

Innovations in the Provision of Human Milk and Breastfeeding for Infants Requiring Intensive Care

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ABSTRACT

Infant admission to the Neonatal Intensive Care Unit requires that the family receives the scientific rationale for the importance of providing human milk for their child. The initiation and maintenance of maternal milk supply must be a priority. Understanding variation in milk composition is crucial so that the infant receives the most appropriate milk throughout the hospital stay. For mothers who wish to breastfeed, a detailed and planned process is essential to ensure success.

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Human milk is the preferred form of nutrition for all infants. For many infants admitted to a Neonatal Intensive Care Unit (NICU), breastfeeding cannot proceed in the traditional fashion. For mothers who planned to breastfeed prior to their child's NICU admission, the loss of control over breastfeeding can cause stress and anxiety. For a mother who had no intention of breastfeeding, she should be informed about the provision of human milk and not breastfeeding per se. Health care providers should ensure that human milk and breastfeeding are priorities in the NICU. Each family should be encouraged to meet their personal goals for providing human milk/breastfeeding their child. The first step in the journey of providing human milk and breastfeeding in the NICU is ensuring that all family members understand the unique ways in which human milk will help their children be healthier.

Informed Decision

The lack of health care provider knowledge about human milk and breastfeeding has been well documented (U.S. Department of Health and Human Services, 2011). In addition, though many women know breastfeeding is beneficial for their infants, few can articulate the exact mechanisms of how

human milk protects their infant from disease and illness (U.S. Department of Health and Human Services). The ideal time to educate the family about the benefits related to human milk for infant nutrition is before admission to the NICU. High-risk infants are often the product of high-risk pregnancies, therefore, opportunities often exist during pregnancy for a breastfeeding consultation prior to birth.

Nurses play a critical role in the provision of evidence-based lactation support and are the ideal persons to meet with the mother prior to delivery (Spatz, 2010a, 2010b). At the Children's Hospital of Philadelphia (CHOP), a well-established prenatal lactation consultation program exists. Prior to delivery in CHOP's Special Delivery Unit (SDU) and as a part of routine prenatal care, an advanced practice nurse meets with each mother for an individualized prenatal consult with the focus being on the provision of human milk. Four key components about the provision of human milk taught to the family include the following: (a) protection of the infant from nosocomial infections; (b) improved enteral feeding tolerance and reduction in the incidence and severity of necrotizing enterocolitis (Rodriguez, Miracle, & Meier, 2005); (c) developmental and immunobiologic properties of

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human milk (Kim & Froh, 2012); and (d) empowerment of the mother by allowing her to participate in her child's care to promote her child's health and development while in the NICU. Women and their families have a right to make an informed choice about providing human milk for their infant in the NICU, and health care providers have the responsibility to provide the family with research-based information. Researchers found that prenatal lactation consultation focused on informed decision can result in an increase of pumping initiation rates to more than 95% (Edwards & Spatz, 2010).

Initiation of Milk Supply & Use of Colostrum

In the healthy breastfeeding dyad, breastfeeding initiation is recommended immediately postbirth and ideally within the first hour (World Health Organization [WHO], 2010). Therefore, when maternal infant separation occurs, the early initiation of pumping is essential. For mothers with vaginal births, pumping initiation should occur within 2 hours, and for mothers with Cesarean births, pumping initiation should occur within 4 hours to be consistent with WHO guidelines. Several measures that can facilitate this practice include available equipment and nursing support.

For instance, it is important to have bedside pumps in the labor and delivery area or at each postpartum bedside. The availability of a bedside pumping log to track 24-hour milk production and to evaluate the progression of the mother's milk volume is essential. Importantly, nurses who provide around the clock care to new postpartum mothers are the best persons to assist the mother with the initiation of pumping and ensure that the mother is pumping every 2 to 3 hours for a goal of eight pumping sessions in a 24-hour period (Spatz, 2004).

New pumping technology allows mothers to maximize removal of colostrum from the breast and achieve "normal" milk production more successfully (Meier, Engstrom, Janes, Jegier, & Loera, 2011). The Premie Plus pattern development was field tested and adjusted until mothers reported that the pattern was effective, efficient, comfortable, and convenient (Meier et al.). This pumping pattern led to mothers obtaining more milk by Day 4 and a statistically significant increase in milk production beginning on Day 6 when compared to women who initiated pumping with the standard Symphony two-phase expression pattern (Meier et al.). This author's experience with the Premie

Upon admission to the Neonatal Intensive Care Unit, the emphasis should be on the provision of human milk, not breastfeeding per se.

