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Timing is everything: Lipid and Energy Losses with Simulated Nasogastric Tube Feeds

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Abstract

Objective: To determine the proportion of human milk (pooled and homogenized) fat loss via feeding tube in a simulated 24-hour feeding cycle.

Methods: Anonymous samples of frozen human milk were obtained, thawed and pooled (pHM) in a 1000 mL glass beaker with a magnetic stir bar. Eight syringes (30 mL each) were prepared and attached to 60" extension tubing and a 5 FR polyurethane or silicone nasogastric (NG) tube. Samples to test for pool uniformity were collected at the beginning, middle and end of syringe preparation. Milk was delivered sequentially via gravity, 30-minute or 60-minute infusion. Pooled human milk was analyzed for macronutrient content at the end of each feeding "cycle". All scenarios were repeated using homogenized donor human milk (hDHM).

Results: For simulated NG tube feeds using pHM, significant lipid losses occurred at 60-minute infusion (13%) when compared to 30-minute (3%) and gravity (7%) ($p=0.001$ gravity vs. 60 minutes; $p<0.001$ 30 vs. 60 minutes). Lipid losses were less with hDHM (3%, 1%, 6% for gravity, 30-min and 60-min, respectively; $p<0.001$ gravity vs. 30 and 60 minutes). When comparing pHM to hDHM, lipid losses were greater with pHM for gravity ($p<0.001$) and 60 minutes ($p=0.001$), but not for 30 minutes ($p=0.13$)

Conclusions: Statistically significant lipid and energy losses occur with prolonged pump infusions. Shorter feeding times appear to be preferred. Lipid losses are less for hDHM.

Keywords: Human Milk; Donor Human Milk; Naso-Gastric Feeding

Introduction

Human milk (HM) is the recommended nutrition source for infants and breastfeeding is the standard method for milk delivery [1]. However, many preterm infants are unable to nurse at the breast immediately after birth. Instead, they receive milk by naso- or oro- gastric feeding tube infusion. One inherent property of HM is that it is not homogenized and the fat creams out upon standing. In 1978, Brooke and Barley simulated nasogastric tube feedings in the lab using HM. Analysis using bomb calorimetry showed that human milk samples collected every 2 hours over an 8-10-hour infusion period were an average of 11% lower in energy when compared to an initial baseline sample. Agitation of the milk every 1-2 hours was recommended to avoid fat separation and energy losses [2]. Additional studies have since confirmed that fat and energy losses occur with gavage feeding and that a shorter feeding duration results in less fat and energy losses [3-6]. If using a pump, setting the pump in a vertical position rather than horizontal allows fat to be pushed through as it rises to the top. The use of syringes with eccentrically positioned nozzles to aid in expulsion of fat while the pump is in a horizontal position is now common practice [4].

In addition to feeding duration, gavage feeding materials may also play a role in lipid loss. For many years naso- and oro- gastric tubes were made of PVC. Polyurethane has replaced PVC for NG and OG tubes as PVC became stiff in the presence of stomach acid. Silicone tubes are also available. This material remains soft and is less likely to cause trauma [7]. It is unclear, however if one material type is superior with respect to lipid and energy loss. The frequency with which tubing is changed may also impact macronutrient losses and is generally dictated by the manufacturer's recommendation. The ideal frequency is unknown.

Ultrasonic homogenization of human milk has been shown to reduce the size of fat globules and to reduce fat loss during infusion. Martinez et al compared fat recovery in treated and untreated milk after simulated tube feeding and found a statistically significant difference in fat recovery both for long (4 hour; $p<0.01$) and short (30 minutes; $p<0.05$) infusions [8]. Recently, a homogenized milk product (Medolac Co-op donor milk) has become commercially available for clinical use. How this product would compare to non-homogenized human milk during gavage feeds is unknown.

Mid-infrared (IR) spectroscopy can be used for analysis of human milk macronutrient content using devices that originated in the dairy industry. When compared to traditional laboratory methods, mid-IR has been shown to be both precise and accurate [9,10]. In addition, mid-IR spectroscopy is the approved method for milk analysis by the Association of Analytical Chemists [11].

We analyzed the proportion of human milk fat loss via feeding tube in a simulated 24-hour feeding cycle.

