

How NICU
Syringe Choice
Can Reduce Fat
Loss In Human
Breast Milk

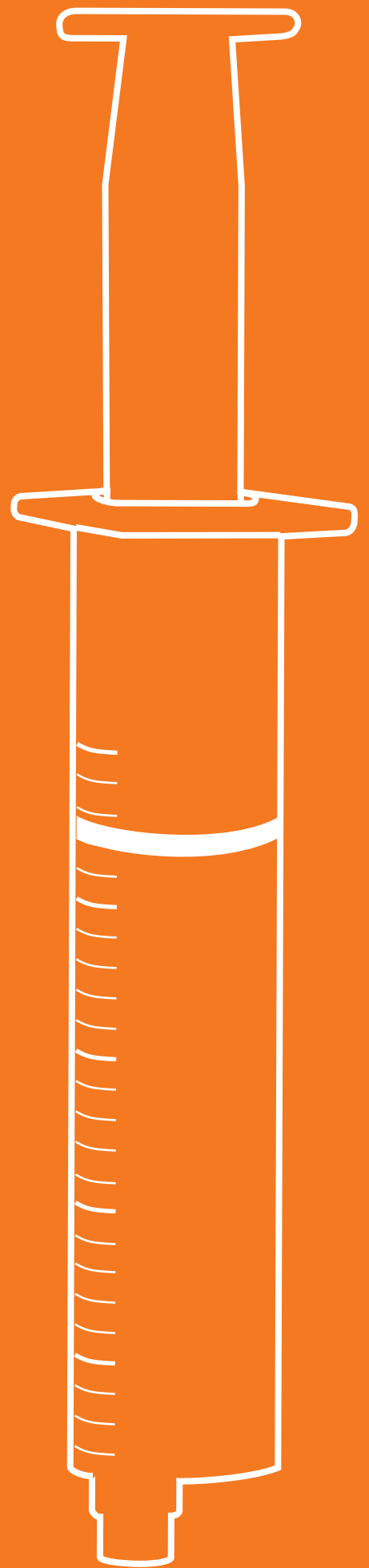


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Background Information

The Benefits of Human Breast Milk

“Human milk is species-specific, and all substitute feeding preparations differ markedly from it, making human milk uniquely superior for infant feeding.”

Hambraeus L, Forsum E, Lönnerdal B. Nutritional aspects of breast milk and cow's milk formulas. In: Hambraeus L, Hanson L, MacFarlane H, eds. *Symposium on Food and Immunology*. Stockholm, Sweden: Almqvist and Wiksell; 1975.



The importance of human breast milk (HBM) in the development of neonates and infants is well established. Lois Arnold, in Human Milk in the NICU¹ identifies several benefits of human milk for the preterm infant, summarized below:

Species Specificity

HBM is tailored for human infants.

Gut Development

HBM coats and protects the gut with high levels of immune proteins and antibodies, contains growth factors to support growth of absorptive cells found in the gut lining, supports gut closure, and reduces permeability to pathogens.

Disease Protection

HBM delivers immunoglobulins, lactoferrin, and lysozyme. It also contains complex carbohydrates such as mucins, oligosaccharides, glycans, and others that prevent bacterial and parasitic adhesion.

Digestibility

Premature babies can absorb 95% of human milk fat. HBM has the appropriate composition of digestible proteins, as well as supplementary digestive enzymes. HBM contains enzymes that digest fat.

Bioavailability

Nutrients found in HBM are bioavailable to the baby and more easily metabolized. This may be particularly true for iron.

Bioactivity

“...all of its components work together in a synergistic fashion to provide the baby with optimal nutrition and optimal disease protection when immune systems are immature, no matter what the baby's age”².

Only 5% of HBM is fat and fat-soluble components, including many vitamins.



The other 95% is water and water soluble components.

Triglycerides are the major form of fat in the diet and typically provide 98% of the fat in human milk.

