by the oral cavity of a feeding newborn. Breast pumps may be bilateral or unilateral and may be powered either electrically, manually or by foot. Electric pumps are the most widely used method of expression in the U.S. today¹ and may be powered either by direct electrical current or by battery. Of note, manually-powered breast pumps may also be called “hand pumps,” which can be confused with hand expression.

For mothers who choose to use a pump, pumping for 15 minutes or until 2 min after milk flow ceases is often recommended, and this approach results in the highest volumes of expressed milk, with higher fat content noted in milk removed at the end of a session of milk expression. However, studies have shown that 80% of expressed milk is collected in the first 6 minutes, so mothers who have time constraints and are not pump-dependent may wish to consider shorter durations of milk expression based on their own individual needs.⁷ A vacuum range of 0 to –250mm Hg and a cycle time of 47–55 cycles/min may result in optimal volumes.⁸ A fundamental principle of pumping is that the level of vacuum chosen must be comfortable for the mother. Vacuum settings that are high enough to cause pain greatly increase the risk of tissue damage from pumping. One study of 21 mothers estimated that maximal comfortable vacuum is approximately -191 ± 9 mm Hg.⁹ One option is to begin a pumping session with a stimulation pattern of 1 to –250 mm Hg at 105 – 120 cycles /min, which may initiate let-down more rapidly.¹⁰ However, it is important for mothers to know that initiation of let-down with a pump may be slower than with a breastfeeding infant. Let-down may occur earlier during pumping if a mother looks at a photograph of her baby or smells an item of her baby’s clothes.

Simultaneous (as opposed to sequential) pumping of both breasts is generally preferred when using electric pumps.¹¹ In clinical trials, milk volumes expressed with simultaneous pumping was similar or increased compared to sequential pumping.^{11–13} Simultaneous pumping also takes less time, which may be of value to many mothers.¹² Several other interventions have been shown to be effective at increasing pumped milk volume. Breast massage,¹¹ warm compresses prior to beginning milk expression,¹⁴ and/or warm nipple shields¹⁵ may increase milk volume and decrease the time required for milk expression. In addition, recorded music-based interventions improve the volume of milk expressed by pumping.¹⁶

Identifying the best type or brand of bilateral electric pump may depend more on personal preference than on an objective standard. A study comparing the Symphony breast pump

(Medela Inc., McHenry, IL) to the Classic breast pump (Medela Inc., McHenry, IL) found no differences in milk output.¹⁷ In another study, the Pump In Style pump (Medela, Inc., McHenry, IL) had both a higher volume of milk extracted and a higher creatinocrit compared to the Embrace pump (Playtex, Westport, CT).¹⁸ Comparing four different types of hand pumps, Bernabe-Garcia et al. recently reported no difference between types of hand pumps with respect to volume of milk expressed or duration of milk expression.¹⁹ It is important to remind mothers that the volume of milk extracted by pumping may be larger or smaller than the amount extracted during an infant's feeding.²⁰ This topic is discussed further below, but it is important to recognize that some mothers worry about milk supply when they notice what they perceive as a "small" volume of expressed milk,^{21–24} and such milk supply concern can be a major risk factor for breastfeeding discontinuation.^{22, 25–35}

Considering the high prevalence of pump use, the frequency of adverse events associated with breast pumping appears to be quite low. The Food and Drug Administration (FDA) received 37 reports of adverse events from breast pumps between 1992 and 2003, of which 24 reports identified at least one patient problem, including pain, soreness, discomfort, tissue damage, erythema and swelling.³⁶ Very rarely, breast pumps have been associated with infectious disease. In one reported case, contamination of breast pump equipment with *Pseudomonas aeruginosa* caused illness in a set of premature twins. In a separate case, a mother's breast pump tubing changed color and was found to be colonized by *Serratia marcescens*.³⁷ This mother discontinued breastfeeding, although neither she nor her twin infants had had signs or symptoms of illness.

Hands-on pumping

Pioneered by Jane Morton, hands-on pumping is an approach that combines hand expression with simultaneous bilateral electric breast pumping. This approach often produces more milk than either bilateral breast pumping or hand expression alone.³⁸ This technique may be especially useful for mothers of premature newborns (see section below), who may need to generate a high level of breast milk production without direct breastfeeding. These results also highlight the importance of continued research into optimal methods of milk expression.

Comparative effectiveness of methods of milk expression

There have been several studies comparing different methods of milk expression in a variety of settings (Table 2). Once a mature milk supply is well-established, bilateral electric breast pumping expresses more milk in less time than unilateral pumping, hand pumping or hand expression.^{3, 4, 39–41} Since electric pumps may remove up to 50% more milk than hand expression with greater ease of use, mothers who are making mature milk often strongly prefer electric pumps.^{42, 43} However, individual mothers may prefer manual pumps or hand expression, and many mothers may be able to express adequate milk volumes using any of these approaches. Also, though bilateral electric breast pumps have better efficacy than hand pumps and express milk more efficiently than hand pumps, these differences may not have an impact on breastfeeding duration. Examining mothers enrolled in the Women, Infants and Children (WIC) branch of the Hawaii Department of Public Health, Hayes et al. found no

difference in breastfeeding duration between working mothers who used an electric breast pump and those who used a hand pump.⁴⁴

Anatomy of milk expression

The anatomy of breast pumping is quite different from the anatomy of hand expression. Hand expression uses positive pressure to release milk from the ducts, and with experience, hand expression may also generate let-down, which can assist in the removal of milk. A breast pump generates negative pressure, which works in two ways. First, the pump initiates let-down of milk, an average of four times per pumping session. Second, the negative pressure generated in the phalange of the pump extracts milk from the ducts, in a manner similar to the negative pressure generated in the posterior pharynx of the infant. The pump will draw the mother's nipple and areola deep into the phalange. Therefore, when using a pump, it is of paramount importance to choose a size for the pump shield that will match the nipple and areola of the mother. Use of a shield that is too small can cause trauma to the nipple.

Physiology of milk expression

During mature milk production, milk expression raises maternal levels of oxytocin and prolactin. Pumping has a much stronger effect on prolactin than does hand expression, and studies have shown that pumping raises prolactin levels even more than does direct breastfeeding.^{39, 45} However, higher levels of prolactin and oxytocin do not necessarily correlate with increased milk production; a recent study comparing two different pumps found that one yielded a higher milk volume and a higher creatinocrit (indicating more complete breast emptying), while the other pump had much higher release in prolactin. The physiological relationship between pumping, milk production and hormonal regulation is clearly complex, and the current evidence base in this area often raises more questions than it answers. For example, a recent study found that hormonal responses to pumping are blunted among mothers with family history of alcoholism.⁴⁶ Of note, the hormonal response to milk expression during lactogenesis I has not been reported and might differ from the response during later phases of lactation.

Mother's experiences of milk expression

Women's experiences of milk expression are quite diverse. Some mothers find expressing milk to be a pleasant, comfortable or relaxing activity, while others find milk expression painful, stressful or embarrassing. It is important for providers to note that their own personal experience with milk expression may not be reflective of the experience of individual mothers in their practice. In a qualitative study of milk expression experiences found that one mother reported that "I feel like a cow" while another said, "I like to be able to do it."⁴⁷ A recent study found that while 64% of mothers who expressed breast milk had expressed in the presence of family or friends, but 36% had not.² In the development of the Breast Milk Expression Experience Scale, mothers' learning experiences related to breast milk expression ranged from 1.5–5 on a scale of 1–5, and mothers' personal experiences ranged from 1–3.6 on a scale of 1–5.⁴⁸ Clearly, women differ in their experience and

perception of milk expression. See Table 3 for some suggested parent resources regarding milk expression.