Methods

The University of Louisville Institutional Review Board determined this to be non-human subjects research prior to initiation. Anonymous samples of human milk (no identifiers) which were designated for waste disposal were obtained. Samples were thawed in the refrigerator overnight (4 ˚C), pooled in a 1000 mL glass beaker and mixed slowly with a magnetic stir bar (pHM). Eight eccentric syringes (30 mL each) were prepared (Neomed, Woodstock, GA). Test samples were drawn at the beginning, middle and end of syringe preparation to check for uniformity of the milk pool. The first syringe was connected to 60” extension tubing with the nipple at the top and a 5 FR polyurethane or silicone nasogastric (NG) tube (Neomed, Woodstock, GA). pHM was delivered via gravity, and collected in a 45 mL plastic centrifuge tube (VWR Ultra high Performance, VWR International, Suwanee, GA). The samples were warmed in a 40 ˚C water bath for 10 minutes prior to analysis (Calais Human Milk Analyzer, North American Instruments, Solon, OH). Using the same extension tubing and NG tube, the process was repeated a total of eight times to simulate a 24-hour period, assuming an every 3-hour feeding schedule. The process was repeated with a different pooled sample on separate days for gravity, 30-minute and 60-minute infusion times (Medfusion 3500, Smiths Medical ASD Inc., St. Paul, MN). All delivery scenarios were performed in duplicate. Homogenized, donor human milk (Co-op Donor Milk, Medolac, Lake Oswego, OR) was also tested in the same way.

Descriptive statistics were applied. Comparisons of continuous variables were by ANOVA.

Results

Comparisons of macronutrients drawn during the preparation of the syringes (beginning, middle and end) were not statistically different (data not shown). Lipid loss with silicone NG tubes trended to be lower than with polyurethane tubes but did not reach statistical significance, so results for both were combined. No statistically significant losses were seen for protein or lactose with either pHM or hDHM (Tables 1 and 2). For simulated nasogastric tube feeds using pHM, significant lipid losses occurred at 60-minute infusion when compared to 30-minute and gravity (Table 1). Lipid losses were significantly less with hDHM (Table 2). When comparing pHM to hDHM, lipid losses were statistically greater with pHM for gravity ($p<0.001$) and 60 minutes ($p=0.001$), but not for 30 minutes ($p=0.13$).

	Gravity				**30 minute infusion**				**60 minute infusion**			
Fraction	**Protein g/dL**	**Lactose g/dL**	**Fat g/dL**	**Energy Kcal/oz**	**Protein g/dL**	**Lactose g/dL**	**Fat g/dL**	**Energy Kcal/oz**	**Protein g/dL**	**Lactose g/dL**	**Fat g/dL**	**Energy Kcal/oz**
1	1.52(0)	6.32(0)	2.81(7)	16.2(4)	1.58(0)	6.38(1)	2.91(9)	16.6(5)	1.66(0)	6.30(1)	2.30(22)	14.9(11)
2	1.52(0)	6.29(1)	2.85(6)	16.3(3)	1.58(0)	6.42(0)	3.14(1)	17.2(1)	1.65(0)	6.30(1)	2.44(17)	15.3(9)
3	1.52(0)	6.31(0)	2.84(6)	16.3(3)	1.58(0)	6.45(0)	3.11(2)	17.2(1)	1.67(0)	6.30(1)	2.65(10)	15.9(5)
4	1.52(0)	6.32(0)	2.83(7)	16.2(3)	1.57(0)	6.45(0)	3.10(3)	17.2(1)	1.66(0)	6.29(1)	2.49(15)	15.4(8)
5	1.51(0)	6.31(0)	2.81(7)	16.2(4)	1.57(0)	6.47(0)	3.07(4)	17.1(2)	1.67(0)	6.31(1)	2.62(11)	15.8(5)
6	1.52(0)	6.32(0)	2.77(9)	16.1(4)	1.58(0)	6.44(0)	3.14(1)	17.2(1)	1.67(0)	6.33(0)	2.65(10)	15.9(5)
7	1.53(0)	6.35(0)	2.87(5)	16.4(2)	1.57(0)	6.43(0)	3.11(2)	17.1(1)	1.67(0)	6.31(1)	2.68(9)	15.9(5)
8	1.52(0)	6.30(1)	2.86(5)	16.3(3)	1.57(0)	6.45(0)	3.19(0)	17.4(0)	1.64(1)	6.32(1)	2.60(12)	15.7(6)
Average	**1.52(0)**	**6.32(0)**	**2.83(7)**	**16.2(3)**	**1.58(0)**	**6.43(0)**	**3.10(3)**	**17.1(1)**	**1.66(0)**	**6.31(1)**	**2.57(13)**	**15.6(7)**

Fat and energy: $p=0.001$ gravity vs. 60 minutes; $p<0.001$ 30 vs. 60 minutes

Table 1: Results for pooled human milk (pHM): (% loss from baseline)

