Original Article

Nutritional analysis of blenderized enteral diets in the Philippines

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The objective of this study was to analyze the nutritional quality and viscosity of blenderized enteral tube feedings (BTFs) from four hospitals in the Philippines. Samples of two different BTFs (one standard and one modified) were collected from each hospital on three separate occasions and analyzed for macronutrients, micronutrients, and viscosity. There was considerable variation among the BTFs for the concentrations of most nutrients measured. For standard BTF samples, the caloric density ranged from 66-123 kcal/100g and the percentages of total weight for protein, carbohydrate, and fat ranged from 1.5-4.0%, 8.6-21.4%, and 0.27-3.40%, respectively. Levels of specific vitamins were undetectable in 10 standard and 15 modified BTF samples. In samples where vitamin levels were detectable, results were: vitamin A, 625-8850 IU/kg; riboflavin, 0.40-5.00 mg/kg; and pyridoxine, 0.14-3.00 mg/kg. Mineral concentrations also varied greatly (eg calcium, 64-524 mg/kg; sodium, 148-886 mg/kg; iron, 3.0-13.7 mg/kg; and zinc, 1.8- 11.5 mg/kg). Correlation coefficients were statistically significant only for carbohydrate ($r = 0.48$, $P = 0.017$). Measured values tended to be lower than expected values for all nutrients, although the difference was statistically significant only for calories ($P = 0.023$). The viscosity of BTF samples ranged from 2.3-45,060 centipoise, excluding three samples that were too viscous for analysis. This study demonstrates that hospital prepared blenderized enteral tube feedings render unpredictable levels of micronutrients and macronutrients and appear likely to deliver less than the desired amounts of nutrients. Additionally, the viscosity of these feedings may be unsuitable for infusion through feeding tubes.

Key Words: blenderized enteral feedings, caloric density, vitamin content, mineral content, viscosity, Philippines.

Introduction

Enteral tube feedings are commonly used in hospitals to provide nutritional support. While commercial, ready-to-use formulas have been available for over 20 years, many institutions prefer the use of "homemade", blenderized tube feedings (BTF). This preference may result from believing them to be more "natural" (physiologic) or more economical. Blenderized tube feedings typically contain common foodstuffs such as milk, eggs, meat, soft fruits, and vegetables that are pureed in a food blender or mixer. Other BTFs are made from a base of a commercial nutritional powder, which is reconstituted with water or other liquid. To this base, other foods may be added to modify the consistency or nutritional composition.

While BTFs appear to permit flexibility with regard to the selection of ingredients, and therefore nutritional content, problems with their use have been reported. Gallagher-Allred analyzed prepared BTFs for nutritional content, osmolality, and bacterial contamination.[1] An institutionally prepared "high calorie" formula expected to deliver 1.5 kcal/mL yielded only 1.0 kcal/mL on analysis. In addition, this "high calorie" formula did not meet the US Recommended Dietary Allowances (US RDA) for vitamin B_{12}, biotin, iron, and copper in 3,000 kcal. By contrast, commercial feedings designated to provide 1.0 kcal/mL and 1.5 kcal/mL met all nutrient standards and provided the expected caloric density. A similar study was conducted in the Philippines in which 17 hospitals were randomly selected to provide blenderized diets for analysis.[2] Measured calories were consistently much lower than expected values. In practice, this would result in patients receiving a lower intake of energy and micro-nutrients than prescribed. In Gallagher-Allred's study, the propensity for tube occlusion was determined by allowing tube-feeding formula to drip unrestricted through a size 8 or 12 French nasogastric feeding tube. Milk-based and commercial feedings flowed unaided through a size 12 French feeding tube and

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Table 1. Methods of analysis*

Laboratory Test	Method
Water Soluble Vitamins:	
Pyridoxine, riboflavin	High performance liquid chromatography
Minerals	
Sodium, potassium, magnesium, calcium, iron, zinc	Atomic absorption spectrophotometry
Phosphorus	Spectrophotometry
Macronutrients	
Total fat	Sohxlet method
Saturated fat, cholesterol	Gas chromatography
Protein	Kjeltic automatic protein analyzer
Carbohydrate, calories	Computation
Viscosity	Viscosimeter

* References for analysis of vitamins and minerals: pyridoxine, riboflavin-HPLC (In-house method); minerals-AOAC 985.35; saturated fat, cholesterol-AOAC 1995

feeding tube and delivered 240 mL in less than 30 minutes. The institutionally prepared "high calorie" formula did not flow through the size 12 tube. Milk-based and commercial formulas were also able to flow unaided through a size 8 French nasogastric tube, but the blenderized formula could not.