Indications for milk expression

There are a variety of indications for milk expression, and the type and approach to milk expression may vary by indication. Return to work or school is the most common reason for regular breast pumping, and working mothers should note that time of day may affect volume of milk extracted by pumping, with highest volumes expressed from 6 a.m. to noon and lowest volumes expressed from 6 p.m. onward.⁴² Some mothers will have no trouble expressing enough milk while working, but for those who do, it may be advisable to breastfeed the baby just before leaving for work and just after returning from work, and to use a bilateral electric breast pump every three hours while separated from the baby. Of note, after 6 months of age, babies begin to eat solid food, maternal milk supply becomes more stable and mothers may not need to pump as frequently or at all during separations.⁴⁹

Some mothers express milk as a substitute for direct breastfeeding. This may occur when an infant is born premature or critically ill (see section below), and may also be necessary for newborns with a cleft palate, who may not be able to generate adequate negative pressure to feed directly from their mothers' breast. Some mothers do not want to breastfeed directly or have infants who have difficulty establishing an effective latch. These women may choose to feed their baby pumped milk only, but it should be noted that it can be difficult to maintain milk supply by expression alone. Among 80 mothers of healthy term infants who were pumping only, without direct breastfeeding, none were able to provide breast milk through 6 months.⁵⁰ Mothers may also express milk because of casual, occasional mother-infant separation, or because they want others to have the experience of feeding the baby. In some cases, mothers may express milk when they have consumed alcohol, drugs or medication that is contraindicated with breastfeeding. In such situations, the milk must be discarded after expression.

Another common indication for milk expression is to encourage a larger milk supply. Since use of a breast pump twice daily for two weeks in addition to ordinary breastfeeding raises milk production by an average of 175 mL/day for mothers who already have a good milk supply,¹⁸ it may be thought that milk expression will have a similar effect on mothers who are experiencing milk supply challenges. For example, mothers may often initiate milk expression because of delayed onset of lactation, or because of high newborn weight loss or other newborn signs of inadequate milk intake. While such milk expression after breastfeeding may often be recommended for mothers with milk supply concern, it is important to note that the evidence base for it is limited, with one randomized trial finding a trend towards lower milk transfer from mother to infant for mothers who pumped in addition to breastfeeding.⁵¹ Further research is needed to demonstrate the optimal approaches to milk expression for mothers having trouble establishing an adequate mature milk supply.

Lastly, a globally important indication for milk expression may be the use of flash-pasteurization of breast milk. Much pediatric HIV infection worldwide is caused by breastfeeding, especially after complementary foods are introduced around 6 months of age. However, substituting other fluids for breast milk may result in even higher morbidity and

mortality from gastroenteritis and other infectious diseases. Expressing breast milk could help reduce mother-to-infant transmission after 6 months if mothers are able to treat the expressed milk with flash-pasteurization in their home kitchen. This technique has been demonstrated to be feasible and safe, with its effectiveness requiring further study.^{5, 52}

Early Milk Expression

Early milk expression, prior to the onset of lactogenesis II, differs from milk expression occurring after the onset of lactogenesis II in several important respects and will be discussed separately in this section. In the U.S., about half of breastfeeding mothers express milk during the first week after birth, and almost all who express milk in this early time do so using a mechanical pump.^{1, 53} The first few days after birth are a period of dramatic maternal hormonal changes, with rapidly rising levels of prolactin and oxytocin initiating and maintaining lactation. The effect of milk expression on hormones during this early period is unknown, but it is possible that early expression may raise hormone levels and hasten the onset of lactogenesis II. However, it is also possible that early milk expression is not effective at hastening lactogenesis II. Milk volume is low during lactogenesis I, and at each feeding or expression mothers produce about 0–5 cc of colostrum, a thick fluid rich in immunoglobulins. These small volumes are in stark contrast to the volumes produced once lactogenesis II begins and mothers begin to make copious volumes of mature, white milk. The effect of type of expression on the volume of milk expressed prior to the onset of mature milk production has not yet been determined, with some studies reporting that hand expression removes more milk than pumping, and some studies reporting the opposite.^{40, 54–56} A recent study also found that a breast pump suction pattern that mimics the rapid suck rate and irregular suck rhythm of a breastfeeding newborn prior to the onset of lactogenesis II did not have a significant effect on volume of colostrum or timing of onset of lactogenesis II, but was associated with a higher milk output beginning on day 6.⁵⁷

A challenge associated with any method of early milk expression is that expression allows mothers to visualize the small volumes of milk. While mothers who are solely breastfeeding may not have a sense of how much milk they are producing, milk expression makes mothers aware of the volume. Unfortunately, mothers who are not able to express significant volumes of milk may experience feelings of embarrassment and increased milk supply concern.⁴⁷ This is especially challenging because maternal concern regarding low milk supply can become a self-fulfilling prophecy. Mothers with concerns about low milk supply may begin formula supplementation, which may lead to decreased infant breastfeeding demand and increased milk stasis, which may in turn lead to truly insufficient milk supply. In addition, it is important to remember that mothers in the immediate postpartum period may have residual pain or fatigue from childbirth and may have less comfort with exposing and manipulating their breasts than mothers who have been breastfeeding for weeks or months. Therefore, a mother's reaction to milk expression prior to the onset of lactogenesis II may be unrelated to her reaction to milk expression once the onset of mature milk production has begun.

A recent Cochrane review found a “lack of data relating to how various methods and techniques of milk expression or pumping assist mothers to meet their own goals.”⁴⁰ Indeed,

the outcome studies have highly variable findings, and there is some evidence that the timing of initiating of pumping might have an influence. Pumping in the first month does not have a significant influence on breastfeeding duration.⁵⁸ However, pumping in the first 6 months is associated with longer breastfeeding duration, while pumping at 3 days postpartum is associated with shorter breastfeeding duration.⁵⁰ Furthermore, one study found that expressing breast milk (defined as either use of a mechanical pump or hand expression) in the first three weeks was associated with breastfeeding discontinuation by 3 months of age.²⁸

The method of expression taught in the immediate postpartum period may have a significant effect on breastfeeding and may even impact breastfeeding duration. A randomized controlled trial comparing breast pumping to hand expression reported that early hand expression increased breastfeeding rates at 2 months by 25% compared to early breast pumping.⁵⁹ The positive effect of learning hand expression instead of pumping might be attributable to two factors: first, normal colostrum volume might appear more appropriate when expressed by hand rather than by pump, and second, mothers who hand expressed initially reported greater comfort expressing in front of others than mothers who initially pumped.

The WHO and the Academy of Breastfeeding Medicine recommend teaching milk expression to mothers prior to discharge from the birth hospitalization.^{60, 61} Additionally, the CDC has endorsed the WHO's Baby Friendly Hospital Initiative, which requires teaching of milk expression to all mothers during the birth hospitalization.⁶² These policies are based on research showing that frequent milk expression improves breastfeeding duration for mothers who have returned to paid employment,^{63–65, 66–69} and the idea that mothers are available during the birth hospitalization to learn milk expression. However, Chen et al. recently reported that receiving breast pump education from a physician or physician assistant was a risk factor for shorter breastfeeding duration, while receiving breast pump education from a class or support group was a protective factor associated with longer breastfeeding duration.⁷⁰ These associations could be attributable to differences in the quality of counseling received from these different sources, but the study's results might also be attributable to the fact that breast pump teaching by a physician is a marker of learning breast pumping as an inpatient, which, as discussed above, may not be the best time to learn pumping.

Milk storage for healthy term newborn

Room temperature milk storage is safe for at least 3–4 hours and may be safe for up to 8 hours when it has been expressed in a very clean manner and stored in cooler room temperatures. Milk may be stored for at least 72 hours refrigerated at 4°C, and may be stored for 6–12 months in a freezer at –17°C. New, warm milk should not be added to cooled, stored milk as this could increase bacterial contamination. Of note, although several companies make cooler bags for the transport and storage of expressed breast milk, these cooler bags maintain a temperature of at 15°C, and only one study has examined the safety of milk stored at this temperature.⁷¹ Further research is needed in this area. The antibacterial activity in milk declines the longer it is stored, and some studies have noted a decline in

levels of Vitamin C in milk frozen for more than 3 months.^{72, 73} Frozen milk should be thawed in the refrigerator overnight or by running under warm water or gentle agitation in a dish of warm water; refrigerated milk may be served cool or warmed as noted above for thawing frozen milk.⁷⁴

Expression of milk for preterm infants in the neonatal intensive care unit

Mothers whose infants are admitted to the neonatal intensive care unit (NICU) will face more challenges than other mothers in initiating and sustaining breast milk feeding.^{75, 76} These mothers are more likely to have experienced complications in pregnancy and childbirth, such as cesarean section delivery, and may be receiving medications that may interfere with breastfeeding or milk expression.^{77, 78} In addition, the physical environment of the NICU may not be conducive for breastfeeding or pumping, and the infant's illness may preclude oral feeding for some time. These challenges are most prominent for mothers of preterm infants, as such infants will not actually be able to breastfeed for up to several weeks until they transition from tube feedings to oral feedings.⁷⁹ Support in initiating milk expression early in the hospital course will help to increase the likelihood of achieving full breast milk feeding.

