

Decrease in gastric emptying time and episodes of regurgitation in children with spastic quadriplegia fed a whey-based formula

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The gastric emptying times associated with three whey-based formulas were significantly shorter than that associated with a casein-based formula in nine gastrostomy-fed patients with spastic quadriplegia ($p < 0.001$). Patients fed whey-based formulas had significantly fewer episodes of emesis than when they were fed casein-based formula ($p < 0.001$). We conclude that whey-based formulas reduce the frequency of emesis by improving the rate of gastric emptying. (J PEDIATR 1992;120:569-72)

Gastroesophageal reflux, a frequent complication in patients with cerebral palsy, may result in undernutrition and aspiration pneumonia.¹ Delayed gastric emptying is an important factor in gastroesophageal reflux in children older

than 3 years,² especially those with cerebral palsy.¹ The rate of gastric emptying associated with a formula is affected by the type of protein the formula contains; for example, gastric emptying occurs more slowly in patients fed a casein-predominant formula than in those fed whey-based formulas.³

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We undertook this study to determine whether whey-based formulas would improve the rate of gastric emptying and decrease the amount of regurgitation in patients with cerebral palsy, spastic quadriplegia, severe developmental delay, and scoliosis who have been fed casein-predominant formulas.

Table. Composition of formulas per 150 ml of test feeding

	Casein predominant	Whey predominant	Whey hydrolysate	Whey hydrolysate (70% MCT)
Protein source	80% Casein 20% Soy	60% Whey 40% Casein	100% Whey hydrolysate	100% Whey hydrolysate
Protein (gm)	5.1*	3.4†	3.6	6.0
Carbohydrates (gm)	20.0	17.2	16.6	19.1
Fat (gm)	6.6	7.7	7.7	5.8
Percentage of fat as MCT	21.0	8.0	9.0	70.0
Osmolality (mOsm/kg water)‡	314.0	470.0	403.0	318.0
Energy (kcal)	159.0	150.0	150.0	150.0

MCT, Medium-chain triglycerides

*Casein 4.08 gm, soy 1.02 gm.

†Casein 1.36 gm, whey 2.04 gm.

‡Measured by the biochemistry laboratory at the Hospital for Sick Children, Toronto, Ontario, Canada.

METHODS

Inclusion criteria. We studied nine consecutive outpatients with spastic quadriplegia who were attending the clinical nutrition outpatient clinic at the Hospital for Sick Children, Toronto, Ontario, from July 1990 through February 1991. The study was approved by the hospital's human subjects review committee. Written consent was obtained for all patients. All patients included in the study had profound mental retardation, spastic quadriplegia, scoliosis, and developmental delay; all were unable to speak or walk. We chose subjects older than 3 years because gastroesophageal reflux is more closely associated with delayed gastric emptying in children of this age group than in younger children.² Only patients already being fed through a gastrostomy tube that had been in place for longer than 1 month before the study were included; delayed gastric emptying may occur as long as 8 days after surgical placement of a gastrostomy tube.⁴ None of our patients underwent fundoplication, which can alter the rate of gastric emptying.⁵ All had clinical evidence of gastroesophageal reflux; their care givers reported repeated episodes of involuntary regurgitation of food.

Subjects. Nine patients (age range 3 to 18 years) were recruited from the clinical nutrition clinic because of their frequent episodes of vomiting. Patients were being fed a formula containing casein (80%) and soy (20%) (Isosource, Sandoz Co., Whitby, Ontario, Canada) through a gastrostomy tube. This was the standard tube formulation in use at our hospital. When the patients were recruited their care givers were instructed to record the number of episodes of regurgitation per day for 1 month. Within 2 weeks from the start of the study a gastric-emptying scan with radiolabeled liquid-technetium Tc 99m sulfur colloid documented delayed gastric emptying in all nine patients. The same casein-predominant formula that patients were routinely fed was used for the scan.