Neu J, Polin R. *Gastroenterology and Nutrition: Neonatology Questions and Controversies*. Philadelphia, PA: Elsevier Saunders; 2012³.

From a practical standpoint, lipids can be considered as compounds that are soluble in organic solvents, and they include triglycerides and fatty acids, sterols and their esters, glycerophospholipids, sphingolipids, and fat-soluble vitamins⁴.

HBM's energy content is 60-75 kcal/100 mL. The very-low-birth-weight (VLBW) preterm infant has endogenous energy reserves of only about 200-400 kcal: enough to maintain energy balance for only about 3 or 4 days without an exogenous energy supply. Thus the VLBW infant is extremely vulnerable to inadequate nutritional intake⁵.

Macronutrients

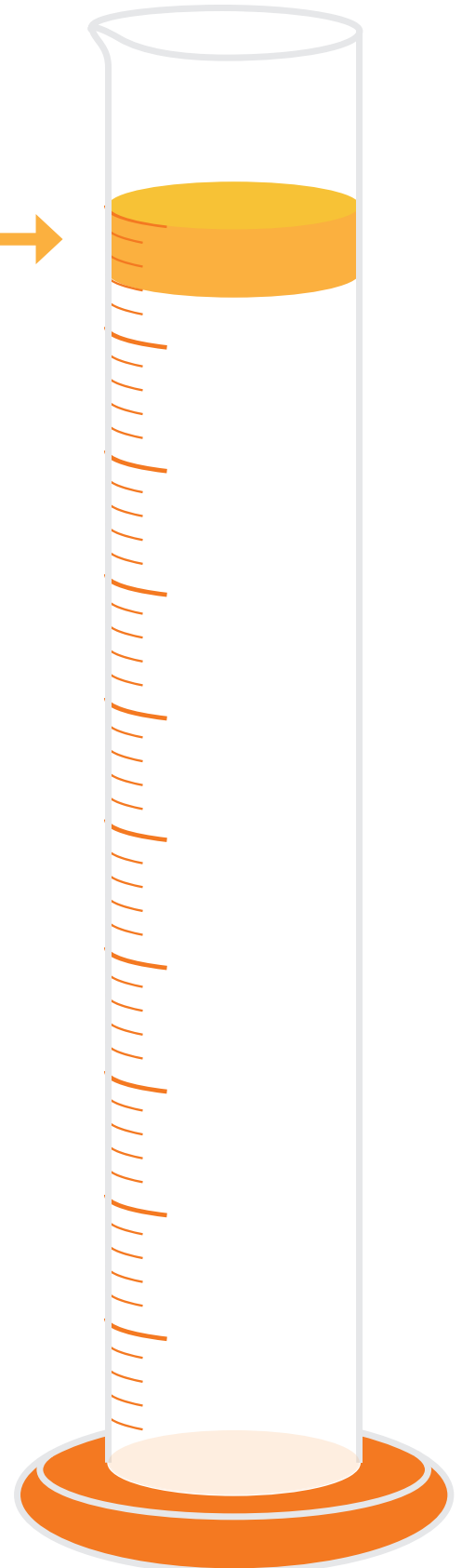
Energy, protein, lactose, total fat, saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, linoleic acid (18:2 n-6), alpha-linolenic acid (18:3 n-3), arachidonic acid (20:4 n-6), docosahexaenoic acid (22:6 n-3), and trans fatty acids

Vitamins

Retinol/carotene; vitamins B6, B12, C, D, and E; thiamin; riboflavin; niacin; folate; pantothenate; and biotin

Minerals

Calcium, phosphorus, magnesium, sodium, potassium, chloride, copper, iron, zinc, manganese, selenium, and iodine⁶



Human Breast Milk & Necrotizing Enterocolitis (NEC)

“The unique composition and properties of human milk... appear to have multifaceted roles in promoting development and reducing morbidity in infants fed human milk.”

