An audit of preterm nutritional intake using a human milk analyser

In preterm infants the protein and calorie content of human milk is often inadequate for their nutritional requirements and so it is standard practice to supplement expressed breast milk with breast milk fortifier. To decide whether this practice provides best care, an audit of breast milk composition between days 10-14 after birth was carried out using a Miris breast milk analyser to determine individual infant's nutritional intake.

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Keywords

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Key points

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1. The majority of preterm babies required breast milk fortification to meet protein requirements on days 10-14 following delivery.
2. In 13% of babies with a birth weight >1kg, protein requirements were met without fortification.
3. Fifty-nine per cent of infants received above the recommended calories following breast milk fortification.
4. Using a human milk analyser in clinical practice is an effective tool to monitor infant nutritional intake on an individual basis.

Human milk is considered the best choice for nutrition in both term and preterm infants[1]. However, after the first 2-3 weeks of lactation the protein and energy content of human milk is usually insufficient to meet the nutritional demands of rapidly growing preterm infants[2]. Since protein is essential for neurocognitive development and growth in preterm infants[3], mothers own breast milk is fortified according to manufacturers' instructions based on an assumed macro-nutrient composition. However, since the composition of human milk is extremely variable, this can result in either over or under fortification[4].

Infrared (IR) spectroscopy has proven to be a useful analytical tool for determining the macro-nutrient content of human milk[5-7]. Recently, a mid – IR (MIR) human milk analyser (HMA) has been developed by Miris AB (Uppsala, Sweden) (**FIGURE 1**). The HMA is calibrated with human milk standards and can measure fat, protein, lactose and total solids simultaneously in human milk. Currently clinical practice on the neonatal intensive care unit (NICU) at the University Hospital of North Staffordshire is to analyse mothers' own expressed milk at 10-14 days to determine milk composition (**FIGURE 2**). This information is used as an assessment tool to meet the recommended protein and energy requirements for preterm infants[8].

In order to decide if this practice provides delivery of best care, an audit was undertaken between March and October 2011.

Aims and objectives of the audit

The audit was undertaken at the University Hospital of North Staffordshire, which is a level three non-surgical NICU based in Stoke-on-Trent in the UK.

The aim was to determine breast milk composition between days 10-14 after birth. This information was used to compare the protein and energy intake per kg with the current guidelines on preterm enteral nutrition. These guidelines were produced by the European Society for Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition (ESPHGAN)[8]. The secondary objective of the audit was to identify if using an HMA in clinical practice is a practical and effective tool to monitor infant nutrition on an individual basis.

FIGURE 1 Miris human milk analyser.

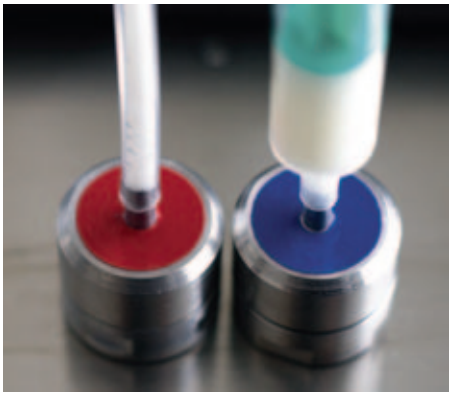

FIGURE 2 An analysis being performed.

Subjects and method

On day 10, or when full enteral feeds were achieved (150mL/kg/day) production of milk by mothers of infants born before 35 weeks' gestation was assessed. If the supply was greater than infant requirement, verbal consent was obtained from mothers for breast milk analysis. Since there is a large variation in protein and lipid content between expressions, each milk expression in 24 hours must be tested to ensure a representative result.

Mothers were taught to collect their own samples and a proportional sample of milk (a 10% sample from each collection bottle) was taken directly after expression while the sample was still warm to minimise fat loss. The syringes were then capped and stored in a refrigerator until analysis was undertaken. Prior to analysis the samples were warmed to 40°C, pooled and analysed using 2-3mL of breast milk. The macro-nutrient values calculated by Miris are displayed for protein, lactose and fat in grams per 100mL. All the data collected were recorded in the patient record after analysis.