There are no published standards for tube feeding viscosity; however, tube feeding formulas should be expected to flow through a small bore feeding tube at the desired infusion rate without causing tube occlusion. Commercial fiber-containing feedings, which are known to flow unaided through small bore (8 French) feeding tubes, typically have a viscosity of less than 60 centipoise (cps). Tube occlusion may result from inadequate flushing, addition of medication to the feeding, or coagulation of the protein moiety by gastric acid.[3] Tube occlusion has been cited as a reason why enteral tube feedings may not meet patient's energy requirements.[4] The purpose of this study was to evaluate the nutritional content and viscosity of hospital-prepared blenderized enteral tube feedings in the Philippines.

Materials and Methods

Four hospitals in Manila, Philippines were selected for participation in the study. The participating hospitals all used BTFs as a standard of practice for their enteral tube fed patients. Each hospital submitted two different tube feeding recipes; one representing a "standard" or general diet and the other a “modified” or therapeutic (eg diabetic, sodium-restricted, anti-diarrheal) diet of the hospital's choice. The providers of the recipes believed them to be nutritionally complete, providing all essential nutrients. Supplies used for the collection of the tube feeding samples (sterile containers, dry ice, cooler) were provided by SGS Philippines, Inc. (Makati City, Philippines). Each hospital prepared at least one liter of both BTF recipes on three separate occasions with an SGS technician present. The BTFs were prepared by the same personnel and with the same procedures used in the preparation of tube feedings for patients. Immediately following the preparation of all tube feedings, the SGS technician took a 600 mL aliquot of each feeding and divided it into three sterile, Nalgene bottles using clean technique. An additional 10 mL was poured into a sterile, Nalgene bottle for microbial analysis. Results of microbial analysis have been reported elsewhere.[5] Samples were sealed, labelled and immediately placed in a cooler with dry ice. Samples were transported from the hospital to the laboratory on dry ice and transferred to a -70°C freezer within ten hours of collection. SGS Philippines analyzed the samples for viscosity and the following nutritional components: vitamins (A, riboflavin, and pyridoxine), minerals (calcium, magnesium, phosphorus, sodium, iron, potassium, and zinc), cholesterol, saturated fatty acids, caloric density, and the percentage (by weight) of carbohydrate, fat, and protein. The laboratory used for this study lacked methods sensitive enough to reliably detect low levels of the following vitamins and minerals: vitamins B_{12}, C, D, E, and K, thiamin, niacin, folic acid, selenium, and iodine. Therefore, these vitamins and minerals were not considered for analysis. Methods of analysis are shown in Table 1.

The dietitians from each institution determined the “expected” nutrient content of each recipe, which was derived from the recipe ingredients. If this was not available, the recipe was analyzed using nutritional analysis software (Nutritionist V, First Data Bank, San Bruno, CA, 1998) and Philippine Food Composition Tables.[6] The “expected” nutritional content was compared with the measured nutritional content as determined from the laboratory analyses. The recipes were generally prepared from blended foods such as meat, fruit, and vegetables. However, two hospitals used a commercial powder formula as a base to which water alone or water and fruit were added: Hospital A, standard and modified feedings; Hospital B, standard feeding. Recipes for all feedings are shown in Table 2.

Statistical methods

All statistical tests were two-sided with a 0.05 significance level. Statistical analyses were performed separately for each hospital and for the combined data from all hospitals. For each BTF, descriptive statistics were calculated for nutritional parameters and viscosity. Paired statistical tests were used to determine whether the measured nutrient levels differed from the expected levels. Paired t-tests were used to compare results when the differences showed a normal or approximately normal distribution, and the nonparametric paired sign test was used when the differences showed an extremely non-normal distribution.