Boyd CA, Quigley MA, Brocklehurst P. “Donor breast milk versus infant formula for preterm infants: systematic review and meta-analysis.” *Arch Dis Child Fetal Neonatal Ed.* 2007;92(3):F169-F175.

HBM significantly influences positive outcomes for brain, lung, eye (retinal), and immune system development, as well as reduces NEC and bronchopulmonary dysplasia (BPD).

“...protein and calorie intakes have been independently correlated with performance in the Mental Developmental Index (MDI) at 18 months of age. In the first postnatal week, every additional 10 kcal/day has been associated with an improved MDI performance of 4.6 points and each gram of protein per day with an improvement of 8.2 points, even after controlling for neonatal morbidities”³.

“Early enteral feeding, however, prevents gut atrophy, stimulates maturation of the gastrointestinal system, may actually enhance eventual feeding tolerance, and may reduce the incidence of NEC, especially when colostrum and human milk are used”³.

Feeding human milk in the neonatal intensive care unit (NICU) is a major evidence-based strategy recommended by the American Academy of Pediatrics (AAP) and the National Institute of Child Health and Human Development (NICHD) and Digestive Diseases Interagency Coordinating Committee. Human milk feeding is the only known practice to reduce the likelihood of necrotizing enterocolitis, sepsis, bronchopulmonary dysplasia, infection, and retinopathy of prematurity surgery in preterm infants. Human milk-fed preterm infants are documented to have shorter hospital stays, which can substantially change infant health care costs. **Human milk-fed preterm infants are documented to have shorter hospital stays, which can substantially change infant health care costs. The cost savings assured by human milk feeding may be as high as \$11 for each \$1 spent on human milk feedings**³.

Metaanalysis of randomized, controlled trials indicates that human milk feeding of preterm infants provides significant protection against NEC and suggests that donor human milk use may reduce NEC by 79%⁴.

79%

Reduction in NEC

Donor human breast milk may reduce the risk of necrotizing enterocolitis by 79%.

Boyd CA, Quigley MA, Brocklehurst P. Donor breast milk versus infant formula for preterm infants: systematic review and meta-analysis. Arch Dis Child Fetal Neonatal Ed. 2007;92(3):F169-F175.



If 10% of fat is lost before feeding, then 5% of available caloric energy is lost too.



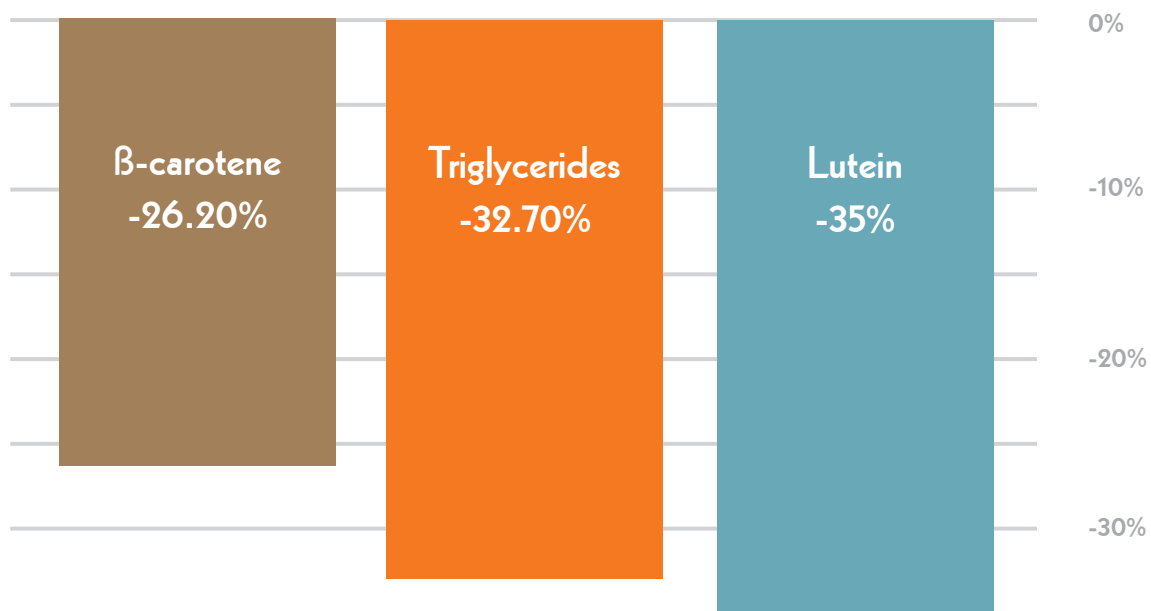
Clinicians are concerned about nutritional loss during collection, storage, and transfer of HBM. Research has identified systemic losses of fat and lipids during the enteral delivery process.