Maternal counseling for the preterm or critically ill newborn

Early counseling of mothers of preterm or critically ill newborns is a crucial component of ensuring sufficient breast milk for this population. Mothers who have given birth prematurely are more likely to have characteristics that make them less likely to breastfeed, including younger age, lower-income strata, having usage of tobacco, alcohol, and drugs, and having medical complications.^{80–82} Because mothers with these risk factors may not have thought about breastfeeding prior to delivery, may have already made a decision to formula feed,^{83–85} or may not have received much guidance on the topic of breast milk,^{85–87} they may benefit greatly from education on the specific benefits of breast milk for preterm infants. Such counseling may motivate mothers to provide breast milk during their infants' hospitalization, even if they do not eventually make the commitment to breastfeeding after discharge.

Counseling on both the benefits of breast milk and techniques to initiate and maintain supply can be discussed early on, even prior to birth if the mother is hospitalized with the likelihood of preterm birth. Although some hospitals may assign a lactation consultant to offer counseling on milk expression, repeated counseling by several members of the team including obstetricians, labor and delivery nurses, nutritionists, social workers, neonatologists, and NICU nurses may help to reinforce the importance of breast milk for preterm infants.⁸⁸ The benefit of breast milk for the premature population is well described^{89–91} and it can be suggested to the mother that breast milk and her task of milk expression is a medical therapy that cannot be replaced by pharmaceuticals and is something that only she can provide for her infant.⁹²

A consideration of clinicians caring for mothers who have given birth prematurely is the potential for causing more anxiety for a family in an already stressful and traumatic situation. In a study of a counseling intervention aimed at mothers of premature infants who

were initially planning to formula-feed, 69 of 81 (85%) such mothers initiated breast milk expression, compared to 100% of a control group of mothers intending to breastfeed. Initiation rates did not differ by race or income status. Anxiety status and stress as measured by several scales did not increase with counseling for either group and actually declined over the hospital course.⁹³

Creating an optimal environment for NICU patients

Adequate resources including equipment, environment, and staff training are necessary in order to support clinicians and parents in the effort to provide breast milk for premature and critically ill neonates. The success of a mother in initiating and sustaining breast milk expression until discharge requires a multi-disciplinary approach.⁹⁴ Education of staff on breast milk feeding should involve all healthcare professionals in the NICU including nurses, nurse practitioners, therapists, neonatologists, and anyone who may have contact with parents.⁹⁵ The presence of a physician attitude that breast milk expression is the responsibility of nurses alone has been identified as a potential barrier to improving practice in nurseries.⁹⁶ Studies have shown that socio-demographic factors such as younger age, lower educational attainment, non-White race, and inadequate prenatal care are associated with decreased success in breast milk provision for preterm infants.^{81, 82, 97} These high risk groups should be considered as targets for implementation of best practices and quality improvement efforts,⁹⁸ and it should not be assumed that these risk factors preclude successful establishment of milk expression.

The California Perinatal Quality Care Collaborative (CPQCC) has published a Nutritional Toolkit that outlines several aspects of supporting breast milk provision for premature infants.⁹⁴ Using this toolkit as a basis for best practices, a multi-hospital collaborative project to improve quality in this area resulted in a 25% increase in breast milk provision for very low birth weight infants and a corresponding decrease in necrotizing enterocolitis.⁹⁹ Other examples of comprehensive nutrition plans that facilitate breast milk feeding and eventual transition to breastfeeding have been developed by individual NICUs.^{98, 100} While the WHO's Baby Friendly Hospital Initiative is primarily designed for the healthy newborn population, implementation of the Ten Steps to Successful Breastfeeding may also lead to increased breast milk provision in the NICU.¹⁰¹

Timing of milk expression for the preterm infant

An early start to pumping will greatly increase the likelihood of sufficient breast milk supply for the preterm infant. An earlier start to milk expression is more likely to lead to success in lactation and sustained expression. Mothers of newborns who are not breastfeeding should begin milk expression in the first 6 hours after birth, and there may be benefit to starting sooner, within one hour of delivery if no contra-indications exist.^{97, 102}

Earlier gestational age at birth is associated with delayed lactogenesis II, and mothers should be counseled about this expectation in order to avoid frustration in the first days of milk expression.¹⁰³ Informing mothers about the variation in milk production in the first few days may potentially prevent mothers from becoming discouraged, and this may be important because some mothers may stop pumping after a few days without milk production due to

the perception that they are not being successful. It may also help some mothers to be aware that differences in milk volumes from the left and right breasts may occur, particularly for primiparous mothers, and do not have an impact on total milk output.^{104, 105}

Frequency of pumping is another important aspect of ensuring enough supply. Mothers should be encouraged to pump a minimum of 8 times a day, and potentially up to 12 times a day during the first several weeks when breast milk supply is being established.¹⁰⁰ In the first few days prior to the onset of mature milk production, the mother should pump for 10 to 15 minutes each session. As the milk begins to come in, the mother should continue to pump for about 2 minutes after the final droplets of milk are released in order to ensure that the breasts are completely emptied.¹⁰⁶

Approaches to NICU milk expression

Although the equipment and techniques of milk expression are the same for mothers of healthy newborns as for those of newborns in the NICU, the approach to milk expression needs to be more intense for mothers who are expressing for premature or critically ill infants. There have been several trials comparing effectiveness of various pumping regimens and pump types, but the importance of any particular method is probably less important than having a concerted approach.^{4, 96}

For premature babies, electric pumping may be the most efficient approach and is likely to produce more milk volume in the long run.⁴ Simultaneous (as opposed to sequential) pumping is generally preferred.¹¹ In clinical trials of mothers who had given birth prematurely, milk volumes expressed with simultaneous pumping were similar or increased compared to sequential pumping.^{11–13} Simultaneous pumping also provides some efficiency, thereby providing more free time for mothers to spend resting or visiting with their infant.¹² This extra time may be more important for mothers of premature babies, as it may be necessary to express milk for weeks or months. Pain and discomfort while pumping, which may be due to vacuum level or phalange size, should be addressed early in order to prevent a mother from giving up due to those reasons.