Correlation coefficients were obtained for measured versus expected nutrient content to determine how close these values were. Pearson correlation coefficients were

Table 2. Recipes for blenderized enteral tube feedings

Hospital A	*Hospital B*	*Hospital C*	*Hospital D*
Standard Feedings			
Ensure ® powder†, 333 g Tap water, 1350 mL	Ensure ® powder†, 265 g Tap water, 960 mL	Squash, 135 g Banana, 80 g Nonfat dry milk, 17 g White bread, 150 g Corn oil, 26 mL Chicken breast, 67.5 g Lugao*, 360 mL	Banana, 4 whole peeled White bread, 5 slices Lugao*, 240 mL Egg, cooked, 1 Corn oil, 7.5 mL White sugar, 4.2 g
1500 mL Total	1200 mL Total	1000 mL Total	Total Volume NA
Modified Feedings			
(Constipating Diet) Ensure® powder†, 289 g Banana, 2.5 whole peeled Tap water, 1275 mL	*(Natural Formula Diet)* Squash, 245 g Banana, 5 whole peeled Egg cooked, 272 g Corn oil, 60 mL White sugar, 12.6 g	*(High Fibre Low Cholesterol Diet)* Squash, 180 g Banana, 120 g Pineapple juice, 120 mL Mung beans, 62 g Nonfat milk, 8.5 g Egg, cooked 12.5 g White sugar, 16.8 g Oatmeal, 227 g White bread, 110 g Corn oil, 10 mL Olive oil, 12.5 mL	*(Diabetic Diet)* Bananas 4.5 whole peeled White bread, 5 slices Egg, cooked, 1 Corn oil, 7.5 mL Lugao*, 240 mL
1500 mL Total	1000 mL Total	1000 mL Total	Total Volume NA

†Ensure®, Abbott Laboratories, Zwolle, Netherlands; * Lugao = rice gruel; NA = not available

used to test the hypothesis of zero correlation when the measured nutrient levels had a normal or approximately normal distribution. Spearman correlation coefficients were used when the measured nutrient levels had an extremely non-normal distribution. SPSS for Windows (version 8) was used for data management and statistical analyses.

Results

There was a high degree of variability in the concentrations of most nutrients measured both among samples from a single hospital and among samples from different hospitals. In addition, vitamin levels were not detectable in all samples. Descriptive statistics for all nutrients include only those samples with detectable levels. The measured nutrient concentrations of the standard and modified feedings from each hospital are presented in Tables 3 and 4, respectively. At each hospital, the values for caloric density and the percentages (by weight) of carbohydrate, fat, and protein were generally within ± 20%-30% of the mean value at that hospital. However, variability for cholesterol concentrations was much greater, particularly for standard feedings prepared at Hospital D (range 14-172 mg/kg) and modified feedings prepared at Hospital B (range 4-198 mg/kg). For standard feedings, the mean caloric density between hospitals ranged from 80.9 - 106.5 kcal/100g and the mean percentages (by weight) of protein, carbohydrate, and fat ranged from 2.13% - 3.63%, 12.0% - 18.7%, and 1.63% - 2.57%, respectively.

Vitamin levels were undetectable in many samples. For standard BTFs, vitamin A and riboflavin were detectable in 9 of the 12 samples, and pyridoxine was detectable in 8 of the 12 samples. For modified BTFs, pyridoxine was detectable in 9 of 12 samples, vitamin A in 7 of 12 samples, and riboflavin in 5 of 12 samples. Concentrations of all vitamins measured varied widely, particularly for feedings prepared at Hospital B (vitamin A, 2250 - 8075 IU/kg; riboflavin, 1.10 - 5.00 mg/kg; pyridoxine, 0.30 - 3.00 mg/kg).