	Gravity				30 minute infusion				60 minute infusion			
Fraction	**Protein g/dL**	**Lactose g/dL**	**Fat g/dL**	**Energy Kcal/oz**	**Protein g/dL**	**Lactose g/dL**	**Fat g/dL**	**Energy Kcal/oz**	**Protein g/dL**	**Lactose g/dL**	**Fat g/dL**	**Energy Kcal/oz**
1	0.99(+3)	6.35(0)	2.77(4)	15.7(2)	0.97(+1)	6.34(0)	2.72(3)	15.5(1)	0.96(1)	6.35(0)	2.71(7)	15.5(4)
2	0.96(0)	6.36(0)	2.83(2)	15.8(1)	0.97(+1)	6.35(0)	2.83(0)	15.8(0)	0.96(1)	6.34(1)	2.76(6)	15.6(3)
3	0.96(0)	6.36(0)	2.83(2)	15.8(1)	0.98(+2)	6.36(0)	2.81(0)	15.7(0)	0.97(0)	6.37(0)	2.86(2)	15.9(1)
4	0.96(0)	6.36(0)	2.82(2)	15.8(1)	0.97(+1)	6.35(0)	2.78(1)	15.6(0)	0.97(0)	6.36(0)	2.74(7)	15.5(3)
5	0.97(+1)	6.38(0)	2.83(2)	15.8(1)	0.97(+1)	6.36(0)	2.76(2)	15.6(1)	0.96(1)	6.37(0)	2.75(6)	15.6(3)
6	0.97(+1)	6.37(0)	2.79(3)	15.7(2)	0.96(0)	6.36(0)	2.80(0)	15.7(0)	0.96(1)	6.36(0)	2.71(8)	15.5(4)
7	0.98(+2)	6.37(0)	2.81(2)	15.8(1)	0.97(+1)	6.35(0)	2.78(0)	15.6(0)	0.98(+1)	6.37(0)	2.74(7)	15.6(3)
8	0.98(+2)	6.36(0)	2.76(4)	15.6(2)	0.96(0)	6.36(0)	2.74(2)	15.5(1)	0.97(0)	6.40(0)	2.72(7)	15.6(3)
Average	**0.97(+1)**	**6.36(0)**	**2.79(3)**	**15.7(1)**	**0.97(+1)**	**6.35(0)**	**2.78(1)**	**15.6(0)**	**0.97(0)**	**6.37(0)**	**2.75(6)**	**15.6(3)**

Fat: $p<0.001$ gravity vs. 30 and 60 minutes
Energy: $p=0.021$ gravity vs. 30 minutes; $p<0.001$ gravity vs. 60 minutes.
Table 2: Results for homogenized donor human milk (hDHM): (% loss from baseline)

Discussion

Statistically significant, but likely clinically unimportant, fat and energy losses were observed with simulated nasogastric tube feeds using raw (non-homogenized) human milk. Both gravity and 30 minute infusion times generated average losses of 1-3% per feeding. Losses with a 1 hour infusion time were larger (average 7% per feed) and may be of greater concern. Protein content was not affected.

The tubing materials (polyurethane and silicone) did not affect the degree of losses. Furthermore, using the same extension and NG tubing did not appear to alter fat loss from beginning to end of the 24-hour simulation. In this experiment, upon completion of one feed "cycle", the next was immediately started. In the clinical setting, however, time between feeds would have been approximately 2 hours (depending on feeding interval). Ultimately, this may impact lipid and energy losses.

A shorter pump time (30-minutes) resulted in less fat loss compared to a longer duration (60-minutes). While gravity feeding times averaged 12 minutes, more fat loss occurred when compared to 30-minute pump infusion. This may be due to the efficiency of the plunger in pushing the contents forward and preventing milk fat from sticking to the syringe wall during pump feeds. At the end of the gravity feeds, there were droplets of milk/milk fat observed on syringe walls.

Homogenized donor human milk showed consistently less fat/energy loss compared to raw human milk. There was some creaming out of fat observed visually over time. Energy losses for both pHM and hDHM were less than one calorie per ounce.

In conclusion, statistically significant lipid and energy losses occurred with prolonged pump infusions. Shorter infusion times appear to be preferred. NG tubing materials (polyurethane and silicone) did not affect the degree of losses. Sequentially, there was neither an increase nor decrease in lipid losses while using the same sets of tubing. Lipid losses were lower for homogenized donor human milk. However, the safety and efficacy of this product has not been shown in clinical trials.

Acknowledgements

Tubing, syringes and pumps were provided by NeoMed® (Woodstock, GA).

Homogenized donor human milk was donated by Medolac Laboratories (Lake Oswego, OR).

What is new

- Nasogastric tubing material does not affect the degree of lipid and energy losses
- More lipid loss was seen with gravity feeds when compared to 30-min pump infusion despite the fact that gravity feeding duration was shorter.
- A new, homogenized donor human milk is commercially available for clinical use.
- Lipid and energy losses were less for homogenized donor human milk.

What is known

- Human milk is the recommended nutrition source for infants.
- Human milk is not homogenized and separates on standing.
- Prolonged feeding times result in lipid and energy losses.

Conflicts of interests

Conflicts of interest and sources of funding: The authors acknowledge Medolac Laboratories (Lake Oswego, OR) for donation of Co-op Donor Milk and NeoMed® (Woodstock, GA) for donation of syringes, pumps and tubing.

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