About 50% of the energy in human milk is from fat, and this is almost entirely accounted for by the milk triglycerides and their fatty acids⁷.

Each 10% loss of fat during enteral delivery represents a 5% loss of available caloric energy to the NICU infant, because about half of the energy available in HBM comes from the fat. In addition, critical fat-soluble nutrients are not available to the baby if the fat component of HBM is under-delivered⁷.

Complex methodologies are required to evaluate the impact of multiple variables on the outcome. In other words, the loss of fats in the HBM delivery model is well documented, but the individual contribution of fat loss for each component in the enteral delivery system has not been adequately studied to date.

Various studies have been done in an effort to quantify the fat (lipid), carbohydrate, and volume loss associated with enteral delivery.



Dr. Jae Kim demonstrated that 10% lipid loss is caused by transferring expressed breast milk during routine handling of HBM before delivery⁸.

The Netherland study demonstrated loss of 33% triglycerides, 35% lutein, and 26% β-Carotene in the enteral delivery system⁹.

The Netherland study goes further to state that triglyceride loss accounts for 16% of the total caloric intake of neonates.

Neither study specifically addresses the impact of oil/lipid soluble micronutrients that are contained in the lost lipids nor the possible NICU impacts of growth and thriving, lung development, eye development, cognitive development, or other physiological attributes.

One thing is certain: fat loss reduces nutrient delivery and energy availability.

“This loss was approximately 11 calories per 100 mL, accounting for 16% of the total caloric intake, which can be clinically important.”

Jorgensen MH, Lauritzen L, Michaelsen KF. Does Human Milk DHA Level Affect Functional Outcome in Infants? *Journal of Human Lactation*. 1999; 15(1), 3-6.

Delivery of nutrition through breastfeeding is an objective of most clinical practice. However, breastfeeding is not always possible for fragile NICU babies. Under these circumstances, collection and delivery of HBM is critical to nutritional support of the baby.

Efforts to identify the root cause of nutrient loss must consider the impact of feeding protocols and methodology, as well as devices used.

Approaches & Protocol

Collection and Storage of HBM

A variety of protocols for collection and storage of HBM are available. Some of the recommendations include²:

- Using aseptic containers with caps that have airtight seals to reduce contamination and exposure of nutrients in the milk to oxidation.
- Choosing hard plastic or glass containers to minimize fat adherence to sides and surfaces.
- Avoiding rigorous shaking when trying to mix fat back into HBM in containers since rigorous shaking can break the milk fat globule membranes.

To minimize nutritional loss in the NICU, comprehensive studies should address a variety of factors:

Approaches to Feeding

Pump Feeds (Horizontal syringe orientation)

Pump Feeds (Non-horizontal syringe orientation, against protocol for some pumps)¹⁰

Continuous Feeds

Bolus Syringe Pump Feeds

Trophic/Colostrum Feedings

Gravity Feeds

Safety & Delivery

A comprehensive solution for enteral delivery requires addressing both clinical efficacy and patient safety.

The Role of Devices in Delivery

Enteral devices, their connectors, their unique design features, proprietary interfaces, dead space, and priming volumes create opportunities to reduce volume losses of HBM in the enteral delivery system. In addition, fat losses created by fat separation through discrete components in the system may be reduced.