Plus pattern in clinical practice is that many mothers will get a substantial amount of colostrum (1–20 milliliters) out on the first few pumping sessions, followed by some "dry" pumping sessions or pumping sessions yielding only drops, followed by increasing milk volumes. Mothers who used the Premie Plus pattern for the research study did so until the onset of lactogenesis II, which is the time when copious amounts of mature milk is produced (Meier et al.). In clinical practice, mothers may find it valuable to use this pattern until they achieve approximately 20 milliliters per breast per pump.

Smaller collection containers are ideal, as large containers often packaged with most pump kits are intimidating for mothers. Teaching families about normal milk volumes ingested by healthy infants is important, as mothers can feel pumping is not worthwhile or that they are doing something wrong when they are only obtaining small amounts of milk. Santoro, Martinez, Ricco, and Jorge (2010) found that mean daily intake of colostrum in the first 24 hours of life is 15 grams \pm 11 grams, which is equivalent to 15 milliliters \pm 11 grams. The milk transfer per feed was 1.5 \pm 1.1 grams as measured with a highly sensitive scale (Santoro et al.). Sharing this science with families will help them to understand the normality of achieving a few drops or milliliters with the first few days of pumping and stress the importance of maintaining a pumping schedule as compared to focusing on the amount of the volume collected.

The nurse should also teach the family to take special care when labeling and storing the colostrum. The antioxidant and radical scavenging properties of colostrum are significantly different than transitional and mature milk (Zarban, Taheri, Chahkandi, Sharifzadeh, & Khorashadizadeh, 2009). Therefore, labeling the colostrum in the exact pumping order is necessary for easy identification during the initiation of enteral human milk feeds. Family members can assist in sequential numbering of each milk collection container. Families and nurses valued this type of family involvement in the care of their infants (Spatz, 2004).

Before freezing the colostrum for later use for enteral feeds, oral care should be initiated (Rodriguez et al., 2010) due to the potential

immunomodulatory protection from infection. Colostrum is rich in cytokines and other immune agents that may have immunomodulatory effects in the infant (Rodriguez et al.). Research demonstrates that administration of mother's own colostrum is easy, inexpensive, and well tolerated by even the most critically ill infants (Rodriguez et al.). During oral care, the mother or father is first taught to use appropriate hand hygiene. Next, they are instructed to use their finger to take even the smallest drops of colostrum and to apply the colostrum to the infant's lips and inside of the mouth (Spatz & Edwards, 2009). With larger amounts of colostrum or mature milk, a sterile swab is practical to use. This milk-saturated swab is used to paint the inside of the infant's cheeks with the milk by the parents (Spatz & Edwards).

Teaching a mother to perform oral care with colostrum or mature milk every time she pumps at the bedside is vital as is instructing her to leave a small amount of mature milk (5–10 milliliters) once establishing milk supply for oral care use during periods of her absence. The nurse can use this milk to perform oral care with a sterile swab every 3 hours while providing other care to the infant. Beside the potential immunomodulatory protection from infection for the infant, this technique is an excellent means for establishing attachment between parents and infants. Even the most critically ill infants respond to oral care with tongue motions and suckling behavior, and this interaction can be meaningful to the parents. If mother is able, she can pump directly at the infant's bedside, but if this is not feasible or the mother is at a different institution, families are instructed to bring the colostrum to the NICU in a fresh and refrigerated state.

Maintenance of Milk Supply and Feeding of Human Milk

A milk production goal of 500 to 1,000 milliliters per day by the end of the first week is set for the mother to ensure adequate volumes of milk to feed to the infant through discharge from the NICU (Spatz, 2004). On a daily basis, the NICU nurse or the NICU lactation consultant should go over the pumping log with the mother to evaluate the total number of pumping sessions per day and the total daily volume. A large variation in individual mother's production capacities for making milk exists. Mothers with smaller production capacity (500 milliliters per day) will probably always have to maintain a pumping schedule of every 2 to 3 hours to maintain supply. Mothers with

large storage capacity (≥ 800 –1,000 milliliters per day) may be able to decrease the frequency of their pumping provided overall daily volumes are sustainable (Spatz, 2006). Daily monitoring of milk supply by the NICU nurse will ensure that the infant can achieve a diet of exclusive human milk through the entire hospital stay.

When the infant is stable to receive enteral feeds, the order of the colostrum feeding matches the order the mother expressed it. Colostrum should be used for minimal enteral nutrition. The immunobiological components of colostrum are critical in establishment of positive gut flora and priming the fragile gut wall. Following 48 to 96 hours of colostrum (to mimic the experience of a healthy term infant), the infant should receive freshly pumped and refrigerated milk from the mother. Frozen milk is an "emergency" backup supply when fresh milk is not available. Although frozen thawed milk has extensive advantages over formula, the immunobiological properties of human milk are not the same after freezing (Kim & Froh, 2012). Furthermore, Akinbi et al. (2010) documented that effectiveness of the immune properties of human milk is reduced with freezing and pasteurization, and the risk of bacterial proliferation is increased (Akinbi et al.).