In mothers producing variable volumes of EBM, adequate proportional samples were difficult to collect accurately. Therefore, each bottle was sampled and analysed individually, and the mean was calculated separately for all of the micro-nutrients.

The data from HMA were used to calculate nutritional intake on an individual basis. Each baby's daily nutritional intake was then compared to the 2010 guideline from ESPHGAN[8].

In order to ensure optimal nutritional intake the following adjustments were made: In clinically stable babies who weighed less than 1kg (in instances where the volume could not be increased above 150mL/kg/day and the protein content of unfortified expressed breast milk (EBM) was less than 2.7g per 100mL); EBM was supplemented with breast milk fortifier (BMF).

In clinically stable babies over 1kg, (in instances where the volume could not be increased above 150mL/kg/day and the protein content of unfortified EBM was below 2.3g per 100mL), EBM was also supplemented with BMF.

Where additional protein was needed a standard BMF sachet was added to 50 mL EBM. The fortifier used contained: 0.4g protein (hydrolysed whey), and 1.5g glucose polymer (8 kcal) per sachet (2.1g).

Demographics of the infants	
Gestation	**%**
<30 weeks	33%
30-35 weeks	67%
Birth weight (kg)	
>1kg	86%
<1kg	14%

TABLE 1 Demographics of the preterm infants in audit March 2011-October 2011.

Results

Milk from 34 mothers was analysed using the HMA during the audit period. Regarding gestational age, 33% of babies studied were born before 30 weeks' gestation and 67% of babies were born between 30-35 weeks' gestation (**TABLE 1**). The majority of babies weighed more than 1kg at birth (86%), with only 14% of the babies being born with a birth weight of less than 1kg (**TABLE 1**).

Results from the 24 hour samples showed a wide variation between mothers for both calories and protein content. The data ranged from 52kcal/100mL to 108kcal/100mL and from 1.3g protein/100mL to 2.6g/100 protein/100mL.

The calorie content in two thirds of unfortified breast milk met the recommended calorie requirements of preterm infants at 110-135kcal/kg/day receiving enteral feeds at 150mL/kg/day.

TABLE 2 and FIGURE 3 show the protein and energy value of the expressed breast milk (n=34) and nutritional intake of individual babies with and without breast milk fortifier. The data from HMA were then titrated against nutritional requirements from ESPHGAN 2010[8] on an individual basis to ensure optimal intake (**TABLE 3**).

In babies under 1kg, the results indicate that by days 10-14 (after the enteral feed volume had been maximised) all of the EBM samples contained insufficient protein content to meet the recommended protein requirements[8]. After supplementation with BMF, 80% of infants in this weight criterion still had protein intakes that did not meet the lower limits of the recommended requirements (4g protein/kg/day).

Each infant's energy intake was also assessed to ensure it met the recommended requirement of 110kcal-135kcal/kg/day[8]. Over half of infants weighing less than 1kg were receiving an energy intake of 11% greater than the recommended value of 135kcal/kg/day following supplementation.

In babies weighing greater than 1kg, 13% of infants met the recommended value for protein intake (3.5-4.0g/kg/day) without the addition of BMF.

After maximising daily volumes, 87% of infants weighing more than 1kg required supplementation with BMF. Since it is not possible to titrate BMF precisely to an individual infant's requirement, following the addition of BMF six babies (22%) were receiving more than the recommended levels of protein, and eight babies (30%) were being fed less than the minimum level of protein (3.5g protein/kg/day).

In addition over half of these babies weighing more than 1kg were receiving an energy intake of 4% more than the upper limit following the addition of BMF, with some infant's receiving as much as 22% above 135kcal/kg/day.

The Miris HMA analyser proved to be a simple and effective method for the bedside analysis of mothers' own expressed breast milk. None of the mothers in the audit had any difficulties in collecting samples for analysis and none of them reported feeling undermined by the macronutrient analysis of their milk.

Discussion

Recent research has highlighted the importance of ensuring that preterm infants receive adequate protein requirements. Protein is essential for neurocognitive development and growth outcomes in preterm infants[3]. Since protein is a limiting nutrient in breast milk and may not meet the requirements of preterm infants, the addition of a protein supplementation is often needed.

