The gastric response to a transpyloric duodenal tube¹

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SUMMARY The quantification of gastric, pancreatic, biliary, and small bowel functions in man often requires the use of intestinal tubes. In this study, the presence of a transpyloric tube did not alter gastric emptying, acid secretion, or serum gastrin levels in response to an ordinary solid meal.

Recent advances in the correlation of human gastric physiology with associated functions of the pancreas, biliary tract and upper small intestine have involved intubation with both duodenal and gastric tubes (Go, Hofmann, and Summerskill, 1970; Brunner, Northfield, Hofmann, Go, and Summerskill, 1974; Moberg, 1974; Johansson, 1974). Evidence that a transpyloric duodenal tube does not affect gastric function is limited. Forty years ago Shay and Gershon-Cohen (1935) reported that a small bowel tube did not affect gastric emptying of a barium and water meal. Previous studies from our laboratory, utilizing duodenal recovery of a meal marker (Meeroff, Go, and Phillips, 1973), revealed no difference in the rate of gastric emptying of saline compared with published data based on a gastric aspiration method (George, 1968), providing indirect evidence that a duodenal tube does not alter emptying of saline. The present study was designed to determine whether a duodenal tube affects the rates of gastric emptying, acid production, and serum gastrin response following the ingestion of an ordinary solid meal.

Methods

Each of five healthy men (ages 22 to 33 years) was studied twice. On one day a triple-lumen tube (total outside diameter, about 4 mm) was positioned fluoroscopically, as if duodenal perfusion were planned, with its tip at the level of the angle of Treitz (Go *et al*, 1970). In addition, a single-lumen gastric sump tube (16 F) with enlarged aspiration

Fig 1 Intubation techniques.

holes was positioned with its tip in the antrum. On another day and in randomized order, both tubes were positioned in the antrum (fig 1). Volunteers were not aware of the position of the tubes since the time spent for intubation was intentionally the same on both days.

Each procedure commenced at 07.00 after an overnight fast. After the tubes had been placed, the volunteer assumed a sitting position in bed, which he maintained until the end of the study. Continuous gastric aspiration (–40 mm Hg), assisted by manual suction, was conducted for one hour to establish the basal secretory rate of acid. The subject then ate a standardized meal of 90 g (uncooked weight) of ground tenderloin steak seasoned with 0.1 g of salt, 25 g of white bread with 8 g of butter, and 60 g of vanilla ice cream with 35 g of chocolate syrup. Also he drank one glass of water (240 ml) containing 15 g of polyethylene glycol (PEG 4000) (three subjects) or 20 μ Ci of [¹⁴C] PEG (two subjects) as a water-soluble, nonabsorbable gastric marker. The meal provided 458 Cal distributed approximately as 40% carbohydrate, 40% fat, and 20% protein. An identical meal had a total volume of 400 ml with an osmolality of 540 mosmol and pH of 6.0 after mechanical blending.

After the meal a 10-ml sample of gastric contents was collected every 10 minutes for determination of marker concentrations, pH, and acid concentration.

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Fig 2 Left, volume of total postprandial gastric contents with (x) and without (y) transpyloric tube. Right, volume of postprandial solid gastric contents with (x) and without (y) transpyloric tube. Identity line is shown.

Fig 3 Postprandial gastric marker concentrations with (●—●) and without (x x) transpyloric tube in each subject.

Complete aspiration of gastric contents was done at a different time in each subject (one, one and a half, two, two and a half, and three hours, respectively, after the meal). The time interval was the same in every pair of studies, with and without the transpyloric tube. When the stomach appeared to be empty, it was lavaged with 200 ml of isotonic saline and aspirated again so that the residual volume could be estimated from the recovered marker. Blood samples (10 ml) were obtained for gastrin assay at 30-minute intervals twice before the meal and again, beginning 15 minutes after it was served, until the end of the study.

