Human milk banking; current evidence and future challenges

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Abstract

Human milk banks systematically collect, pasteurize, store, and distribute donated breast milk. In situations when a mother's own milk is insufficient or unavailable donor milk may be used as an alternative. There are a number of clinical groups who may benefit from donor milk; due to limitations in supply and evidence of benefit in term infants, most commonly donor milk is administered to preterm infants. Guidelines regarding the management of milk banks recommend potential donors are screened and tested and that milk is heat treated to minimize risk of transmission of infectious agents. Although essential to safety, pasteurization alters bioactive and nutritional properties of human milk. Pasteurized donor milk is lower in protein, calories and bioactive molecules compared with mother's own preterm milk produced in the first few weeks after delivery.

Current evidence suggests that there are some health advantages for preterm infants to being fed pasteurized donor milk over preterm formula. There are challenges with regard to providing adequate nutrition with donor milk as well as logistical and ethical concerns. Formation of a national milk-bank network within the UK combined with standardized data collection would assist in the distribution and further evaluation of the potential benefits of this precious resource.

Keywords breast milk; CMV; HIV; human milk; milk bank; preterm infant

Introduction

Donation of milk from women to feed unrelated infants has occurred for centuries through the practice of wet-nursing. However, the first organized milk bank was established just over 100 years ago in Vienna. Interest in milk banking fluctuated over the last century, affected by varying factors such as the popularity of commercial formula feeds and concerns regarding HIV transmission. In 1980 WHO and UNICEF made a joint statement: "Where it is not possible for the biological mother to breast feed, the first alternative, if available, should be the use of human milk from other sources. Human milk banks should be made available in appropriate situations." Since the 1990s, after pasteurization was proven to eliminate the risk of HIV transmission, there has been growing global support for milk banking, and increasing amounts of research demonstrate the benefits of feeding vulnerable NICU patients with donor milk.

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The purpose of this article is to review the current evidence regarding the use of donor milk focussing on the preterm infant, and discuss the future challenges of milk banking.

Benefits of breast milk

Breast milk is the standard nutritional source for infants including premature and sick newborns, with rare exceptions. In addition to nutrients, it contains a combination of antimicrobial and anti-inflammatory factors, enzymes, hormones and growth factors.

Breastfeeding has been shown to have beneficial effects on both childhood and adult health outcomes for infants. Studies of term infants fed maternal breast milk have described reductions in respiratory and gastrointestinal illnesses in childhood, improvement in stereoscopic vision, cognitive function, reductions in obesity, systemic blood pressure and cholesterol levels in adulthood.

Feeding preterm infants breast milk has been shown to lower morbidity in this vulnerable population, with reduced risks of developing necrotizing enterocolitis late onset sepsis, retinopathy of prematurity and neurodevelopmental outcomes. Studies of preterm infants who have reached adolescence and adulthood show infants fed human milk have reduced rates of metabolic syndrome, less insulin and leptin resistance, lower low-density lipoprotein levels and lower blood pressure as compared to formula fed preterm infants.

There are situations where maternal breast milk may not be available. Maternal illness, medications or substance abuse may mean maternal milk cannot be used. There may be a delay in lactation after preterm delivery. Many mothers of sick infants find the stress of their baby being in NICU reduces their milk production. Donor human milk can be used for at-risk infants to supplement the mother's own milk if insufficient or if the mother is unable to supply her own milk for her infant.

Donor milk banking in the United Kingdom

In the UK there are currently 17 milk banks, all voluntary members of the UK Association for Milk Banking (UKAMB). Over the past 30 years, donor milk banks have been following guidance issued by various bodies. In 2010 the National Institute for Health and Clinical Excellence (NICE) published its clinical guideline 93, making recommendations on the safe and effective operation of donor milk bank services providing donor milk for use in the NHS. Donor breast milk is not pooled in the UK, unlike in other countries, but is prepared in aliquots from individual donors.

Processing of donor milk and effects on immunoactivity of milk

In the UK milk collected from screened donors is stored and processed according to NICE clinical guidelines. The process from expression to administration is recognized to affect the nutritional and biological value of the milk. Milk may be refrigerated at 4 °C for up to 24 hours before freezing. Cooling to this temperature has been shown to reduce levels of Vitamin C, lactoferrin, lysozyme, lipase activity and IgA levels. Phagocytic activity is also diminished by refrigeration. Milk may then be frozen for up to 3 months at −20 °C prior to pasteurization. This low temperature has some effects on lysozyme and IgA levels, and almost completely destroys white blood cells.