Variability for mineral concentrations was generally within ± 20% of the mean value at each hospital. However, for standard feedings, sodium and calcium concentrations ranged from 148 - 389 mg/kg and 64 - 204 mg/kg, respectively, at Hospital D, and zinc concentrations ranged from 3.6 - 11.5 mg/kg at Hospital A. For modified feedings, sodium and potassium concentrations ranged from 144 - 404 mg/kg and 423 - 1242 mg/kg, respectively, at Hospital D, and zinc concentrations ranged from 2.0 - 9.3 mg/kg at Hospital A. Mean concentrations of minerals also varied considerably between hospitals for standard feedings: calcium, 139 - 467 mg/kg; phosphorus, 293 - 499 mg/kg; iron, 3.4 - 11.2 mg/kg; sodium, 280 - 679 mg/kg; potassium, 757 - 1095 mg/kg; and zinc, 2.8 - 8.6 mg/kg. Mean concentrations of most minerals measured in standard and modified feedings were generally higher when prepared from powdered formula; i.e standard feeding Hospital A and B, modified feeding Hospital A.

There were marked discrepancies between the measured and expected values for calories and percentage of carbohydrate, fat, and protein in both the standard and modified feedings (Tables 5 and 6). There was no overall correlation between measured and expected nutrient concentrations. When all feedings were analyzed together, the Pearson correlation coefficients were almost

Table 3. Measured nutrient concentrations of BTF samples: standard feedings

	Hospital A Mean ± SD (Range)	*Hospital B* Mean ± SD (Range)	*Hospital C* Mean ± SD (Range)	*Hospital D* Mean ± SD (Range)
Macronutrients				
Calories (kcal/100g)	80.9±9.1 (73.1-90.9)	85.9±14.8 (70.4-99.8)	90.2±21.7 (66.0-108.0)	106.5±19.8 (84.5-123.0)
Protein (%)#	2.83±0.60 (2.20-3.40)	3.00±0.44 (2.70-3.50)	3.63±0.55 (3.00-4.00)	2.13±0.65 (1.50-2.80)
Carbohydrate (%)#	13.4±2.7 (10.9-16.2)	12.0±2.9 (8.6-13.8)	15.2±3.9 (10.8-18.4)	18.7±3.5 (14.7-21.4)
Fat (%)#	1.77±0.47 (1.40-2.30)	2.16±1.66 (0.27-3.40)	1.63±0.40 (1.20-2.00)	2.57±0.58 (1.90-2.90)
Saturated fat (%)#	1.13±0.31 (0.80-1.40)	2.08±1.57 (0.34-3.40)	1.13±0.23 (1.00-1.40)	2.53±0.70 (1.80-3.20)
Cholesterol (mg/kg)	16.8±8.2 (7.4-21.7)	12.1±7.9 (3.0-17.0)	27.2±22.0 (7.6-51.0)	114±87 (14-172)
Vitamins				
Vitamin A (IU/kg)	6967±2581 (4025-8850)	4977±2930 (2250-8075)	1197±602 (625-1825)	ND
% with detectable level$	100%	100%	100%	0%
Riboflavin (mg/kg)	3.05±1.20 (2.20-3.90)	3.05±2.76 (1.10-5.00)	2.80±0.28 (2.60-3.00)	0.55±0.21 (0.40-0.70)
%with detectable level$	67%	67%	67%	100%
Pyridoxine (mg/kg)	2.30±0.28 (2.10-2.50)	1.90±1.42 (0.30-3.00)	0.14	0.65±0.64 (0.20-1.10)
%with detectable level$	67%	100%	33%	67%
Minerals				
Calcium (mg/kg)	467±51 (426-524)	406±18 (388-424)	313±60 (256-376)	139±71 (64-204)
Magnesium (mg/kg)	175±23 (154-200)	155±24 (135-181)	120±22 (102-145)	130±38 (104-173)
Phosphorus (mg/kg)	454±42 (410-493)	396±22 (372-413)	499±60 (430-539)	293±82 (235-387)
Iron (mg/kg)	11.2±2.3 (9.3-13.7)	8.5±1.8 (6.4-9.7)	3.4±0.6 (3.0-4.1)	4.5±1.4 (3.5-6.1)
Sodium (mg/kg)	679±204 (478-886)	672±102 (590-786)	405±78 (350-494)	280±122 (148-389)
Potassium (mg/kg)	998±141 (862-1143)	1095±183 (884-1210)	757±90(704-860)	822±218 (608-1043)
Zinc (mg/kg)	8.6±4.4 (3.6-11.5)	8.1±0.1 (8.0-8.2)	2.9±1.1 (1.8-4.0)	2.8±0.4 (2.3-3.0)
% with detectable level$	100%	67%	100%	100%