Other methods for increasing milk supply have been studied. Breast massage may help to increase expressed volumes,¹¹ as may combining hand expression with electric pumping.³⁸ A mechanical pumping pattern that was designed to closely mimic the pattern of a healthy term infant has been shown to increase efficiency and supply.⁵⁷ The pattern consisted of two phases, the first 2 minutes consisting of rapid suction events which simulated a non-nutritive initiation phase, and a second slower phase mimicking nutritive sucking to facilitate regular milk flow. Relaxation at the bedside while pumping, skin-to-skin contact and kangaroo care may also help to facilitate increased milk production.^{96, 107–109} Galactogues may be another consideration when there is a concern about inadequate supply (see articles in this issue by Rowe, xxx, and Hale, and by Chantry and Howard). In order to ensure establishment of an adequate milk supply, a mother will need access to breast pumps in the postpartum area, the NICU, and at home. Therefore, each NICU should have an adequate supply of equipment for use in the hospital in conjunction with an efficient program for providing equipment for home use. Hospital grade pumps are approved by the FDA for multiple users, and providers must disinfect and clean the pump between users. Each user must have her own pump kit

that she does not share. Women who receive healthcare coverage through Medicaid or those who qualify for WIC will typically be covered through those programs for home use of a hospital-grade pump. Programs may vary by state. For mothers whose infants are hospitalized in the NICU, private insurance companies and health maintenance organizations should also cover pumps, but individual plans may vary. A sample letter to request insurance coverage for pump equipment is available in the CPQCC toolkit.¹¹⁰

In situations where electric pumps are not available due to resource limitations, manual pumps may be just as efficient as electric pumps.^{111, 112} Manual pumps may also be preferable for mothers who feel intimidated or uncomfortable with electric pumps. Hand expression may be especially useful in the first days to initiate supply,^{38, 113} because the suction generated by pumps may not fully simulate the biological action of breastfeeding. However, hand expression may not be as efficient as mechanical pumping in the long-term, and therefore may be considered an adjunct at various times during the hospital course.¹¹⁴

Hand expression may also be helpful in the first day or two in order to capture small amounts of colostrum for the premature infant. As even small drops can be very valuable for the preterm neonate, providing small volumes may also demonstrate to the mother her ability to contribute to her infant's care. Hand expression may be particularly useful in this situation in order to reduce loss to plastic tubing. Medela, Inc. (Medela, Inc., McHenry, IL) produces a small, 35 ml milk collection container with a curved bottom that is designed to minimize loss of colostrum. The smaller size may also help by setting a reasonable expectation for mothers in the first few days of milk expression. Mothers of twins and higher-order multiples will face the greater challenge of providing milk for more than one infant. Although having a goal of pumping for more than one infant may seem intimidating, observational studies of premature infants have shown that mothers of twins seem to be more successful in sustaining breast milk feeding for their premature infants.^{81, 115}

Storage and collection in the NICU

Each NICU should have its own guidelines about milk collection and storage. If a baby is not receiving milk immediately after pumping, the milk should be refrigerated. If the baby will not receive the milk within the next 48 hours, it should be frozen. General hygiene techniques including washing of hands with soap and water should be followed. Each session of breast milk expression should be held in a different container and labeled. The Human Milk Banking Association of North America (HMBANA) publishes a manual of best practices for expressing, storing and handling of human milk in hospital and at home.¹¹⁶

One consideration for premature infants is the possibility of cytomegalovirus (CMV) transmission through mother's breast milk.^{117–121} The concern for premature infants is that postnatal CMV transmission through maternal breast milk may sometimes cause serious illness. Although freeze-thawing has been a recommended method for reducing transmission, it may not be effective for all cases.¹²¹ General guidelines from the nutrition toolkit of the CPQCC suggest the following steps to reduce CMV transmission:⁹⁴ 1. Screen mothers of very low birth weight infants, 2. Screen infants of CMV seropositive mothers for CMV if maternal breast milk will be provided, 3. Colostrum may be given fresh or frozen, 4.

If the mother is CMV seropositive, freeze all maternal breast milk for at least 24 hours prior to feeding until the infant is > 32 weeks corrected age or feeding directly at the breast. Infants that exhibit symptoms consistent with CMV infection such as respiratory illness, hepatitis, leucopenia, or thrombocytopenia should be tested for CMV. The previous suggestions are not universally accepted and each institution should review the literature and consider their own policies on handling of breast milk during the first few weeks for premature infants. This is a somewhat controversial area and further research is needed to establish a strong evidence base.

Maintenance and monitoring of milk supply

Expression of breast milk for preterm infants is often required for several weeks to even months, and even mothers who were initially motivated will require continued support to sustain adequate supply. For mothers of VLBW infants, the challenges of having to express breast milk in the absence of actual breastfeeding can ultimately lead to low rates of expression by the time of hospital discharge.^{75, 76, 81}

The first 2 weeks are a critical period for initiation and maintenance of lactation in this population, but one in which other priorities of NICU care may overshadow the attention given to breast milk expression by both parents and clinicians.¹²² Since preterm infants often do not receive full enteral feedings for at least 2 weeks, mothers may be falsely reassured that they have expressed “enough” milk during that time period, which may lead eventually to an inadequate supply. The Rush Mothers’ Milk Club program provides a milk volume record for pump-dependent mothers that is monitored by staff in order to alert clinicians if intervention may be needed in order to increase supply.¹²² The mother should be counseled to have an aim of increasing milk supply early on to build a reserve to at least 350ml/day and ideally 750–1000 ml/day during the first 2 weeks.^{55, 122–124} This goal will ensure an eventual adequate supply for VLBW infants.

Special considerations for critically ill term infants

For term infants who are in the NICU, there may be several considerations for feeding. Some infants will be admitted for critical illnesses, requiring a prolonged period without enteral feeding. Others will be relatively well, but require admission for monitoring, phototherapy, or IV antibiotics. These latter infants may be able to feed orally for some or all of their feedings. In some situations, an infant may be starting to feed orally, but may not have the full strength and capacity to take enough nutrition on their own. Even in situations where the infant has the capacity to breastfeed for all feeding, circumstances may prevent the mother from being at the hospital for all feedings, necessitating milk expression during the times that she is away. In these cases, the mother should seek to either breastfeed or pump about 8 times a day in order to maintain her milk supply. If the mother is breastfeeding, but the infant has not yet established an adequate latch and suck, the mother should express after each breastfeeding.

For infants who have significant congenital anomalies and/or those requiring surgical management, breast milk feeding may not be considered a priority. However, since such infants are at higher risk of feeding intolerance, infections, and other morbidities, breast

milk may be even more important for this population. The promotion of breast milk for surgical patients benefits from all the components of an effective approach as described above for premature infants, including adequate counseling, staff support, and early, frequent milk expression. The multidisciplinary team that provides counseling and monitoring may also include physicians, nurses, and nurse practitioners from the surgical team. A successful project to increase breast milk feeding in infants with complex surgical anomalies has been described.¹²⁵ Key components of this project were a multidisciplinary planning team, increased education and bedside nurse involvement in monitoring of milk volumes.

Conclusion

Breast milk expression, whether by hand, manual pump, or electric pump, can be a useful tool for breastfeeding promotion and may be essential for the provision of milk to a baby who cannot breastfeed. The indications for breast milk expression are varied, ranging from maternal employment to extreme prematurity, and the approaches and techniques of milk expression should be tailored to the indication for expression. Milk expression is not necessarily an intuitive process for mothers, both in terms of technique and in terms of maternal experience, and adequate counseling and monitoring by the clinician are needed to help to ensure that each mother's milk expression approach will lead to the intended goals for her family's specific circumstances.

References

1. Labiner-Wolfe J, Fein SB, Shealy KR, Wang C. Prevalence of breast milk expression and associated factors. *Pediatrics*. 2008; 122(Suppl 2):S63–68. [PubMed: 18829833]
2. Clemons SN, Amir LH. Breastfeeding women's experience of expressing: a descriptive study. *J Hum Lact*. 26(3):258–265.
3. Slusher TM, Slusher IL, Keating EM, Curtis BA, Smith EA, Orodriyo E, et al. Comparison of maternal milk (breastmilk) expression methods in an African nursery. *Breastfeed Med*. 7(2):107–111.
4. Slusher T, Slusher IL, Biomdo M, Bode-Thomas F, Curtis BA, Meier P. Electric breast pump use increases maternal milk volume in African nurseries. *Journal of tropical pediatrics*. 2007; 53(2): 125–130. [PubMed: 17409102]
5. Chantry CJ, Young SL, Rennie W, Ngonyani M, Mashio C, Israel-Ballard K, et al. Feasibility of using flash-heated breastmilk as an infant feeding option for HIV-exposed, uninfected infants after 6 months of age in urban Tanzania. *J Acquir Immune Defic Syndr*. 60(1):43–50.
6. Pittard WB 3rd, Geddes KM, Brown S, Mintz S, Hulsey TC. Bacterial contamination of human milk: container type and method of expression. *American journal of perinatology*. 1991; 8(1):25–27. [PubMed: 1987962]
7. Prime DK, Kent JC, Hepworth AR, Trengove NJ, Hartmann PE. Dynamics of milk removal during simultaneous breast expression in women. *Breastfeed Med*. 7(2):100–106.
8. Mitoulas LR, Lai CT, Gurrin LC, Larsson M, Hartmann PE. Effect of vacuum profile on breast milk expression using an electric breast pump. *J Hum Lact*. 2002; 18(4):353–360. [PubMed: 12449051]
9. Kent JC, Mitoulas LR, Cregan MD, Geddes DT, Larsson M, Doherty DA, et al. Importance of vacuum for breastmilk expression. *Breastfeed Med*. 2008; 3(1):11–19. [PubMed: 18333764]
10. Kent JC, Ramsay DT, Doherty D, Larsson M, Hartmann PE. Response of breasts to different stimulation patterns of an electric breast pump. *J Hum Lact*. 2003; 19(2):179–186. quiz 187–178, 218. [PubMed: 12744535]