Donated milk must undergo heat treatment to minimize the risk of transmission of infectious agents. Currently the most common method employed is Holder pasteurization, i.e. heating to 62.5 °C for 30 min. This further alters milk composition. IgA, lactoferrin, lysozyme, lipase and alkaline phosphatase levels are lowered, with complete obliteration of lymphocytes. Cytokine concentration is reduced; one study has also noted an alteration in cytokine profile, with more pro-inflammatory and fewer anti-inflammatory cytokines being retained. Concentrations and patterns of complex oligosaccharides, which are abundant in breast milk, and have recently been identified as having prebiotic, immunomodulatory and antimicrobial effects, are not affected by pasteurization.

Nutritional composition

Maternal milk

The composition of human milk is variable. Depending on the time of day, and the phase of lactation cycle, breast milk can have differing water and calorie content. An example of this would be the difference between foremilk (watery, lower calorie concentration) and hindmilk (thicker, calorie dense). The most variable nutrients in human milk are fat and protein. The composition of milk from women delivering prematurely is also different from milk from mothers delivering at term. Milk from women delivering prematurely has been shown to have higher levels of nitrogen, total protein, total lipid, medium chain fatty acids and total energy. Some vitamins, mineral and trace elements are also present in higher concentrations than in milk from mothers delivering at term. The content of elements such as calcium and phosphate vary less through lactation. However the energy and mineral content may still be inadequate to maintain optimal growth in the preterm infant. In addition, the protein and sodium content of milk decreases over time of lactation. Recent data suggest that higher protein intake in preterm infants is associated with improved long-term neurodevelopment. Supplementation with additional protein, and other nutrients including calcium, phosphate, sodium and vitamins should be considered. The European Society for Paediatric Gastroenterology, Hepatology, and Nutrition has produced updated recommendations for enteral intakes for stable-growing preterm infants up to a weight of approximately 1800 g; no specific recommendations are provided for infants with a weight below 1000 g because data are lacking for this infant group for most nutrients.

Donor milk

The nutritional value of donor milk is also variable. Studies in the 1980s used "drip milk" i.e. milk which spontaneously drips from the contralateral breast when a mother feeds her baby. Drip milk is similar to foremilk in terms of fat composition with an energy density of 46 kcal/100 ml. NICE guidelines recommend donated breast milk is expressed, either by hand or pump, and that donor should receive training and support to achieve this. Although there are variations in the composition of expressed breast milk, pooled expressed milk has higher fat and protein content than drip milk as well as higher sodium and potassium content. However, as most donor milk is obtained from women who delivered term infants and have been lactating for several months it does not contain the higher levels of proteins, or free amino acids found in preterm milk.

Premature infants fed pasteurized mature donor milk have been shown to have a greater prevalence of hyponatraemia, higher levels of alkaline phosphatase, and lower serum phosphorus concentration than similar infants fed formula. Follow-up studies of premature infants at 18 months report infants with the highest alkaline phosphatase levels during their neonatal admission have as much as a 2 cm reduction in linear growth. Further evaluation of this cohort found that the neonatal serum alkaline phosphatase level was negatively associated with attained height at 9–12 years of age. Donor milk also has lower concentrations of the Omega-3 fatty acid Docosahexaenoic acid (DHA), which is essential for the growth and functional development of the infant brain.

Milk fortifiers

The use of nutrient supplementation for preterm infants receiving breast milk is now common practice. As discussed above, the macro and micronutrient content of breast milk is inadequate to meet the higher requirements of the preterm infant. Sick preterm infants may be unable to tolerate large feed volumes; fortification of human milk allows them to receive less volume, with greater intakes of protein and minerals. In theory, standardization of dispensed donor milk is possible, using commercial analyzers to measure the protein, fat and carbohydrate content of milk and supplement accordingly. Some milk banking services, for example in Australia, analyze the nutritional composition of dispensed milk and can use this information for individualized fortification. For practical reasons, commercially prepared fortifiers are more commonly used, providing a mixture of hydrolyzed protein, fat, carbohydrate, vitamins and minerals. The current products do not increase osmolarity of the milk to the same degree as individual supplements, and avoids the risk of error inherent in the measuring out of several supplements. It is worth noting that there is wide variation in the composition of commercially prepared fortifiers. Most contain hydrolyzed bovine protein, although human milk based fortifier is now available in North America. Increases in regurgitation, feed intolerance, glycosuria and hypercalcaemia in extremely preterm infants are common clinical concerns when using fortifier. A Cochrane review of multicomponent fortification of human milk included data from 10 controlled trials studying more than 600 infants with a birthweight less than 1850 g. A number of these studies used fortified donor milk. The addition of multinutrient fortifiers resulted in short-term improvements in weight gain, increments in length and head circumference, and bone mineral content during hospital stay. The reviewers concluded that currently there is no evidence of long-term benefit or deleterious effects of human milk fortification.

Clinical trials of donor milk

As with all treatments, it is important to consider the risks versus the benefits of using donor milk. Much of the published literature discusses the use of donor milk in preterm infant, and compares it to the use of formula milk. A Cochrane review of eight randomized controlled trials involving 1017 infants (less than 37

