

Postprandial Gastric Motility in Infants with Gastroesophageal Reflux and Delayed Gastric Emptying

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Delayed gastric emptying of formula is observed in many infants with gastroesophageal reflux but the mechanisms responsible for this observation are not defined. Postprandial gastric motility was quantified using a perfused catheter placed into the distal stomach of five infants with gastroesophageal reflux and delayed gastric emptying of ^{99m}Tc -sulfur colloid-labeled formula. Five infants with reflux who exhibited normal emptying of formula served as the controls. Gastric motility indices were calculated for 60 min following a meal. Half the patients in each group were given metoclopramide following a 30-min recording period. In both groups, postprandial gastric motility was similar and characterized by minimal gastric contractions. Metoclopramide resulted in increased amplitude and duration of antral contractions, but no significant differences were noted between groups. The findings suggest that minimal delays in gastric emptying in infants with gastroesophageal reflux are not associated with significant alterations of postprandial gastric motility.

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During infancy, signs of gastroesophageal reflux (GER) commonly appear in many children without evidence of other chronic illness. Multiple mechanisms have been suggested to account for GER in this patient group, including inappropriate relaxation of the lower esophageal sphincter (1), delayed esophageal acid clearance (2) and delayed gastric emptying (3). Estimates of gastric emptying obtained from ^{99m}Tc -sulfur colloid-labeled infant formulae have suggested that some infants with clinically significant GER have delayed emptying (Table 1). These data are often compared with data from infants with GER who exhibit rates of gastric emptying within a normal range using this technique (4,5).

The clinical significance of different gastric emptying rates between these two groups is unclear, as is the understanding of the mechanisms responsible for these observations. In neonates, factors that appear to influence empty-

ing include gestational age and the composition of feedings used independent of GER symptoms (6,7). Selective alterations in gastric motor physiology may affect gastric emptying during infancy and account for variable emptying rates of some infants with GER. This study describes the results of postprandial gastric motility investigations in a small group of infants with GER and delayed gastric emptying compared with those with normal emptying rates.

MATERIALS AND METHODS

Patients

Five infants (ages 1-7 mo) who exhibited recurrent vomiting comprised the study group. All had normal physical examinations and developmental milestones. The GER diagnosis was established by barium upper gastrointestinal series and was confirmed by 24-hr esophageal pH monitoring. Radiocolloid-labeled formula gastric emptying studies revealed delayed emptying of cow or soy formula at 1 hr (mean: 75% of isotope remaining; range: 68%-87%).

Five infants (ages 1-6 mo) with similar clinical characteristics comprised the control group. All cases had radiologically normal gastrointestinal anatomy and positive 24-hr esophageal pH monitoring studies. The retention of radiocolloid-labeled formula in this group was within normal ranges at 1 hr (mean: 51% of formula remaining; range: 35%-62%).

This investigation was approved by the Human Subjects Research Committee of the University of California, Davis and written informed consent was obtained from the parents of all patients.

Esophageal pH Monitoring

In each subject, 20-24-hr ambulatory esophageal pH monitoring was performed using computerized pH recording equipment (Del Mar Avionics, Irvine, CA) with feedings of regular infant formula. Studies were scored positive for reflux if the total time less than pH 4.0 equaled 4% or greater and the total reflux score was above 45 (8).

Radiocolloid-Labeled Formula Gastric Emptying Scans

Gastric emptying rates were determined using ^{99m}Tc -sulfur colloid-labeled infant formula (cow or soy milk) at 20 kcal/oz. A total of 150 μCi of ^{99m}Tc isotope was used in a volume of 300 cc/1.73 m^2 body surface area. Images were obtained every 120 sec in the supine position for 1 hr without sedation. Data were acquired using a standard clinical nuclear medicine computer for 60 frames over 3600 sec in a 128 \times 128 \times 8 matrix; patients were then placed in the right lateral decubitus position for an additional 5 min. At

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TABLE 1
Gastric Emptying Times in Infants and Children with GER Measured by Radiocolloid-Labeled Liquids

| Reference | Number of subjects | Mean age | | Liquid | %Retention at 1 hr ± s.d. or s.e.m. |
|----------------------|--------------------|----------|------|--------------|-------------------------------------|
| | | (mo) | (yr) | | |
| Rosen et al. (4) | 26 | 7 | | 5% dextrose | 53 ± 25 |
| | 20 | | 9 | 5% dextrose | 28 ± 18 |
| Seibert et al. (5) | 41 | 5.7 | | Milk formula | 52 ± 27 |
| | 8 | | 9.1 | Milk | 49 ± 7 |
| DiLorenzo et al. (9) | Not specified | 4-6 | | Milk formula | 68 ± 1.7 |
| | | 7-12 | | Milk formula | 68.9 ± 2.6 |
| Tolla et al. (10) | 28 | <12 | | Milk formula | 60.3 |
| | | | | Soy formula | 55.4 |
| | | | | Whey formula | 51.5 |

the end of 5 min, an additional image was obtained for 120 sec and data were acquired for 60 sec after returning the patient to the supine position. Percentage retention was calculated both at the end of 60 min and following the additional 5 min in the right lateral decubitus position. Normal values using this technique result in a 53%–55% residual using 5% dextrose and water (4) or 52% retention of radiocolloid-labeled milk formula at 60 min (5). Some reported values for gastric emptying of radiocolloid labeled liquids in children are summarized in the table.