11. Jones E, Dimmock PW, Spencer SA. A randomised controlled trial to compare methods of milk expression after preterm delivery. *Archives of disease in childhood Fetal and neonatal edition*. 2001; 85(2):F91–95. [PubMed: 11517200]
12. Groh-Wargo S, Toth A, Mahoney K, Simonian S, Wasser T, Rose S. The utility of a bilateral breast pumping system for mothers of premature infants. *Neonatal network: NN*. 1995; 14(8):31–36.
13. Auerbach KG. Sequential and simultaneous breast pumping: a comparison. *International journal of nursing studies*. 1990; 27(3):257–265. [PubMed: 2379986]
14. Yigit F, Cigdem Z, Temizsoy E, Cingi ME, Korel O, Yildirim E, et al. Does Warming the Breasts Affect the Amount of Breastmilk Production? *Breastfeed Med*.
15. Kent JC, Geddes DT, Hepworth AR, Hartmann PE. Effect of warm breastshields on breast milk pumping. *J Hum Lact*. 27(4):331–338.
16. Keith DR, Weaver BS, Vogel RL. The effect of music-based listening interventions on the volume, fat content, and caloric content of breast milk-produced by mothers of premature and critically ill infants. *Adv Neonatal Care*. 12(2):112–119.
17. Meier PP, Engstrom JL, Hurst NM, Ackerman B, Allen M, Motykowski JE, et al. A comparison of the efficiency, efficacy, comfort, and convenience of two hospital-grade electric breast pumps for mothers of very low birthweight infants. *Breastfeed Med*. 2008; 3(3):141–150. [PubMed: 18778208]
18. Hopkinson J, Heird W. Maternal response to two electric breast pumps. *Breastfeed Med*. 2009; 4(1):17–23. [PubMed: 19196038]
19. Bernabe-Garcia M, Lopez-Alarcon M, Villegas-Silva R, Rodriguez-Cruz M, Jimenez-Galicia C. Effectiveness of four manual breast pumps for mothers after preterm delivery in a developing country. *J Am Coll Nutr*. 31(1):63–69.
20. Mitoulas LR, Lai CT, Gurrin LC, Larsson M, Hartmann PE. Efficacy of breast milk expression using an electric breast pump. *J Hum Lact*. 2002; 18(4):344–352. [PubMed: 12449050]
21. Hill PD. Insufficient milk supply syndrome. *NAACOGS Clin Issu Perinat Womens Health Nurs*. 1992; 3(4):605–612. [PubMed: 1476839]
22. Hill PD. The enigma of insufficient milk supply. *MCN Am J Matern Child Nurs*. 1991; 16(6):312–316. [PubMed: 1824557]
23. Hill PD, Humenick SS. Development of the H & H Lactation Scale. *Nurs Res*. 1996; 45(3):136–140. [PubMed: 8637793]
24. Flaherman VJ, Hicks KG, Cabana MD, Lee KA. Maternal Experience of Interactions with Providers Among Mothers with Milk Supply Concern. *Clinical Pediatrics*. 2012
25. Chan SM, Nelson EA, Leung SS, Li CY. Breastfeeding failure in a longitudinal post-partum maternal nutrition study in Hong Kong. *J Paediatr Child Health*. 2000; 36(5):466–471. [PubMed: 11036803]
26. Lewallen LP, Dick MJ, Flowers J, Powell W, Zickefoose KT, Wall YG, et al. Breastfeeding support and early cessation. *J Obstet Gynecol Neonatal Nurs*. 2006; 35(2):166–172.
27. Amir LH, Cwikel J. Why do women stop breastfeeding? A closer look at 'not enough milk' among Israeli women in the Negev Region. *Breastfeed Rev*. 2005; 13(3):7–13. [PubMed: 16342407]
28. Schwartz K, D'Arcy HJ, Gillespie B, Bobo J, Longeway M, Foxman B. Factors associated with weaning in the first 3 months postpartum. *J Fam Pract*. 2002; 51(5):439–444. [PubMed: 12019051]
29. Rempel LA. Factors influencing the breastfeeding decisions of long-term breastfeeders. *J Hum Lact*. 2004; 20(3):306–318. [PubMed: 15296585]
30. Yang Q, Wen SW, Dubois L, Chen Y, Walker MC, Krewski D. Determinants of breast-feeding and weaning in Alberta, Canada. *J Obstet Gynaecol Can*. 2004; 26(11):975–981. [PubMed: 15560860]
31. Williams PL, Innis SM, Vogel AM, Stephen LJ. Factors influencing infant feeding practices of mothers in Vancouver. *Can J Public Health*. 1999; 90(2):114–119. [PubMed: 10349218]
32. Evans ML, Dick MJ, Lewallen LP, Jeffrey C. Modified breastfeeding attrition prediction tool: prenatal and postpartum tests. *J Perinat Educ*. 2004; 13(1):1–8.
33. Colin WB, Scott JA. Breastfeeding: reasons for starting, reasons for stopping and problems along the way. *Breastfeed Rev*. 2002; 10(2):13–19. [PubMed: 12227559]