Fortification and supplements are often utilized to ensure that the NICU patient receives optimal nutrition. Clinicians have devised work around approaches to try to reduce the amount of fat and nutrient loss.

Lipid Delivery Challenges

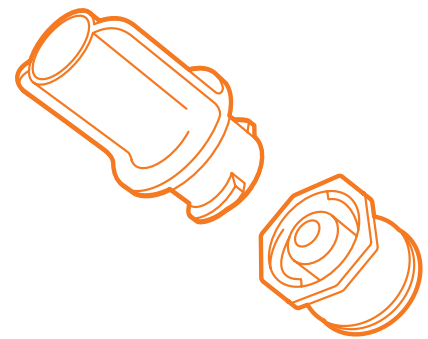
Some protocols suggest that enteral delivery be made with the syringe tip pointed up. In gravity feeds, this is not physically possible. With pump delivery, many pump manufacturers exclude vertical syringe orientation. With many pumps, vertical presentation is not advisable and is, in fact, contraindicated in the user manuals¹⁰.

Safety & Misconnection Prevention

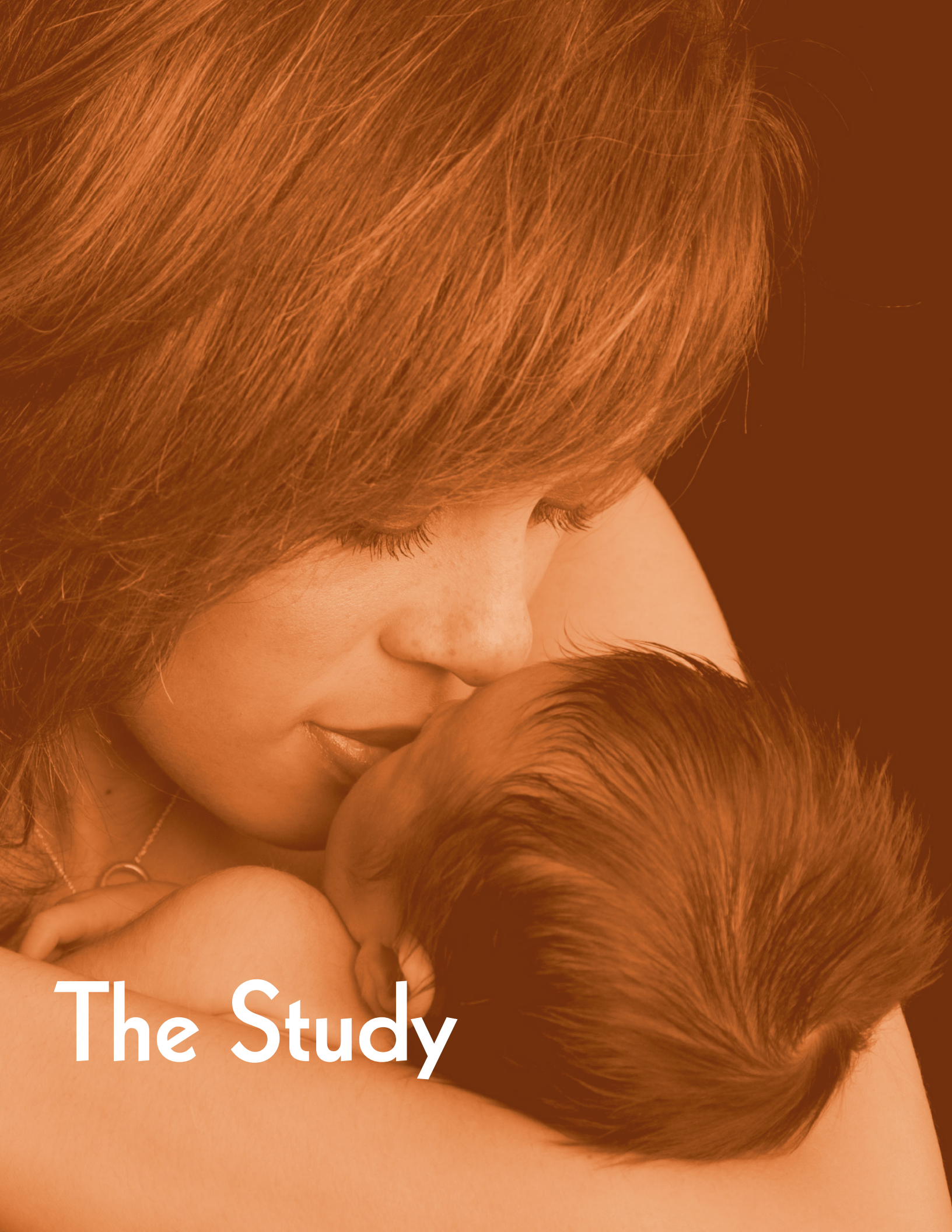
Providers have established solutions to prevent misconnections between enteral delivery devices and Luer connectors.