Nurses are in the ideal position to prioritize fresh milk feeds for the infant in the NICU. On a daily basis, the nurse should educate the family about the infant's 24-hour enteral feeding intake requirements. After a long period between pumping sessions, the breasts will be fuller, which will result in an overall lower caloric density of the milk (Daly, Di Rosso, Owens, & Hartmann, 1993). Evaluating the caloric density of human milk is easily performed with a creatocrit (Meier et al., 2006). Fat and calories are the most variable component in human milk. Therefore, evaluating individual pumping sessions for caloric density in the NICU is important.

New research also demonstrates that preterm milk is higher in fat, protein, and carbohydrate and that these differences persist for 8-weeks postdelivery (Bauer & Geress, 2011). Related to the significant differences in human milk dependent upon gestational age are the concepts of fortification and evaluation of nutrient content. Two important innovations in the feeding of human milk to NICU infants are the ability to measure macronutrients in mother's milk reliably and without analyzing milk samples in a laboratory, and a human milk fortifier made from human milk.

Prolacta Plus is a human milk fortifier made from human milk, unlike traditionally available human milk fortifier made from cow's milk. Sullivan et al. (2010) demonstrated a significant reduction in the rate of necrotizing enterocolitis when feeding very low-birth-weight infants on an exclusive human milk diet with fortifier made from human milk. Currently, the main barrier to the widespread use of this product is cost that is approximately \$5.63 per milliliter (Sullivan et al.). Granted, the benefits of this product may well outweigh the costs, but until NICUs can receive reimbursement for the product, the use will likely be limited.

New technology also now allows for performing nutrient analysis of human milk using a mid-infrared analyzer. Miris AB (Uppsala, Sweden) has developed a mid-infrared human milk analyzer that has been evaluated by researchers who concluded that it can provide a practical measurement of macronutrients in human milk (Casadio et al., 2010). Efficient and reliable analysis of nutrient content of human milk will allow clinicians to more appropriately fortify the milk.

Recently, Arslanoglu, Moro, Ekhard, Ziegler and the World Association of Perinatal Medicine Working Group on Nutrition (WAPM) (2010) recommended individualized fortification for infants in the NICU to optimize human milk fortification. Two methods are suggested: adjustable fortification and targeted fortification. Targeted fortification requires the NICU to have access to a human milk analyzer as described above. Human milk is periodically analyzed and a target nutrient intake (protein) is chosen based on predefined requirements of NICU infants. The amount of fortifier added to the human milk is calculated to reach the targeted goal (Arslanoglu et al.).

Adjustable fortification of the human milk feeding considers the infant's metabolic response evaluated through periodic sampling of the infant's blood urea nitrogen, for adjustment of protein intake (Arslanoglu et al., 2010). Adjustable fortification does not make any assumptions regarding the infant's protein needs, avoids possible excessive protein intake, and does not require routine nutrient analysis (Arslanoglu et al.). Therefore, using adjustable fortification is a beneficial technique in NICUs to help infants receive the proper nutrition.

Additionally, human milk may be adapted for the NICU infant with chylous pleural effusions. Chan and Lechtenberg (2007) described centrifuging mother's own milk at 3000 r.p.m for 15 minutes

Nurses must understand concepts of the immunobiological and nutritional contents of human milk and prioritize feeds based on the science.

at 2 degrees Celsius and fed the fat-free milk to seven infants with chylous pleural effusions (presence of chyle in the thoracic cavity) after one month of age. The infants were on the fat-free milk for an average of 16 days (range 7–34), and no reaccumulation of the chylous pleural effusions was detected in any of the infants (Chan & Lechtenberg). In our NICU, we have been able to adapt this technique for some infants without the use of the cold centrifuge. When treating NICU infants with chylothorax, modifying human milk so that the infant still benefits from the immunobiological properties of the milk is considered.

Instructing mothers to let their milk sit undisturbed until the fat rises to the top is key (Lessen, 2009). Initially, mothers should let the milk set in breast milk containers, placing a nasogastric tube in the bottom of the container at the bottom of the milk and carefully aspirating the skim milk into a syringe leaving the fat behind (Lessen). We have since modified this technique and have mothers store their milk in 60-milliliter syringes upright in a breast milk container. Once the fat layer has risen to the top, we gently squirt the skimmed milk into the container. Performing a crematocrit on all skim milk collected to ensure that milk content is less than 1% milk fat is essential.