34. Blyth R, Creedy DK, Dennis CL, Moyle W, Pratt J, De Vries SM. Effect of maternal confidence on breastfeeding duration: an application of breastfeeding self-efficacy theory. *Birth*. 2002; 29(4): 278–284. [PubMed: 12484390]
35. Forman MR, Lewando-Hundt G, Graubard BI, Chang D, Sarov B, Naggan L, et al. Factors influencing milk insufficiency and its long-term health effects: the Bedouin Infant Feeding Study. *Int J Epidemiol*. 1992; 21(1):53–58. [PubMed: 1544758]
36. Brown SL, Bright RA, Dwyer DE, Foxman B. Breast pump adverse events: reports to the food and drug administration. *J Hum Lact*. 2005; 21(2):169–174. [PubMed: 15886342]
37. Faro J, Katz A, Berens P, Ross PJ. Premature termination of nursing secondary to *Serratia marcescens* breast pump contamination. *Obstet Gynecol*. 117(2 Pt 2):485–486.
38. Morton J, Hall JY, Wong RJ, Thairu L, Benitz WE, Rhine WD. Combining hand techniques with electric pumping increases milk production in mothers of preterm infants. *J Perinatol*. 2009; 29(11):757–764. [PubMed: 19571815]
39. Zinaman MJ, Hughes V, Queenan JT, Labbok MH, Albertson B. Acute prolactin and oxytocin responses and milk yield to infant suckling and artificial methods of expression in lactating women. *Pediatrics*. 1992; 89(3):437–440. [PubMed: 1741218]
40. Becker GE, Cooney F, Smith HA. Methods of milk expression for lactating women. *Cochrane Database Syst Rev*. 12:CD006170.
41. Garza C, Johnson CA, Harrist R, Nichols BL. Effects of methods of collection and storage on nutrients in human milk. *Early Hum Dev*. 1982; 6(3):295–303. [PubMed: 7128509]
42. Boutte CA, Garza C, Fraley JK, Stuff JE, Smith EO. Comparison of hand- and electric-operated breast pumps. *Hum Nutr Appl Nutr*. 1985; 39(6):426–430. [PubMed: 4093328]
43. Green D, Moye L, Schreiner RL, Lemons JA. The relative efficacy of four methods of human milk expression. *Early Hum Dev*. 1982; 6(2):153–159. [PubMed: 7094853]
44. Hayes DK, Prince CB, Espinueva V, Fuddy LJ, Li R, Grummer-Strawn LM. Comparison of manual and electric breast pumps among WIC women returning to work or school in Hawaii. *Breastfeed Med*. 2008; 3(1):3–10. [PubMed: 18333763]
45. Hill PD, Aldag JC, Demirtas H, Naeem V, Parker NP, Zinaman MJ, et al. Association of serum prolactin and oxytocin with milk production in mothers of preterm and term infants. *Biol Res Nurs*. 2009; 10(4):340–349. [PubMed: 19224938]
46. Mennella JA, Pepino MY. Breastfeeding and prolactin levels in lactating women with a family history of alcoholism. *Pediatrics*. 125(5):e1162–1170.
47. Morse JM, Bottorff JL. The emotional experience of breast expression. *J Nurse Midwifery*. 1988; 33(4):165–170. [PubMed: 3404280]
48. Flaherman VJ, Gay B, Scott C, Aby J, Stewart AL, Lee KA. Development of the breast milk expression experience measure. *Matern Child Nutr*.
49. Morse JM, Harrison MJ, Prowse M. Minimal breastfeeding. *J Obstet Gynecol Neonatal Nurs*. 1986; 15(4):333–338.
50. Geraghty SR, Khoury JC, Kalkwarf HJ. Human milk pumping rates of mothers of singletons and mothers of multiples. *J Hum Lact*. 2005; 21(4):413–420. [PubMed: 16280557]
51. Chapman DJ, Young S, Ferris AM, Perez-Escamilla R. Impact of breast pumping on lactogenesis stage II after cesarean delivery: a randomized clinical trial. *Pediatrics*. 2001; 107(6):E94. [PubMed: 11389292]
52. Mbuya MN, Humphrey JH, Majo F, Chasekwa B, Jenkins A, Israel-Ballard K, et al. Heat treatment of expressed breast milk is a feasible option for feeding HIV-exposed, uninfected children after 6 months of age in rural Zimbabwe. *J Nutr*. 140(8):1481–1488.
53. Centers for Disease Control. Web Tables Report for the Infant Feeding Practices Study. http://cdc.gov/ifps/pdfs/data/IFPS2_tables_ch3.pdf. Published 2011. Accessed December 20, 2011
54. Flaherman VJ, Aby J, Burgos AE, Lee KA, Cabana MD, Newman TB. Randomized Trial of Early Limited Formula To Reduce Formula Use at 1 Week and Promote Breastfeeding at 3 Months in Infants with High Early Weight Loss. Boston: Abstract Presentation, Pediatric Academic Societies Annual Meeting. 2012
55. Slusher T, Hampton R, Bode-Thomas F, Pam S, Akor F, Meier P. Promoting the exclusive feeding of own mother's milk through the use of hindmilk and increased maternal milk volume for

- hospitalized, low birth weight infants (< 1800 grams) in Nigeria: a feasibility study. *Journal of human lactation: official journal of International Lactation Consultant Association*. 2003; 19(2): 191–198. [PubMed: 12744537]
56. Ohyama M, Watabe H, Hayasaka Y. Manual expression and electric breast pumping in the first 48 h after delivery. *Pediatr Int*. 52(1):39–43.
  57. Meier PP, Engstrom JL, Janes JE, Jegier BJ, Loera F. Breast pump suction patterns that mimic the human infant during breastfeeding: greater milk output in less time spent pumping for breast pump-dependent mothers with premature infants. *J Perinatol*. 2012; 32(2):103–110. [PubMed: 21818062]
  58. Geraghty S, Davidson B, Tabangin M, Morrow A. Predictors of breastmilk expression by 1 month postpartum and influence on breastmilk feeding duration. *Breastfeed Med*. 7(2):112–117.
  59. Flaherman VJ, Gay B, Scott C, Avins A, Lee KA, Newman TB. Randomised trial comparing hand expression with breast pumping for mothers of term newborns feeding poorly. *Arch Dis Child Fetal Neonatal Ed*. 97(1):F18–23.
  60. UNICEF/WHO. Baby-Friendly Hospital Initiative: Revised, Updated and Expanded for Integrated Care, Section 1, Background and Implementation, Preliminary version. http://www.who.int/nutrition/topics/BFHI_Revised_Section1.pdf. Published 2006. Accessed January 17, 2008
  61. ABM Clinical Protocol #2 (2007 revision): guidelines for hospital discharge of the breastfeeding term newborn and mother: “the going home protocol”. *Breastfeed Med*. 2007; 2(3):158–165. [PubMed: 17903102]
  62. Centers for Disease Control. Vital Signs: Hospital Support for Breastfeeding. <http://www.cdc.gov/VitalSigns/Breastfeeding/>. Published 2011. Accessed February 1, 2012
  63. Auerbach KG, Guss E. Maternal employment and breastfeeding. A study of 567 women’s experiences. *Am J Dis Child*. 1984; 138(10):958–960. [PubMed: 6475857]
  64. Hills-Bonczyk SG, Avery MD, Savik K, Potter S, Duckett LJ. Women’s experiences with combining breast-feeding and employment. *J Nurse Midwifery*. 1993; 38(5):257–266. [PubMed: 8246081]
  65. Whaley SE, Meehan K, Lange L, Slusser W, Jenks E. Predictors of breastfeeding duration for employees of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). *J Am Diet Assoc*. 2002; 102(9):1290–1293. [PubMed: 12792629]
  66. Forte A, Mayberry LJ, Ferketich S. Breast milk collection and storage practices among mothers of hospitalized neonates. *J Perinatol*. 1987; 7(1):35–39. [PubMed: 3507540]
  67. Auerbach KG, Walker M. When the mother of a premature infant uses a breast pump: what every NICU nurse needs to know. *Neonatal Netw*. 1994; 13(4):23–29.
  68. Chamberlain LB, McMahon M, Philipp BL, Merewood A. Breast pump access in the inner city: a hospital-based initiative to provide breast pumps for low-income women. *J Hum Lact*. 2006; 22(1): 94–98. [PubMed: 16467290]
  69. Nyqvist KH, Sjoden PO, Ewald U. Mothers’ advice about facilitating breastfeeding in a neonatal intensive care unit. *J Hum Lact*. 1994; 10(4):237–243. [PubMed: 7619278]
  70. Chen PG, Johnson LW, Rosenthal MS. Sources of Education About Breastfeeding and Breast Pump Use: What Effect do they Have on Breastfeeding Duration? An Analysis of the Infant Feeding Practices Survey II. *Matern Child Health J*.
  71. Hamosh M, Ellis LA, Pollock DR, Henderson TR, Hamosh P. Breastfeeding and the working mother: effect of time and temperature of short-term storage on proteolysis, lipolysis, and bacterial growth in milk. *Pediatrics*. 1996; 97(4):492–498. [PubMed: 8632934]
  72. Buss IH, McGill F, Darlow BA, Winterbourn CC. Vitamin C is reduced in human milk after storage. *Acta Paediatr*. 2001; 90(7):813–815. [PubMed: 11519987]
  73. Bank MR, Kirksey A, West K, Giacoia G. Effect of storage time and temperature on folacin and vitamin C levels in term and preterm human milk. *Am J Clin Nutr*. 1985; 41(2):235–242. [PubMed: 3969932]
  74. ABM clinical protocol #8: human milk storage information for home use for full-term infants (original protocol March 2004; revision #1 March 2010). *Breastfeed Med*. 5(3):127–130.