Currently the most practical way of assessing protein requirements for breast fed preterm infants remains controversial. In the UK, the majority of NICUs either add BMF routinely or milk is supplemented following individual assessment based on weight gain and biochemical indices such as a low urea level[11]. Several studies have shown that infrared (IR) spectroscopy is a simple and useful method for determining the macronutrient content of human milk[4-7]. This small audit of practice has also shown how using HMA to analyse mothers' own EBM for macronutrient content prior to fortification is a simple and effective intervention.

Gestational age in weeks/ birth weight g	Analysed EBM protein g per 100mL	Analysed EBM Energy kcal per 100mL	**EBM** @150mL Protein g/Energy kcal per kg per day	**EBM + BMF** @150ml Protein g/Energy kcal per kg per day
24/870	2.1	61	3.1/91	4.4/116
24/720	1.7	83	2.5/124	3.8/149
25/580	1.7	84	2.5126	3.8/150
27/900	1.7	87	2.5/130	3.8/155
28/830	1.7	65	2.5/97	3.8/122
28/1230	1.4	65	2.1/97	3.3/122
28/1080	1.4	78	2.1/117	3.3/141
28/1220	1.8	93	2.7/139	3.9/164
29/1390	1.7	87	2.5/130	3.8/155
29/1450	1.9	82	2.8/123	4.1/147
29/1490	1.9	82	2.8/123	4.1/147
29/1620	2.0	58	3/87	4.2/111
30/1570	1.7	80	2.5/120	3.8/144
30/1290	1.8	91	2.7/136	3.9/161
31/1710	2.3	89	3.5/134	
31/1280	2.4	79	3.6/119	
31/1190	1.4	75	2.1/112	3.3/137
31/1810	1.4	75	2.1/112	3.3/137
31/1550	1.4	70	2.1/105	3.3/129
31/1045	1.8	69	2.7/103	3.9/128
31/1110	1.5	57	2.2/85	3.5/110
31/1780	2.1	108	3.1/162	4.4/186
32/1980	1.6	77	2.4/115	3.6/140
32/1940	1.7	82	2.5/123	3.8/147
32/1950	1.5	69	2.2/103	3.5/128
32/1540	2.6	61	3.9/92	
32/1300	1.9	52	2.8/78	4.1/102
32/1680	1.3	70	1.9/105	3.2/129
32/1840	1.4	63	2.1/94	3.3/119
32/1760	1.5	76	2.2/114	3.5/138
32/2000	1.9	87	2.8/130	4.1/155
33/2100	1.6	78	2.4/117	3.6/141
33/2240	1.6	86	2.4/129	3.6/153
33/1700	1.4	60	2.1/90	3.3/114
34/1740	1.8	71	2.7/106	3.9/131
35/1300	2.2	94	3.6/155	@165mL/kg/day

TABLE 2 Results analysis of breast milk showing gestational age, birth weight, analysis of EBM per 100mL and nutritional intake of infants fed at 150mL/kg/day with and without fortification. ■ Infants who did not require fortifier ■ Twins ■ Infants less than 1kg

Body weight in kg	Nutritional requirements for protein and energy
<1kg	4.0-4.5g protein/kg/day
	110-135kcal/kg/day
>1kg	3.5g-4.0g protein/kg/day
	110-135kcal/kg/day

TABLE 3 Preterm nutritional requirements 2010. European Society for Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition (ESPHGAN) 2010.

The variability in the composition of EBM has been reported by many studies[2,4-6]. The results of this audit also showed a large variation in both protein and calorie content in the EBM of mothers of preterm infants on the NICU. The variability of composition posed difficulties in determining appropriate individual nutritional requirements by the addition of a standard BMF.

The results showed that after addition of fortifier, over half (59%) of babies, were receiving calorie intakes of more than the 135kcal/kg/day. Nutritional regimens that produce excessive fat deposition may put the infant at risk for long-term adverse health outcomes[12]. The outcome of delivering excess energy via BMF to preterm babies needs further investigation.