To determine the volume of solid food in the stomach at the end of the study, the aspirated gastric contents were centrifuged for 10 minutes at 526.5 g and the fraction of solid matter was measured. The total titratable acid concentration in gastric aspirates was determined by titration with 0.05 N NaOH to pH 6.0 (meal pH). The PEG 4000 concentration was measured by the method of Hyden (1955) and the [^{14}C] PEG concentration was measured by liquid scintillation counting (Wingate, Sandberg, and Phillips, 1972). Serum gastrin concentrations were determined by radioimmunoassay (Sizemore, Go, Kaplan, Sanzenbacher, Holtermuller, and Arnaud, 1973).

Results

The total volume of gastric contents and the volume of solid food at the time of complete aspiration were not altered significantly by the presence of the transpyloric tube (fig 2a and 2b).

Gastric marker concentrations measured sequentially after the meal are shown in figure 3. The curves are similar regardless of tube position; however, in several subjects the marker dilution is consistently

greater or consistently less with the transpyloric tube. The differences appeared to be greater for larger marker concentrations.

Mathematical analysis of the data was done to provide a more quantitative assessment of the similarity of values between members of each pair of studies. 'Relative difference' was defined as $100 \times (\text{measurement with tube} - \text{measurement without tube}) / (\text{average of these two measurements})$. For each subject, the mean of the relative differences (MRDi) was calculated. This procedure was used also for the pH, titratable acid, and serum gastrin (table).

There was occasionally a considerable variation in a subject's response, but the differences between subjects were often in the opposite direction. When the responses of the five subjects were averaged, and subjected to F-test analysis (Dixon and Massey, 1969) no significant difference in gastric marker concentration, pH, titratable acidity, or serum gastrin levels was attributable to the transpyloric tube.

Discussion

Although mathematical models have been established for emptying liquid meals (Hunt and Spurrell, 1951; Hopkins, 1966), no predictable profile has been determined for solid meals. Therefore, we measured the intragastric volume (total and solid) at different intervals after ingestion of the meal. We preferred a direct measurement of the volume of gastric contents to the indirect dilutional technique of George (1968) because we felt that the viscosity of gastric contents after a solid meal might not allow the rapid dispersion of the marker required for valid measurement by dye dilution. Our technique measured both the solid and liquid phases of the gastric contents. We chose to express amounts of

Variables Measured	Subject					Mean ($\pm$ SEM)
	1	2	3	4	5	
Marker concentration						
MRDi (%)	-3.1	49.4	-1.9	-17.0	17.8	9.0 (11.5)
No. of pairs	5	8	10	14	17	
pH						
MRDi (%)	1.8	-15.6	-9.0	17.2	-23.3	-5.8 (7.07)
No. of pairs	5	8	10	14	17	
Titratable acid concentration						
MRDi (%)	1.8	30.1	21.3	-33.8	55.9	15.1 (15.0)
No. of pairs	5	8	10	14	17	
Serum gastrin						
MRDi (%)	0.1	34.5	31.8	-0.9	-3.0	12.5 (8.5)
No. of pairs	2	3	4	5	6	

Table Effect of transpyloric tube: Mean relative differences (MRDi)¹

¹MRDi (%) = $100 \times [(\text{measurement with tube} - \text{measurement without tube}) \div (\text{mean of the two measurements})] \div \text{number of paired measurements in a given patient}$.

solid food in the stomach in terms of volume rather than as weight, because we presumed that volume was the more important determinant in gastric emptying mechanisms.

Similar volumes of gastric contents were found at various aspiration times, with and without the duodenal tube. Also, the volume of solids remaining in the stomach was similar in each individual. Thus we concluded that the transpyloric tube did not influence the rate of gastric emptying of meals. In addition, the intragastric pH and titrable acid concentrations measured sequentially during the postprandial period remained unchanged, suggesting that the total buffer content of the stomach was not affected. This observation provides further evidence, since meat protein was the main buffer, that the rate of emptying of solid food remained unaltered. Intragastric marker concentrations monitored throughout the observation interval were similar in each pair of studies suggesting that the gastric secretory response to food was also not influenced by the transpyloric tube.