75. Lefebvre F, Ducharme M. Incidence and duration of lactation and lactational performance among mothers of low-birth-weight and term infants. *CMAJ: Canadian Medical Association journal = journal de l'Association medicale canadienne*. 1989; 140(10):1159–1164.
76. Hill PD, Aldag JC, Chatterton RT, Zinaman M. Comparison of milk output between mothers of preterm and term infants: the first 6 weeks after birth. *Journal of human lactation: official journal of International Lactation Consultant Association*. 2005; 21(1):22–30. [PubMed: 15681632]
77. Garite TJ, Combs CA. Obstetric interventions beneficial to prematurely delivering newborn babies: antenatal corticosteroids, progesterone, magnesium sulfate. *Clinics in perinatology*. 2012; 39(1): 33–45. [PubMed: 22341535]
78. Lee HC, Gould JB. Survival advantage associated with cesarean delivery in very low birth weight vertex neonates. *Obstetrics and gynecology*. 2006; 107(1):97–105. [PubMed: 16394046]
79. Sridhar S, Arguello S, Lee HC. Transition to Oral Feeding in Preterm Infants. *NeoReviews*. 2011; 12(3):e141–e147.
80. Alexander GR, Weiss J, Hulsey TC, Papiernik E. Preterm birth prevention: an evaluation of programs in the United States. *Birth*. 1991; 18(3):160–169. [PubMed: 1930445]
81. Lee HC, Gould JB. Factors influencing breast milk versus formula feeding at discharge for very low birth weight infants in California. *The Journal of pediatrics*. 2009; 155(5):657–662. e651–652. [PubMed: 19628218]
82. Flacking R, Wallin L, Ewald U. Perinatal and socioeconomic determinants of breastfeeding duration in very preterm infants. *Acta Paediatr*. 2007; 96(8):1126–1130. [PubMed: 17578487]
83. Wiemann CM, DuBois JC, Berenson AB. Racial/Ethnic Differences in the Decision to Breastfeed Among Adolescent Mothers. *Pediatrics*. 1998; 101(6):e11.
84. Maehr JC, Lizarraga JL, Wingard DL, Felice ME. A comparative study of adolescent and adult mothers who intend to breastfeed. *The Journal of adolescent health: official publication of the Society for Adolescent Medicine*. 1993; 14(6):453–457. [PubMed: 8241202]
85. Hill GJ, Arnett DB, Mauk E. Breast-feeding intentions among low-income pregnant and lactating women. *American journal of health behavior*. 2008; 32(2):125–136. [PubMed: 18052853]
86. Lu MC, Prentice J, Yu SM, Inkelas M, Lange LO, Halfon N. Childbirth education classes: sociodemographic disparities in attendance and the association of attendance with breastfeeding initiation. *Maternal and child health journal*. 2003; 7(2):87–93. [PubMed: 12870624]
87. Bailey JM, Crane P, Nugent CE. Childbirth education and birth plans. *Obstetrics and gynecology clinics of North America*. 2008; 35(3):497–509, ix. [PubMed: 18760232]
88. Rice SJ, Craig D, McCormick F, Renfrew MJ, Williams AF. Economic evaluation of enhanced staff contact for the promotion of breastfeeding for low birth weight infants. *International journal of technology assessment in health care*. 2010; 26(2):133–140. [PubMed: 20392315]
89. Patel AL, Meier PP, Engstrom JL. The Evidence for Use of Human Milk in Very Low-birthweight Preterm Infants. *NeoReviews*. 2007; 8:e459–466.
90. Schanler RJ. The use of human milk for premature infants. *Pediatric clinics of North America*. 2001; 48(1):207–219. [PubMed: 11236727]
91. Sisk PM, Lovelady CA, Dillard RG, Gruber KJ, O'Shea TM. Early human milk feeding is associated with a lower risk of necrotizing enterocolitis in very low birth weight infants. *J Perinatol*. 2007; 27(7):428–433. [PubMed: 17443195]
92. Merewood A. Breastfeeding: Promotion of a Low-tech Lifesaver. *NeoReviews*. 2007; 8(7):e296–e300.
93. Sisk PM, Lovelady CA, Dillard RG, Gruber KJ. Lactation counseling for mothers of very low birth weight infants: effect on maternal anxiety and infant intake of human milk. *Pediatrics*. 2006; 117(1):e67–75. [PubMed: 16396850]
94. California Perinatal Quality Care Collaborative. Nutritional Support of the Very Low Birth Weight Infant. California Perinatal Quality Care Collaborative. 2008
95. Pineda RG, Foss J, Richards L, Pane CA. Breastfeeding changes for VLBW infants in the NICU following staff education. *Neonatal network: NN*. 2009; 28(5):311–319. [PubMed: 19720595]
96. Renfrew MJ, Craig D, Dyson L, McCormick F, Rice S, King SE, et al. Breastfeeding promotion for infants in neonatal units: a systematic review and economic analysis. *Health Technol Assess*. 2009; 13(40):1–146. iii–iv.

97. Furman L, Minich N, Hack M. Correlates of lactation in mothers of very low birth weight infants. *Pediatrics*. 2002; 109(4):e57. [PubMed: 11927730]
98. Meier PP, Engstrom JL, Mingoelli SS, Miracle DJ, Kiesling S. The Rush Mothers' Milk Club: breastfeeding interventions for mothers with very-low-birth-weight infants. *Journal of obstetric, gynecologic, and neonatal nursing: JOGNN/NAACOG*. 2004; 33(2):164–174.
99. Lee HC, Kurtin PS, Wight NE, Chance K, Cucinotta-Fobes T, Hanson-Timpson TA, et al. A Quality Improvement Project to Increase Breastmilk Use in Very Low Birth Weight Infants. *Pediatrics*. In press - accepted June 18, 2012.
100. Dougherty D, Luther M. Birth to breast—a feeding care map for the NICU: helping the extremely low birth weight infant navigate the course. *Neonatal network: NN*. 2008; 27(6):371–377. [PubMed: 19065966]
101. Merewood A, Philipp BL, Chawla N, Cimo S. The baby-friendly hospital initiative increases breastfeeding rates in a US neonatal intensive care unit. *Journal of human lactation: official journal of International Lactation Consultant Association*. 2003; 19(2):166–171. [PubMed: 12744533]
102. Parker LA, Sullivan S, Krueger C, Kelechi T, Mueller M. Effect of early breast milk expression on milk volume and timing of lactogenesis stage II among mothers of very low birth weight infants: a pilot study. *J Perinatol*. 2012; 32(3):205–209. [PubMed: 21904296]
103. Henderson JJ, Hartmann PE, Newnham JP, Simmer K. Effect of preterm birth and antenatal corticosteroid treatment on lactogenesis II in women. *Pediatrics*. 2008; 121(1):e92–100. [PubMed: 18166549]
104. Engstrom JL, Meier PP, Jegier B, Motykowski JE, Zuleger JL. Comparison of milk output from the right and left breasts during simultaneous pumping in mothers of very low birthweight infants. *Breastfeeding medicine: the official journal of the Academy of Breastfeeding Medicine*. 2007; 2(2):83–91. [PubMed: 17661579]
105. Hill PD, Aldag JC, Zinaman M, Chatterton RT Jr. Comparison of milk output between breasts in pump-dependent mothers. *Journal of human lactation: official journal of International Lactation Consultant Association*. 2007; 23(4):333–337. [PubMed: 17991798]
106. Meier, PP., Brown, LP., Hurst, NM. Breastfeeding the preterm infant. In: Riordan, J., Auerbach, KG., editors. *Breastfeeding and Human Lactation*. 2nd. Boston: Jones & Bartlett; 1998. p. 449-473.
107. Meier PP. Breastfeeding in the special care nursery. Prematures and infants with medical problems. *Pediatric clinics of North America*. 2001; 48(2):425–442. [PubMed: 11339162]
108. Feher SD, Berger LR, Johnson JD, Wilde JB. Increasing breast milk production for premature infants with a relaxation/imagery audiotape. *Pediatrics*. 1989; 83(1):57–60. [PubMed: 2642620]
109. Spatz DL. Ten steps for promoting and protecting breastfeeding for vulnerable infants. *The Journal of perinatal & neonatal nursing*. 2004; 18(4):385–396. [PubMed: 15646308]
110. Appendix 4-L1. #1 Sample Letter: Explanation of Medical Need for Breast Pump. California Perinatal Quality Care Collaborative. *Nutritional Support of the Very Low Birth Weight Infant*. 2008:100–101.
111. Fewtrell MS, Lucas P, Collier S, Singhal A, Ahluwalia JS, Lucas A. Randomized trial comparing the efficacy of a novel manual breast pump with a standard electric breast pump in mothers who delivered preterm infants. *Pediatrics*. 2001; 107(6):1291–1297. [PubMed: 11389245]
112. Hill PD, Aldag JC, Chatterton RT. Effects of pumping style on milk production in mothers of non-nursing preterm infants. *Journal of human lactation: official journal of International Lactation Consultant Association*. 1999; 15(3):209–216. [PubMed: 10578798]
113. Morton J, Wong RJ, Hall JY, Pang WW, Lai CT, Lui J, et al. Combining hand techniques with electric pumping increases the caloric content of milk in mothers of preterm infants. *J Perinatol*. 2012
114. Paul VK, Singh M, Deorari AK, Pacheco J, Taneja U. Manual and pump methods of expression of breast milk. *Indian journal of pediatrics*. 1996; 63(1):87–92. [PubMed: 10829970]
115. Killersreiter B, Grimmer I, Buhner C, Dudenhausen JW, Obladen M. Early cessation of breast milk feeding in very low birthweight infants. *Early human development*. 2001; 60(3):193–205. [PubMed: 11146238]