Delivery Devices in the NICU

- Eccentric enteral syringes with off center tips
- Concentric enteral syringes with center tips
- Extension Sets
- Feeding Tubes
- Enteral Bags
- Syringe Pumps
- Enteral Pumps



The initiative to prevent misconnections to Luer devices has resulted in the creation of the ISO 80369 series of standards to address all small-bore connectors.



The Study

The syringe is the first device in the enteral delivery system, so it seems logical to start an investigation of fat loss at the first stage.

Today, enteral and oral syringes are supplied by several manufacturers and can be broadly grouped into two categories based on their visible design differences. As early as the 1980s, researchers at Queen Charlotte's Maternity Hospital in London evaluated "Fat Loss During Feeding of Human Milk". They included syringes having both concentric (center) and eccentric (off-center) tips¹¹.

"Even in the horizontal position the eccentric nozzle syringe seems to be better."

Narayanan I, Singh B, Harvey D. Fat Loss During Feeding of Human Milk. Diseases in Childhood. 1984; 59(5):475-7.

Eccentric

Baxa/Baxter, NeoMed

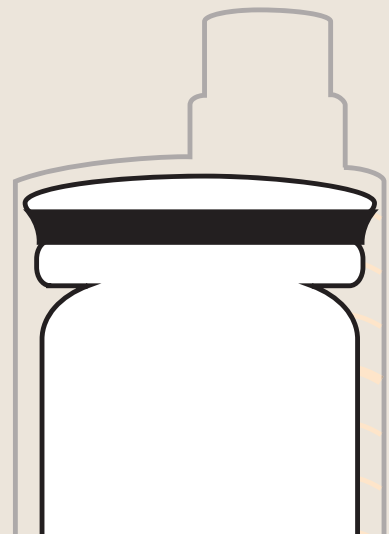
Off-Center Tip

Off-center tip (eccentric) enteral syringes have no history in IV markets and were designed to address needs unique to enteral delivery featuring solid plunger/piston design with O-Ring Style gaskets.



Polypropylene Plunger Head

The solid polypropylene plunger head is flatter, creating less surface area for unwanted lipid/fat adhesion.



Concentric

Acacia, Ameritus, BD, Covidien, Philips/CMV, Vygon

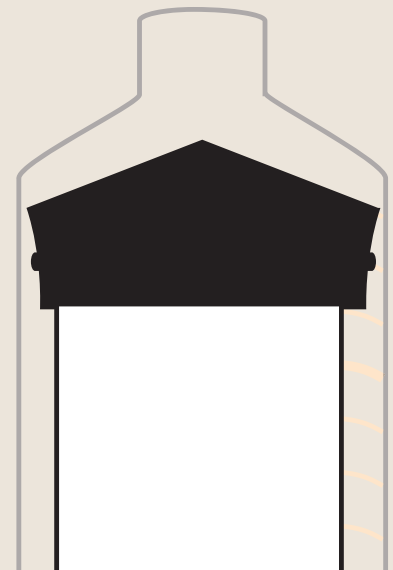
Center Tip

Center tip (concentric) enteral syringes generally evolved from their Luer IV parents and almost exclusively feature an elastomeric black rubber piston tip of various designs.