The serum gastrin response to the meal, like gastric secretion and motility, was unchanged by the duodenal tube. Assuming that serum gastrin levels are related to gastric as well as to duodenal gastrin release (Stern and Walsh, 1973), our data suggest that release of the hormone at these sites is not influenced by a transpyloric tube.

These observations are relevant to the study of human digestive function in health and disease. Indeed, it has become apparent that simultaneous quantifications of duodenal events (amounts of gastric secretions actually delivered into the duodenum, intraluminal pH, etc) are important in the evaluation of gastric function under physiological or pathophysiological conditions. Further, an even better understanding of the digestive process in the upper gut in man requires characterization of the coordinated actions of the stomach, gallbladder, pancreas and small bowel. Thus, current efforts in characterization of the digestive-absorptive sequence of ingested food in man are being carried out employing a transpyloric tube (Brunner *et al*, 1974;

Moberg, 1974; Johansson, 1974). Our studies show that such tubes do not significantly interfere with gastric responses to an ordinary, solid meal, thus facilitating the application of advanced methodology to the study of digestion in man.

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References

- Brunner, H., Northfield, T. C., Hofmann, A. F., Go, V. L. W., and Summerskill, W. H. J. (1974). Gastric emptying and secretion of bile acids, cholesterol, and pancreatic enzymes during digestion: duodenal perfusion studies in healthy subjects. *Mayo Clin. Proc.*, **49**, 851-860.
- Dixon, W. J., and Massey, F. J. (1969). Introduction to statistical analysis. McGraw-Hill Book Co., New York. p. 158.
- George, J. D. (1968). New clinical method for measuring the rate of gastric emptying: the double sampling test meal. *Gut*, **9**, 237-242.
- Go, V. L. W., Hofmann, A. F., and Summerskill, W. H. J. (1970). Simultaneous measurements of total pancreatic, biliary, and gastric outputs in man using a perfusion technique. *Gastroenterology*, **58**, 321-328.
- Hopkins, A. (1966). The pattern of gastric emptying: a new view of old results. *J. Physiol. (Lond.)*, **182**, 144-149.
- Hunt, J. N., and Spurrell, W. R. (1951). The pattern of emptying of the human stomach. *J. Physiol. (Lond.)*, **113**, 157-168.
- Hydén, S. (1956). A turbidimetric method for the determination of higher polyethylene glycols in biological materials. *K. Lantbrukshögsk. Annlr*, **22**, 139-145.
- Johansson, C. (1974). Studies of gastrointestinal interactions. *Scand. J. Gastroent.*, **9**, Suppl. 28.
- Meeroff, J. C., Go, V. L. W., and Phillips, S. F. (1973). Gastric emptying of liquids in man: quantification by duodenal recovery marker. *Mayo Clin. Proc.*, **48**, 728-732.
- Moberg, S. (1974). Gastric emptying and duodenal digestion before and after partial gastrectomy and selective proximal vagotomy. *Scand. J. Gastroent.*, **9**, Suppl. 24.
- Shay, H., and Gershon-Cohen, J. (1935). Experimental studies in gastric physiology in man: the mechanism of gastric evacuation after partial gastrectomy as demonstrated roentgenologically. *Amer. J. dig. Dis.*, **2**, 608-612.
- Sizemore, G. W., Go, V. L. W., Kaplan, E. L., Sanzenbacher, L. J., Holtermuller, K. H., and Arnaud, C. D. (1973). Relations of calcitonin and gastrin in the Zollinger-Ellison syndrome and medullary carcinoma of the thyroid. *New Engl. J. Med.*, **288**, 641-644.
- Stern, D. H., and Walsh, J. H. (1973). Gastrin release in postoperative ulcer patients: evidence for release of duodenal gastrin. *Gastroenterology*, **64**, 363-369.
- Wingate, D. L., Sandberg, R. J., and Phillips, S. F. (1972). A comparison of stable and ¹⁴C-labelled polyethylene glycol as volume indicators in the human jejunum. *Gut*, **13**, 812-815.