Gastric Motility

Gastric manometry was performed using a 3-lumen, perfused catheter with ports located 2.0 cm apart and a pneumocapillary infusion pump (Arndorfer Medical Specialties). The catheter was placed along the greater curvature of the stomach by fluoroscopy, with the distal port in the antrum. Gastric contractions were recorded using a Beckman R612 recording system.

Study Design

This study compared meal-stimulated gastric motility in both patient groups; the size of each group was purposely limited due to the invasive nature of the investigations. Three of five patients in the control group and two of five patients in the study group (delayed emptying) were randomized to receive metoclopramide 30 min following a bolus feeding.

Data Analysis

Motility indices (MI) for the gastric antrum and body were calculated from areas beneath contraction curves on paper recordings using a computer graphics tablet system. Results in both groups were averaged for 5-min segments.

Statistical analysis was performed on the results of gastric emptying studies and motility indices using the Student's t-test for unpaired samples.

RESULTS

Gastric Emptying of Radiocolloid-Labeled Formula

Patients classified as having delayed emptying demonstrated retention of 75% ± 7.5% (mean ± s.e.m.) of formula at 1 hr and control patients exhibited residuals of 51% ± 5.5%. Placement of patients on the right lateral decubitus position for 5 min resulted in a mean retention of 63% ± 6.6% of radiocolloid labeled formula at 65 min. Placement of control patients in the right lateral decubitus position resulted in a mean retention of 40% ± 4.5% of radio-

colloid labeled formula at 65 min. These results are summarized in Figure 1.

Gastric Motility

No significant differences in gastric motility indices (MI) were seen between control patients or subjects with delayed gastric emptying. Infusion of formula inhibited Phase III of the migrating motor complex (MMC) in all patients; only sporadic Phase II contractions were observed during the duration of the monitoring (Fig. 2). Following metoclopramide administration to each subgroup of patients, contraction patterns of the antrum were converted to Phase III contractions within 5–7 min. This result is illustrated by the patient record presented in Figure 3. When MI of antral contractions following metoclopramide were compared, no significant differences were appreciated between groups (Fig. 4).

DISCUSSION

The results of this study suggest that postprandial gastric motility in infants with mild delays in gastric emptying is no different from in those infants with "normal" gastric emptying. However, a number of points require elaboration concerning these findings in this group of patients.

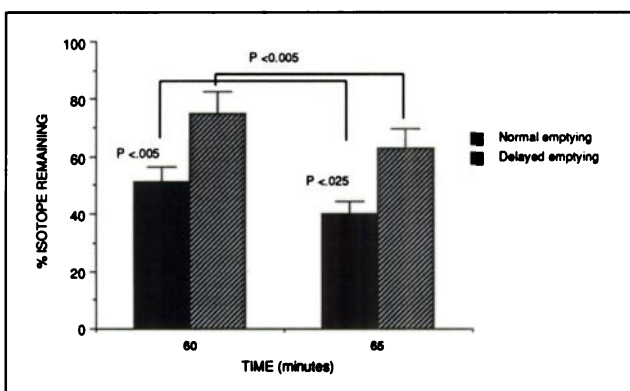


FIGURE 1. Retention of radiocolloid labeled formula in study and control patients. Values for percentage of radiocolloid labeled formula remaining in the stomach at 60 min are compared with those observed at 65 min following positioning of patients on their right side (mean ± s.e.m.).

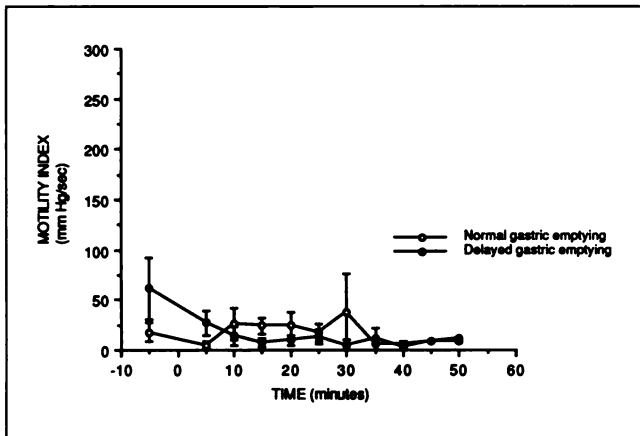


FIGURE 2. Mean motility indices (MI) of the gastric antrum in infants manifesting normal and delayed gastric emptying following a standard meal at time 0.

Gastric emptying is a complex phenomenon; meals of different composition are emptied at different rates through different mechanisms (11). Infant formula partially denatures on contact with hydrochloric acid in the stomach. Although the physical characteristics of formula following partial acid denaturation might suggest a partially digested solid meal, infant formula is emptied as a liquid meal without the contribution of significant antral contractile activity (12).