Gastric emptying scans. After delayed gastric emptying was confirmed, each patient participated in a double-blind (caretaker and radiologist both unaware of formula), randomized trial with gastric-emptying scans that compared the effects of three different types of whey-based formulas: whey predominant (Nan; Nestlé S.A., Vevey, Switzerland), whey hydrolysate (Carnation Good Start; Nestlé Inc., Canada), and whey hydrolysate with 70% of the fat as medium-chain triglycerides (Peptamen; Clin-tec, Baxter Healthcare Corp., Mississauga, Ontario, Canada). The composition of these formulas is provided in the Table.

In the morning, when the patients had fasted 8 to 10 hours after their last casein-predominant feeding, we used the protocol described by Brophy et al.⁶ to study gastric emptying with radionuclide scan. In each patient, three 2-hour studies with each formula were completed during a 2-week period. Studies were performed at least 2 days apart. All whey-based formulas contained the same volume (150 ml) and the same energy per volume (1 kcal/ml, Table).^{7,8} Loss of radionuclide was prevented because the volume of the test feeding (150 ml) was half of the feeding volume (300 ml) that usually resulted in regurgitation. At baseline, 60 ml of formula was labeled with 1 mCi of ^{99m}Tc-sulfur colloid and given as a bolus by syringe through the gastrostomy tube for 1 minute. This feeding was immediately followed by the remaining 90 ml of unlabeled formula, to flush any residual radioactivity from the gastrostomy tube. With the patient in a supine position under a gamma camera, we recorded the radioactive counts in the stomach at baseline and the residual gastric radioactivity at 60 and 120 minutes after initial feeding. Patients sat in their chairs between readings. With the 60- and 120-minute readings, corrected for radioactive decay, we determined the percentage of residual gastric radioactivity at 60 and 120 minutes by dividing the amount of radioactivity found in the stomach at 60 and 120 minutes

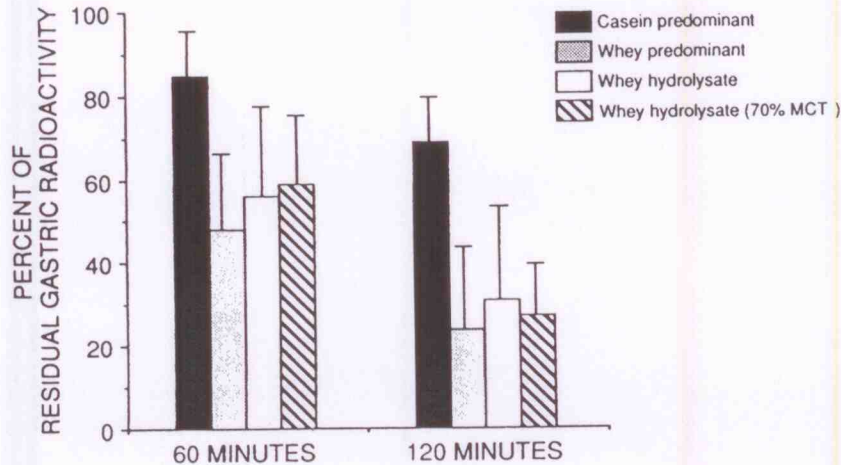


Figure. Percentage of residual gastric radioactivity at 60 and 120 minutes with casein-predominant and whey-based formulas in nine patients with cerebral palsy, spastic quadriplegia, developmental delay, scoliosis, and gastroesophageal reflux. Percentage of residual gastric radioactivity was significantly lower at 60 and 120 minutes ($p < 0.001$) when patients were fed whey-based formulas. Values shown are mean \pm SD (error bars) for each formula. MCT, Medium-chain triglycerides.

by the total amount of radioactivity measured in the stomach at baseline.