Transition to Breastfeeding

The process of preparing a NICU infant for breastfeeding begins as soon as the mother makes the informed decision to provide milk. Spatz (2004) detailed 10 specific steps that protect and promote breastfeeding in vulnerable infants including informed decision, establishment and maintenance of milk supply, breast milk management, feeding of breast milk, skin-to-skin care, nonnutritive sucking at the breast, transition to breast, measuring milk transfer, preparation for discharge, and appropriate follow-up.

These 10 steps have been collapsed into a five-step pathway that can be implemented by the bedside nurse to achieve breastfeeding success with even the most vulnerable infants (Edwards & Spatz, 2010), including the initiation of pumping and maintenance of milk supply, mouth care

Following a transition to breast, using a five-step breastfeeding pathway may allow even the most vulnerable of infants to achieve breastfeeding success.

with human milk, skin-to-skin care, nonnutritive sucking at the breast, and transitioning to breast feeds.

Initiation of pumping and maintenance of milk supply and oral care with human milk were previously discussed. The next step of the pathway is skin-to-skin contact. The research on skin-to-skin contact demonstrates numerous benefits for infants including improved oxygen and heart rate stability, temperature stability, and transition to breastfeeding (Moore, Anderson, & Bergman, 2007). For the mother, skin-to-skin contact has been associated with improved milk production and successful transition to breastfeeding as well as longer breastfeeding duration (Conde-Agudelo, Belizan, & Diaz-Rossello, 2000).

Initiating nonnutritive sucking at the breast as soon as the infant is extubated and exhibits cardio-respiratory stability is vital. If the infant is on a strict feed advance or concern exists about the infant's ability to swallow milk safely, the mother should be instructed to completely empty her breast with a hospital-grade breast pump (Edwards & Spatz, 2010). The ideal time for an infant to participate in nonnutritive sucking is during the time he is receiving a bolus nasogastric feed, thus allowing the infant to associate the feeling of fullness in his stomach with close physical contact to the breast.

Once the infant is ready for nutritive suckling, using pre- and postweights until the infant is able to demonstrate effective feeding from the breast at all breastfeeding sessions is needed (Spatz, 2004). More recently Haase, Barreira, Murphy, Mueller, and Rhodes (2009) documented that correlation coefficient values of weight gain by test weight to actual volume of intake were 0.998 and 0.997 for infants without electrode leads and for infants with electrode leads, respectively (infants with electrode leads were those requiring continuous monitoring and could not be disconnected from the monitors and/or oxygen tubing). The data from this research further supports the use of pre- and postweights as an accurate and objective measurement of milk transfer (Haase et al.). For the NICU infant pre- and postweights are essential to preserve the breastfeeding relation-

ship and prevent under- or overfeeding of the infant. Clinically, many infants may not achieve 100% of feeds at the breast prior to discharge, so counseling mothers to obtain a scale for a home use for the first few weeks postdischarge is necessary.

Over time, the infant in the NICU will become more efficient and effective at milk removal from the breast. New research demonstrated that vacuum plays an important role in milk removal (Geddes, Kent, Mitoulas, & Hartmann, 2008). It is important to counsel mothers of NICU infants that over time the infant will be able to exert stronger vacuum on the breast and will increase the volume of milk transferred. During this time, counseling mothers to continue their current pumping regimen and to pump after the infant breastfeeds to maintain milk supply is necessary.

The thin silicone nipple shield can be a useful device to facilitate milk transfer during early breastfeeding for an infant who is not transferring adequate volume. Meier et al. (2000) found that using the nipple shield increased the number of sucking bursts and the volume of milk consumed. Mothers should be encouraged to use the nipple shield for all breastfeeding sessions until the baby is efficient at the breast. Once the infant is able to take all feeds from the breast with the shield, the mother can gradually wean the infant from the shield. Our data demonstrated that most infants needed the shield for an average of 32.5 days (Meier et al.). Most likely, infant weaning off the shield occurs in the postdischarge period.

As the NICU infant approaches discharge, establishing a breastfeeding and pumping plan for home is important. Most mothers will need to continue to pump to maintain supply while the infant improves efficiency at the breast. A plan should be developed with the mother for the infant's 24-hour minimum intake based on the infant's weight; usually 150 to 180 milliliters/kg (Spatz, 2004). Instructing a mother to breastfeed based on her infant's feeding cues and reminding her that crying is a late hunger cue is essential. Each mother should be encouraged to have substantial skin-to-skin contact with her infant once at home to facilitate breastfeeding. The first month at home will require a great deal of dedication of the mother. The nurse needs to reassure the mother that this commitment in the early weeks postdischarge will pay off and that the process of breastfeeding her baby will become easier and more natural.

Conclusion

To ensure best practices in the NICU related to the use of human milk and breastfeeding, nurses must embrace innovation and the use of technology. Providing human milk and breastfeeding may be more time intensive, but the effort is warranted given the improved health outcomes of infants who receive the maximal exposure to mother's milk.

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