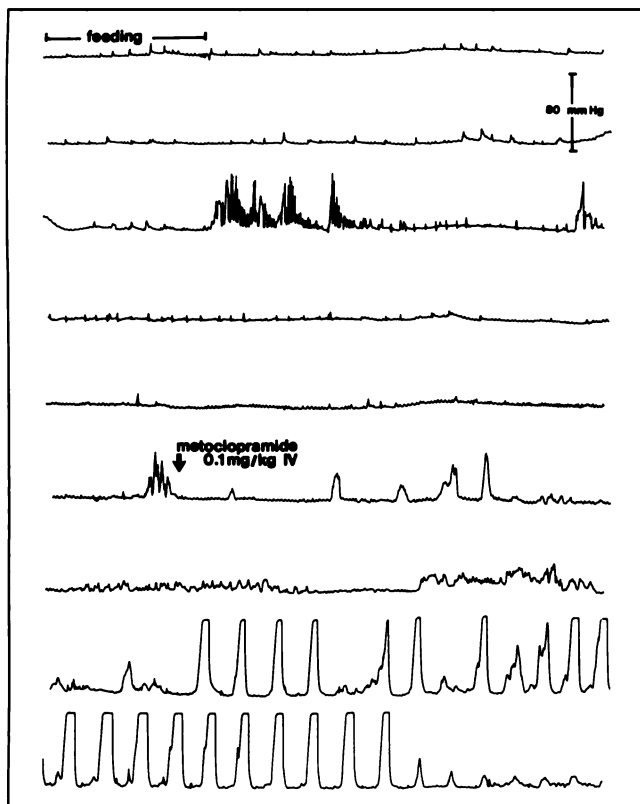


FIGURE 3. Tracings of antral contractions in a 3-mo-old male infant with normal gastric emptying who underwent investigations of gastric motility. Each segment represents 5 min of recording. Following metoclopramide administration (\downarrow), there was a rapid increase in antral contractile activity.

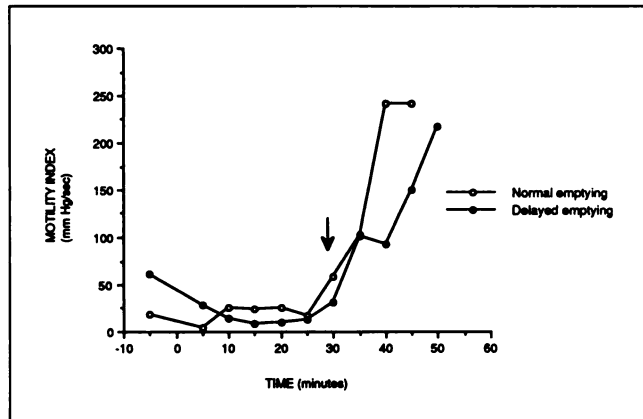


FIGURE 4. Mean motility indices of antral contractile activity before and following metoclopramide administration at 30 min (\downarrow) in two groups of infants with gastroesophageal reflux.

Failure to demonstrate significant differences in motility between patient groups may in part be accounted for by the relative lack of gastric contractions during a time when 40%–60% of a meal is emptied from the stomach. Alternatively, no measurable differences may actually exist between infants with normal and delayed gastric emptying.

Pharmacological intervention in a subgroup of subjects was undertaken to determine if this could unmask differences in response of the gastric antrum to account for variations in gastric emptying rates. Following metoclopramide, both groups showed increased antral motility indices but no significant differences were noted between groups. However, the numbers in each subgroup were small (two and three patients, respectively) and it is difficult to apply these results to a larger population of patients.

Are the minor abnormalities of gastric emptying suggested by radiocolloid-labeled formula scintigraphy in infants with GER real and of any clinical significance? Numerous variables may affect measurement of gastric emptying rates. We attempted to address the issue of positioning with resulting pooling of formula by positioning each patient on the right side for an additional 5 min after completion of the standard scintiscan. When results from this additional period of data collection are compared, two additional conclusions are apparent: placement of patients on the right side increases overall gastric emptying rates and differences between the two groups are still evident (Fig. 1). The clinical significance of “delayed” gastric emptying in infants with GER may be easier to address. The differences in gastric emptying rates observed between these groups are probably not clinically significant, based on long-term clinical follow-up of these and other patients. Furthermore, both groups appear to respond equally to administration of prokinetic agents such as metoclopramide, which has been used clinically for a number of years in infants and may offer some effectiveness for the treatment of GER in selected patients (13).

SUMMARY

Postprandial gastric motility in two groups of normal infants manifesting gastroesophageal reflux and "normal" or "delayed" gastric emptying was compared. Although infants with delayed gastric emptying exhibited a mean retention of radiocolloid-labeled formula 24% greater than the control group at 1 hr, both groups showed similar gastric motility following a formula meal. Administration of metoclopramide resulted in no discernible differences between patient groups, although the numbers were small. Delayed gastric emptying of radiocolloid-labeled formula in infants with GER appears to be real, but does not appear to be associated with significant alterations of postprandial gastric motility. The clinical significance of mildly delayed gastric emptying in neurologically normal infants with GER should be subject to close examination.

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