Rubber Plunger Head

Rubber plunger tips are more conical, creating more surface area for unwanted lipid/fat adhesion to the surfaces of both the plunger piston and the end of the syringe.



NeoMed funded an independent study to look at fat loss in a variety of enteral syringe types. This study was part of a comprehensive review of the design elements of syringes and fat loss during HBM delivery.

Key Points in the Independent Study

- Frozen donor HBM was used (4.1 to 4.2% fat content).
- 60mL enteral syringes from 6 different manufacturers were used.
- HBM volumes of 5mL were used in all syringes.
- Enteral syringes were positioned horizontally on the pump.
- Off-center tips were in the 12 o'clock position relative to the horizontal barrel.
- Statistically valid sample sizes were chosen to provide 95% confidence interval and a power of 90% for comparing two means (control group versus syringe group) .
- Fat content was measured by extraction and FT-IR analysis under the discretion of a PhD chemist.

Results

The results of this independent study may have long-range implications for the NICU and their choice of enteral delivery syringes:

This study identified a statistically significant relationship between fat loss in horizontally positioned 60 mL syringes and aspects of their design¹².

Center (Concentric) syringe tips with elastomeric piston design have fat loss from 11% to 22%.



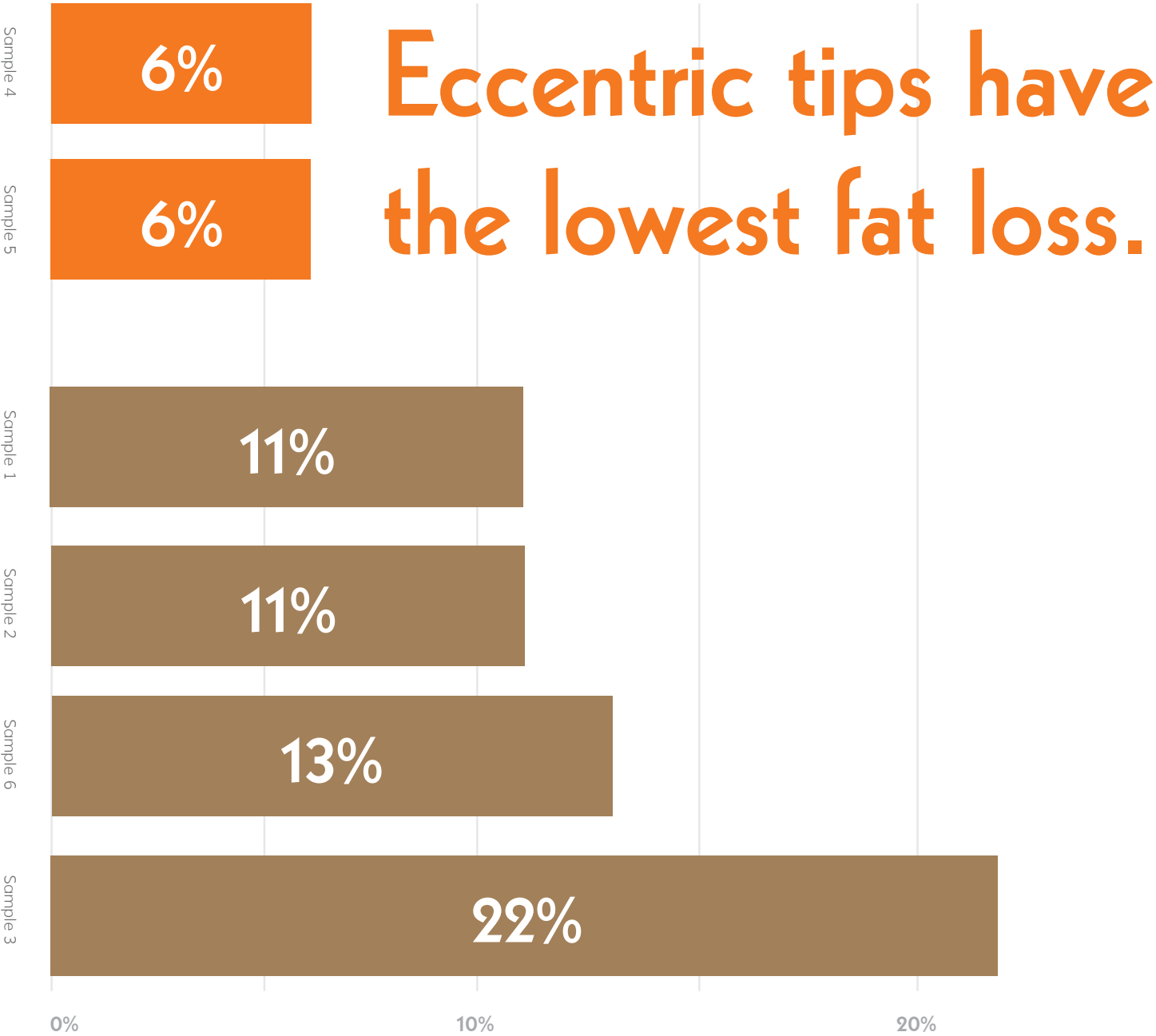
Off-Center (Eccentric) syringe tips with solid piston design have fat loss of 6%.