No normal values for healthy pediatric patients older than 3 years and younger than 18 years have been published. We adopted as normal values for the mean residual percentage of radiolabeled liquid meals those established by Notivol et al⁹ for normal, healthy patients aged 18 to 31 years: $47\% \pm 5\%$ and $22\% \pm 5\%$ at 60 and 120 minutes, respectively. Delayed gastric emptying was then defined as more than 62% and 37% residual gastric radioactivity at 60 and 120 minutes, respectively; these values are more than 3 SD from the mean value.

Episodes of vomiting. Once the three gastric emptying studies were completed, each patient was fed a randomly assigned whey-based formula through the gastrostomy tube for 1 month. The feeding schedule was identical to that previously used for the casein-based standard formula. In this open trial the same care givers who had recorded the preliminary observations for the casein-predominant formula again recorded the number of episodes of emesis per day for 1 month. The number of episodes of emesis that occurred with the casein-predominant formula was then compared with the number that occurred with the whey-based formulas.

Statistical analysis. Analysis of variance was used to compare the gastric-emptying rate associated with the casein-predominant formula with those associated with the three different whey-based formulas. Results are expressed as a mean value \pm SD. A one-tailed paired Student *t* test was used to compare the number of emesis episodes that occurred when patients were fed the casein-predominant

formula with the number that occurred when they were fed whey-based formulas.

RESULTS

The results of the gastric-emptying scans at 60 and 120 minutes are expressed as the mean \pm SD percentage of residual gastric radioactivity for all nine patients for each formula. With the casein-predominant formula, the mean percentage of residual gastric radioactivity at 60 minutes was $85\% \pm 11\%$. There was a significantly lower mean percentage of residual gastric radioactivity associated with each whey-based formula at 60 minutes (whey predominant $48\% \pm 19\%$, whey hydrolysate $56\% \pm 23\%$, and whey hydrolysate with 70% medium-chain triglycerides $59\% \pm 19\%$) than with the casein-predominant formula ($p < 0.001$).

At 120 minutes the mean percentage of residual gastric radioactivity for the casein-predominant formula was $69\% \pm 14\%$. At 120 minutes there was also a significantly lower mean percentage of residual gastric activity for each whey-based formula (whey predominant, $24\% \pm 18\%$, whey hydrolysate $31\% \pm 26\%$, and whey hydrolysate with 70% medium-chain triglycerides $27\% \pm 13\%$) than for the casein-predominant formula ($p < 0.001$) (Figure). The difference in the mean percentage of residual gastric activity among the three whey-based formulas at 60 and 120 minutes was not statistically significant ($p > 0.1$).

There was an accompanying reduction in episodes of vomiting in all patients fed whey-based formulas (2 ± 2 episodes, range up to 7 episodes) from the number associated with casein-predominant formula (mean 12 ± 11 episodes, range 4 to 35 episodes; $p < 0.05$).

DISCUSSION

All patients fulfilling our selection criteria had delayed gastric emptying when fed the casein-predominant formula. This placed them at higher risk for such complications of gastroesophageal reflux as aspiration pneumonia. Our data showed that whey-based formulas are associated with improved rates of gastric emptying and fewer episodes of vomiting in all patients.

One of the major determinants of the rate of gastric emptying is the energy density of the formula used. Isocaloric formulas are emptied at the same rate despite differences in the amounts of protein, carbohydrate, and fat.^{7,8} The whey-based and casein-predominant formulas used in this study were isocaloric, but the casein-predominant formula was still emptied more slowly than were the whey-based formulas, presumably because of differences in the type of protein³—a second major determinant of the rate of gastric emptying. All three isocaloric whey-based formulas were emptied at similar rates despite differences in osmolality,¹⁰ amount of protein, and amount of medium-chain triglycerides.¹¹

We conclude that whey-based formulas reduce the number of episodes of vomiting by improving the rate of gastric emptying in patients 3 years or older with profound mental retardation, spastic quadriplegia, developmental delay, and scoliosis. Improved gastric emptying and fewer episodes of regurgitation should benefit these patients by improving their nutritional status and by decreasing the risk of aspiration pneumonia.

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