This audit also showed that in the local population EBM was inadequate in protein content between days 10-14 for all babies under 1 kg and the majority over 1kg. After fortification with standard BMF, 80% of babies less than 1kg still failed to meet protein requirements. It is also worth noting that in babies more than 1kg, 22% received a protein intake that was greater and 30% received a protein intake that was lower than the recommended amount, after fortification was added. These results highlight how difficult it is to meet the recommended nutritional requirements for preterm infants supplemented by a fortifier based on assumed macro-nutrient content.

Studies have been conducted to look at the feasibility of using an HMA to meet the preterm infant's nutritional needs with an adjustable fortification regimen, based on an individualised analysis of the composition of human milk[4,13-14]. Since these regimens proved feasible and safe, this is an area which urgently requires further investigation.

In conclusion, this was a very small audit to ascertain if the practice of analysing EBM prior to fortification provided best quality care. The numbers were small and samples were obtained only from mothers who had excess milk. The results indicate that the majority of babies required fortification. However, in 13% of babies weighing more than 1kg it was possible to deliver adequate protein without BMF. This flexibility can only be achieved by the use of milk analysis to determine nutrients in mothers' own milk. Although this audit has added to the understanding of meeting nutritional requirements with EBM after addition of a routine BMF, only one HMA

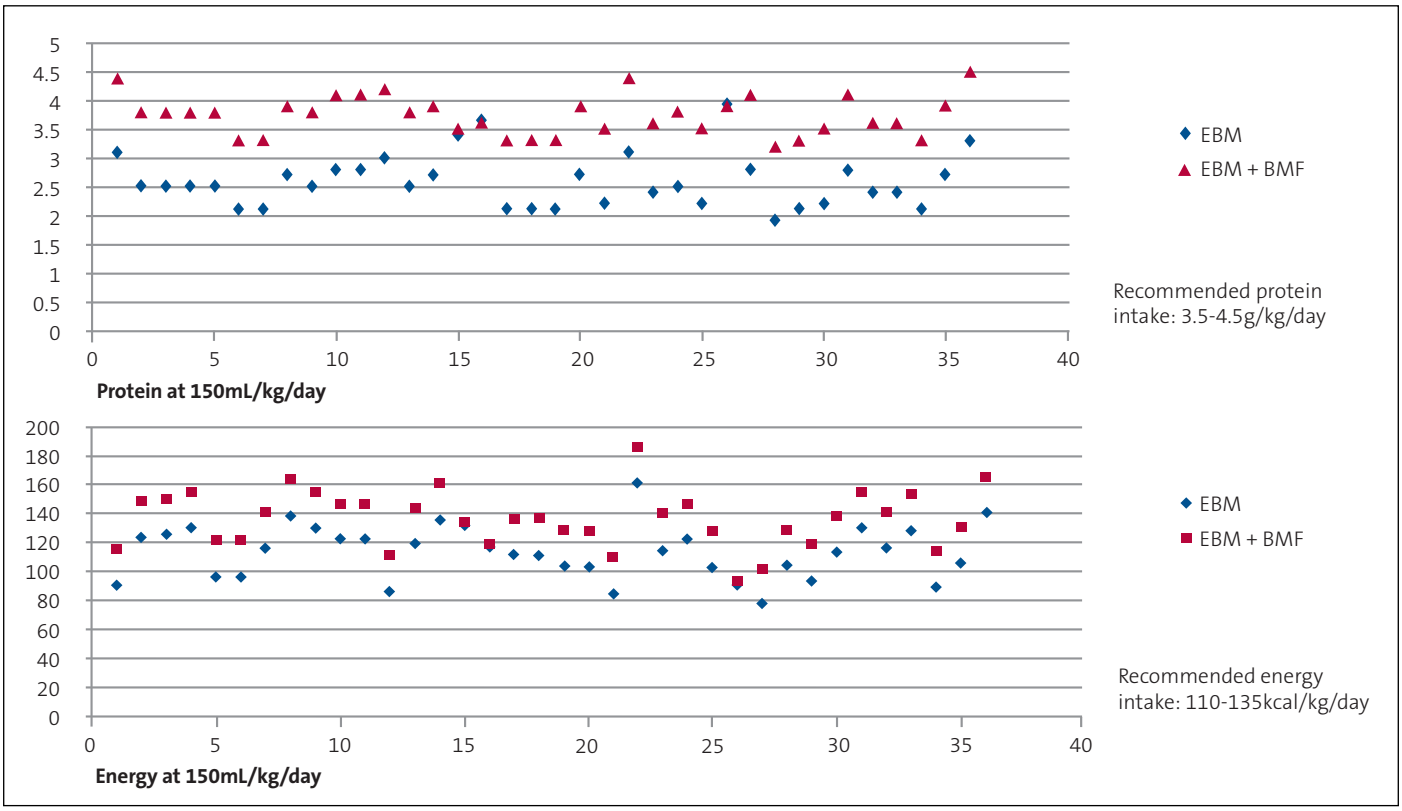

FIGURE 3 Individual protein and energy values of EBM before and after addition of fortifier.

was performed between days 10-14. Weekly serial measurements of EBM would also be helpful to reflect long-term intake.

Conflicts of interest

None reported. No financial support was received for this clinical audit.

References

1. **American Academy of Pediatrics.** Breastfeeding and the use of milk. *Pediatrics* 2005;115:495-506.
2. **Weber A., Loui A., Jochum F., Bührer C., Obladen M.** Breast milk from mothers of very low birthweight infants: variablility in fat and protein content. *Acta Paediatr* 2001;90:772-75.