SD = standard deviation; # Percentages based on weight (g/100g). *N* = 3 for all hospitals; ND = not detectable in any sample; $ % of samples with detectable level of nutrient

zero for measured versus expected caloric density (correlation coefficient r = -0.056, *P* =0.80) and measured versus expected percent protein (r = 0.045, *P* = 0.83). For the measured versus expected percent fat, the Pearson correlation coefficient was negative, but not statistically significant (r =–0.27, *P*=0.20). A statistically significant, positive Pearson correlation coefficient was observed for measured versus expected percent carbohydrate, but this was only a moderate correlation (r = 0.48, *P* = 0.017). The nonparametric sign test was used to investigate the tendency for the measured values to be higher or lower than the expected values. When all samples were analyzed together, the measured values tended to be lower than the expected values for all nutrients, but the difference was statistically significant only for calories (*P*=0.023). *P* values for the differences between measured and expected values for carbohydrate, fat, and protein were *P* = 0.064, *P* = 0.093, and *P* = 0.093, respectively.

Viscosity measurements were obtained for 21 of the 24 samples; three samples were too viscous for analysis. The mean viscosity for the 21 samples was 2,617 cps (median 21.6 cps; range 2.3 - 45,060 cps). The wide range of viscosity values reflected the range of ingredients used for preparation of the feedings. Viscosity was uniformly much lower and more consistent for feedings prepared from powdered formulas and water (usually <10 cps) than for feedings prepared from blenderized whole food ingredients (20 - 45,060 cps).

Discussion

This study demonstrates that hospital prepared blenderized enteral tube feedings render unpredictable and inconsistent levels of micronutrients and macronutrients. These feedings were likely to deliver less than the expected amount of nutrients based on the actual recipes.

There may be clinical implications of under-delivering nutrients in at-risk patient groups, such as paediatric patients, and hypermetabolic patients who have higher nutrient needs compared to normal metabolic ones. For example, a burned patient may require 3000 kcal per day. If a formula were selected that unknowingly provided only 2000 kcal/day or only 66% of his caloric requirements, this deficit could have significant adverse clinical outcomes such as accelerated loss of lean body mass.

The variability in nutrient levels observed over three days of BTF preparation was significant. At Hospital B, preparation of the same recipe (modified diet) on three separate days provided a nearly 50-fold range in measured cholesterol content (4 - 198 mg/kg). Variations in the nutrient compositions of hospital prepared enteral feedings have been observed in other studies.[1,2] The nutrient composition of feedings prepared from normal foodstuffs depends on the nutrient compositions of the foods used. These compositions can vary according to the geographical source of the food, the season and stage of maturity when the food was harvested, food processing methods, storage conditions, and cooking methods.[2]

These factors could explain some of the variability in the nutrient composition of the feedings. It is of concern that 11 standard and 17 modified BTF samples did not have detectable levels of specific nutrients: pyridoxine, riboflavin, vitamin A or zinc. The expected amount of each nutrient was derived from the BTF recipes. The result of undetectable levels of specific nutrients in the prepared samples could have been due to inadequate preparation of the recipes (ie substitution or omission of food from the recipe) or loss of the nutrient during storage of the raw foods prior to BTF preparation. While short-term lack of vitamins may be without consequence, long-term deficiency could negatively impact nutritional status.