Summarized from Wages SA. Examination of Fat Loss from Human Breast Milk in Oral/Enteral Syringes from Different Manufacturers. Alpharetta, GA: April 2014 . Data on File, May 2014¹².

Fat Loss Comparison Between Eccentric Syringe Tips & Concentric Syringe Tips

- Eccentric Tip with Flat, Solid Polypropylene Piston/Plunger with O-Ring
- Concentric Tip with Conical, Black Elastometer Piston/Plunger Assembly



Conclusion

NeoMed offers a comprehensive line of enteral syringes from 1 mL to 100 mL. NeoMed enteral syringes are designed with an off-center tip and a solid polypropylene piston with a flatter head. Using NeoMed enteral syringes could reduce total fat loss typical of concentric enteral syringes by 5%- 15%.

Committed to Best Practices

Our hands-free, self-righting tip caps are designed to minimize excessive handling and maintain a secure seal during storage and warming. Our enteral syringes are manufactured as single-piece molded barrels that do not rely on adapters to create an oral tip, unlike other syringes with histories on the IV market. NeoMed is committed to comply with the best practice recommendations set forth by the Joint Commission and the FDA.

Quality Material

The plunger is designed to fully sweep the sides of the enteral syringe, ensuring the most complete delivery available. The enteral syringe is made from USP Class VI polypropylene material that does not interfere with the delivery of lipids.

Economical

The off-set tip is designed to deliver colostrum first to the patient when placed in a syringe infusion pump. Our enteral syringes are offered at a very economical price compared to other syringes with adapters or concentric tips, and our enteral syringes make the most of available nutrition.



Need For Future Research

NeoMed recognizes the need for ongoing research with regard to fat loss and syringe design.

Additional work must be done to independently distinguish between fat loss attributable to tip placement and fat loss attributable to plunger design. Different syringe sizes must be included in future study.

Further, considerations must be given to formula, fortified versions of HBM or formula, delivery rates and delivery volumes, and storage conditions of the HBM (frozen versus fresh).

Delivery methods and protocols should be assessed for impact on fat loss.

Finally, clinical evaluation must be integrated into the analysis to validate findings and define evidence based solutions to minimize fat loss.

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NM-SMM-020 Rev 2