116. 2011 Best Practice for Expressing, Storing and Handling Human Milk in Hospitals, Homes, and Child Care Settings (3rd). 2011 HMBANA.
117. Bryant P, Morley C, Garland S, Curtis N. Cytomegalovirus transmission from breast milk in premature babies: does it matter? *Archives of disease in childhood Fetal and neonatal edition*. 2002; 87(2):F75–77. [PubMed: 12193509]
118. Hamprecht K, Goelz R, Maschmann J. Breast milk and cytomegalovirus infection in preterm infants. *Early human development*. 2005; 81(12):989–996. [PubMed: 16278059]
119. Hamprecht K, Maschmann J, Muller D, Dietz K, Besenthal I, Goelz R, et al. Cytomegalovirus (CMV) inactivation in breast milk: reassessment of pasteurization and freeze-thawing. *Pediatric research*. 2004; 56(4):529–535. [PubMed: 15295084]
120. Lee HC, Enright A, Benitz WE, Madan A. Postnatal cytomegalovirus infection from frozen breast milk in preterm, low birth weight infants. *The Pediatric infectious disease journal*. 2007; 26(3): 276.
121. Maschmann J, Hamprecht K, Weissbrich B, Dietz K, Jahn G, Speer CP. Freeze-thawing of breast milk does not prevent cytomegalovirus transmission to a preterm infant. *Archives of disease in childhood Fetal and neonatal edition*. 2006; 91(4):F288–290. [PubMed: 16790732]
122. Meier PP, Engstrom JL. Evidence-based Practices to Promote Exclusive Feeding of Human Milk in Very Low-birthweight Infants. *NeoReviews*. 2007; 8(11):e467–e477.
123. Wight, NE., Morton, JA., Kim, JH. *Best Medicine: Human Milk in the NICU*. Amarillo, TX: Hale Publishing; 2008. *Managing Breastfeeding in the NICU*; p. 97-135.
124. Hurst, NM., Meier, PP. Breastfeeding the preterm infant. In: Riordan, J., Sudbury, M., editors. *Breastfeeding and human lactation*. London: Jones & Bartlett; 2005. p. 367-408.
125. Edwards TM, Spatz DL. An innovative model for achieving breast-feeding success in infants with complex surgical anomalies. *The Journal of perinatal & neonatal nursing*. 2010; 24(3):246–253. quiz 254–245. [PubMed: 20697242]

Synopsis

The purpose of this article is to provide the pediatric community with a practical overview of milk expression and an update on the recent literature. Approaches for employed mothers, preterm infants, critically ill infants and mothers prior to lactogenesis II are presented separately, as these groups may benefit from practices tailored to individual needs.

Key Points

- ◆ 85% of breastfeeding mothers have expressed milk
- ◆ Milk may be expressed by hand expression, hand-powered pumping or electric pumping
- ◆ For working mothers, bilateral electric pumps are often more convenient than other methods, but individual mothers may prefer alternative methods
- ◆ For mothers of infants who cannot breastfeed directly, including preterm infants, bilateral electric breast pumps are important for developing and maintaining milk supply, and may be used in conjunction with hand techniques
- ◆ For mothers of healthy term infants who have not yet experienced lactogenesis II, hand expression may be preferable to pumping

Table 1

Terminology of milk expression.

Hand expression
- also called manual expression   - when a mother uses her hands to exert pressure on her breast for milk expression
Breast pumping
- using a pump to generate a vacuum similar to that generated by the oral cavity of a feeding newborn   - 2 types: - o Electrical pump   ■ Powered by battery or direct electrical current   - o Hand pump   ■ Manual pumping by the mother
“Hands-on pumping”
- combines breast compression/hand expression with simultaneous bilateral electric breast pumping   - may be especially useful for mothers of premature newborns

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Table 2

Studies comparing types of milk expression for mothers after the onset of lactogenesis II

Type of study	Author/Year ^{ref}	Country	Comparison groups	Finding
Randomized controlled or crossover trials in mothers of premature infants or sick patients in the NICU	Fewtrell 2001 ¹¹¹	UK	Hand pump vs electric pump	Similar volumes with simultaneous electric pump/ Manual pump with greater volume when sequentially pumped.
	Groh-Wargo 1995 ¹²	US	Simultaneous (bilateral) electric pump vs single electric pump	No difference in milk volumes. Decreased time spent for simultaneous pump.
	Hill 1999 ¹¹²	US	Simultaneous vs single electric pump	No difference in milk volumes.
	Jones 2001 ¹¹	UK	Simultaneous vs sequential electric pumping, +/- breast massage	Simultaneous pumping resulted in greater volume compared to sequential; breast massage had additive effect for both.
	Meier 2012	US	Different electric pump suction patterns (2 groups – both simultaneous electric pumping)	A regimen with an “initiation” pattern mimicking a term infant’s rapid sucking rate and irregular sucking rhythm, when used prior to lactogenesis II, resulted in higher volume than a standard pattern.
	Paul 1996 ¹¹⁴	India	Manual expression vs hand pump	Hand pump resulted in greater expression.
	Slusher 2007 ⁴	Kenya and Nigeria	Electric pump, foot-operated pedal pump, and manual expression	Electric pump resulted in greater expression.
Crossover design for mothers of term infants (mothers that may be returning to work or school)	Auerbach 1990 ¹³	US	Simultaneous vs single electric pump	Simultaneous pumping resulted in greater volume.
	Green 1982 ⁴³	US	Electric pump vs hand pump vs manual	Electric pumping resulted in greater volume than either hand pump or manual expression, the latter two which had similar results.
Observational study of mothers of premature infants	Morton 2009 ³⁸	US	Pre/post design of teaching “hands-on pumping”	Hands-on pumping resulted in increased milk expression volumes.

Table 3

Resources for milk expression.

Websites:

Breastfeeding the High Risk Newborn (Lucile Packard Children's Hospital at Stanford)
<http://www.lpch.org/DiseaseHealthInfo/HealthLibrary/hrnewborn/bresthub.html>

Office of Women's Health, U.S. Department of Health and Human Services
<http://www.womenshealth.gov/breastfeeding/>

La Leche League International
<http://www.lalecheleague.org/>

Videos:

Video of hand expression (Newborn Nursery at Lucile Packard Children's Hospital)
<http://newborns.stanford.edu/Breastfeeding/HandExpression.html>

The Marmet Hand Expression Technique (about.com)
<http://video.about.com/breastfeeding/Hand-Expression-Technique.htm>

A Premie Needs His Mother. First Steps to Breastfeeding Your Premature Baby. Jane Morton, MD
http://www.breastmilkssolutions.com/premie_needs.html

Books:

The Womanly Art of Breastfeeding by the La Leche League

The Breastfeeding Mother's Guide to Making More Milk by Diana West

Nursing Mother, Working Mother, Revised Edition by Gale Pryor and Kathleen Huggins

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