Table 4. Measured nutrient concentrations of BTF samples: modified feedings

	Hospital A (Constipating Diet) Mean + SD (Range)	*Hospital B* (Natural Formula Diet) Mean + SD (Range)	*Hospital C* (High Fibre Low Cholesterol Diet) Mean + SD (Range)	*Hospital D* (Diabetic Diet) Mean + SD (Range)
Macronutrients				
Calories (kcal/100g)	97.8+28.3 (73.9-129.0)	64.8+14.1 (50.7-78.9)	82.2+4.0 (77.7-85.0)	98.5+3.7 (94.6-102.0)
Protein (%)#	2.77+0.59(2.10-3.20)	1.17+0.45(0.71-1.60)	2.57+0.21(2.40-2.80)	1.87+0.40(1.40-2.10)
Carbohydrate (%)#	16.2+5.7 (11.2-22.4)	11.1+2.6 (8.1-13.2)	14.4+1.1 (13.2-15.4)	16.3+1.6 (15.0-18.1)
Fat (%)#	2.43+0.51(2.00-3.00)	1.93+0.67(1.50-2.70)	1.63+0.06(1.60-1.70)	2.87+0.55(2.30-3.40)
Saturated fat (%)#	1.37+0.38(1.10-1.80)	1.47+0.23(1.20-1.60)	1.20+0.36(0.90-1.60)	2.80+0.66(2.10-3.40)
Cholesterol (mg/kg)	19.9+12.2 (6.0-28.9)	110+98 (4-198)	15.5+5.5 (10.8-21.5)	106+79 (16.2-164)
Vitamins				
Vitamin A (IU/kg)	3882+322 (3655-4250)	1832	1372+490 (870-1850)	ND
% with detectable level$	100%	33%	100%	0%
Riboflavin (mg/kg)	3.4	ND	5.10+2.12(3.60-6.60)	0.68+0.59(0.27-1.10)
% with detectable level$	33%	0%	67%	67%
Pyridoxine (mg/kg)	2.15+0.50(1.80-2.50)	0.30+0.28(0.11-0.50)	0.40+0.14(0.30-0.50)	0.36+0.21(0.20-0.60)
% with detectable level$	67%	67%	67%	100%
Minerals				
Calcium (mg/kg)	454+75 (374-524)	58.0+20.8 (34-70)	299+50 (250-350)	141+53 (80-174)
Magnesium (mg/kg)	171+22 (148-192)	44.0+3.5 (40-46)	155+32 (124-188)	136+47 (100-190)
Phosphorus (mg/kg)	432+81 (348-510)	156+50.1 (102-201)	502+27 (475-530)	310+15 (294-322)
Iron (mg/kg)	9.1+1.6 (7.3-10.4)	2.1+1.2 (1.1-3.4)	5.5+1.5 (3.8-6.6)	5.1+2.1 (3.2-7.4)
Sodium (mg/kg)	523.3+62.3 (456-579)	187.3+41.8 (140-219)	369+90.7 (271-450)	261+132 (144-404)
Potassium (mg/kg)	1098+222(901-1339)	268+80(176-320)	1203+234(1035-1470)	776+421(423-1242)
Zinc (mg/kg)	6.0+3.7 (2.0-9.3)	1.6	3.5+0.6 (2.8-4.0)	2.6+1.0 (1.6-3.5)
% with detectable level$	100%	33%	100%	100%

SD = standard deviation; # Percentages based on weight (g/100g). *N* = 3 for all hospitals; $ % of samples with detectable level of nutrient; ND = not detectable in any sample

Table 5. Comparison of measured and expected nutrient content: standard feedings

	Calories (kcal/100g)	Carbohydrate (%)	Fat (%)	Protein (%)
Hospital A				
Measured: Mean + SD	80.9 + 9.1	13.4 + 2.7	1.77 + 0.47	2.83 + 0.60
(Range)	(73.1-90.9)	(10.9-16.2)	(1.40-2.30)	(2.20-3.40)
Expected:	88.0	11.9	3.10	3.10
Hospital B				
Measured: Mean + SD	85.9 + 14.8	12.0 + 2.9	2.16 + 1.66	3.00 + 0.44
(Range)	(70.4-99.8)	(8.6-13.8)	(0.27-3.40)	(2.70-3.50)
Expected:	53.6	7.2	1.90	1.90
Hospital C				
Measured: Mean + SD	90.2 + 21.7	15.2 + 3.9	1.63 + 0.40	3.63 + 0.55
(Range)	(66.0-108.0)	(10.8-18.4)	(1.20-2.00)	(3.00-4.00)
Expected:	152.0	20.5	5.30	5.50
Hospital D				
Measured: Mean + SD	106.5 + 19.8	18.7 + 3.5	2.57 + 0.58	2.13 + 0.65
(Range)	(84.5-123.0)	(14.7-21.4)	(1.90-2.90)	(1.50-2.80
Expected:	129.0	23.9	2.45	2.80