3. **Nagaya K., Tanaka S., Kitajima H., Fujimura M.** The corrected blood urea nitrogen predicts the developmental quotient of extremely low-birth-weight infants at the corrected age of 36 months. *Early Hum Dev* 2007;83:285-91.
4. **Polberger S., Raiha N.C.R., Juvonen P., Moro G.E., Minoli I., Warm A.** Individualized protein fortification of human milk for preterm infants: Comparison of ultrafiltered human milk protein and a bovine whey fortifier. *J Pediatr Gastroenterol Nutr* 1999;29:332-338.
5. **Corvaglia L., Battistini B., Paoletti V., Aceti A., Capretti M.G., Faldella G.** Near-infrared reflectance analysis to evaluate the nitrogen and fat content of human milk in neonatal intensive care units. *Arch Dis Child Fetal Neonatal Ed* 2008;93:F372-F375.
6. **Menjo A., Mizuno K., Murase M. et al.** Bedside analysis of human milk for adjustable nutrition strategy. *Acta Paediatr* 2009;98:380-84.
7. **Michaelsen K.F., Pedersen S.B., Skafte L., et al.** Infrared analysis for determining macronutrient in human milk. *J Pediatr Gastroenterol Nutr* 1988;7:229-35.
8. **Agostini C., Buonocare G., Carnielli V.P. et al.** Enteral Nutrient Supply for Preterm Infants: Commentary from the European Society for Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition. *JPGN* 2010;50;85-91.
9. **FSA.** *McCance and Widdowson's the Composition of Foods*. Sixth Summary Edition. Food Standards Agency 2002. RSC Publishing.
10. **Casadio Y.S., Williams T.M., Lai C.T. et al.** Evaluation of a mid-infrared analyzer for the determination of the macronutrient composition of human milk. *J Hum Lact* 2010; DOI: 10.1177/0890334410376948.
11. **King C.** Human milk for preterm infants – when and how to fortify. *Infant* 2005;1:44-48.
12. **Kashyap S., Ohira-Kist K., Abildskov K. et al.** Effects of quality of energy intake on growth and metabolic response of enterally fed low-birthweight infants. *Pediatr Res* 2001;50:390-97.
13. **Arslanoglu S., Moro G.E., Ziegler E.E.** Optimization of human milk fortification for preterm infants: New concepts and recommendations. *J Perinat Med* 2010;38:233-38.
14. **Moro G.E., Minoli I., Ostrom M., Jacobs J.R. et al.** Fortification of human milk: evaluation of a novel fortification scheme and of a new fortifier. *J Pediatr Gastroenterol Nutr* 1995;20:162-72.