SD = standard deviation; *N* = 3 for all hospitals

The mean calcium content for two hospitals was inadequate. The mean calcium content derived for 1000 kcal was only 90 mg for Hospital B's modified feeding and 131mg for Hospital D's standard feeding. This is clearly insufficient for all patient groups. While the US Dietary Reference Intakes recommend an intake of 1000 mg calcium per day[8] for adults 19-50 years old, needs for some individuals, such as those at risk for osteoporosis, may be as high as 1500 mg/day.[9]

The mean viscosity (2,617 cps) for the 21 samples analyzed was more than 43 times higher than typical commercial formulas (60 cps). It is likely that some of these samples would not flow easily through nasogastric or nasoenteric feeding tubes and could occlude these tubes. To prevent tube occlusion from a high viscosity formula, rapid feeding by bolus method or the use of large bore feeding tubes may be required. In general, these methods of feeding are poorly tolerated compared to continuous feeding through a small bore feeding tube. Coben *et al*., compared lower oesophageal sphincter pressure (LES) in response to a rapid feeding bolus versus continuous feeding in tube fed adults.[10] The LES was significantly lower following the bolus feeding than after the continuous feeding. Relaxation of LES is associated with gastroesophageal reflux.[11,12] Gastroesophageal reflux has also been associated with the use of large bore feeding tubes.[11]

Table 6. Comparison of measured and expected nutrient content: modified feedings

		Calories (kcal/100g)	Carbohydrate (%)	Fat (%)	Protein (%)
Hospital A (Anti-diarrheal Diet)					
Measured:	Mean ± SD	97.8 ± 28.3	16.2 ± 5.7	2.43 ± 0.51	2.77 ± 0.59
	(Range)	(73.9-129.0)	(11.2-22.4)	(2.00-3.00)	(2.10-3.20)
Expected:		84.9	13.0	2.50	2.60
Hospital B (Natural Formula Diet)					
Measured:	Mean ± SD	64.8 ± 14.1	11.1 ± 2.6	1.93 ± 0.67	1.17 ± 0.45
	(Range)	(50.7-78.9)	(8.1-13.2)	(1.50-2.70)	(0.71-1.60)
Expected:		148.0	14.2	8.10	4.60
Hospital C (High Fibre Low Cholesterol Diet)					
Measured:	Mean ± SD	82.2 ± 4.0	14.4 ± 1.1	1.63 ± 0.06	2.57 ± 0.21
	(Range)	(77.7-85.0)	(13.2-15.4)	(1.60-1.70)	(2.40-2.80)
Expected:		112.0	18.1	3.20	2.70
Hospital D (Diabetic Diet)					
Measured:	Mean ± SD	98.5 ± 3.7	16.3 ± 1.6	2.87 ± 0.55	1.87 ± 0.40
	(Range)	(94.6-102.0)	(15.0-18.1)	(2.30-3.40)	(1.40-2.10)
Expected:		126.0	23.5	2.30	2.70

SD = standard deviation; N = 3 for all hospitals

Situations that prevent the patient's energy requirements from being met through enteral nutrition have been identified. The reasons stated in the literature for caloric goals not being met in the hospitalized tube fed patient are: mechanical complications with the tube, gastro-intestinal intolerance, and cessation of feeding due to diagnostic procedures.[4,13] This study has shown that unreliable composition of blenderized enteral formulas may pose an additional risk for inadequate nutritional intake among tube fed patients. Recent studies by De Jonghe *et al.,* and McClave *et al*., have investigated the adequacy of energy delivery through tube feeding using available commercial formulas.[13,14] In these studies, the investigators did not question the reliability of the nutritional content of the feeding formula since the composition of commercial feedings is assumed.

It was unfortunate that we were not able to measure all nutrients. However, we did have a representative sample of micronutrients, including: vitamins, minerals, and electrolytes. Whenever the nutrient content of an enteral feeding does not correspond with the expected nutrient levels, adverse outcomes may result.

The results of this study demonstrate that despite standardized recipes, hospital prepared enteral tube feedings render unpredictable levels of micro-nutrients and macronutrients. These feedings were more likely to under-deliver rather than over-deliver nutrients, which may result in clinical and nutritional implications for patients at risk of malnutrition.

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