Postprandial Acid Reflux is Reduced by Delayed Gastric Emptying

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Abstract

The aim of this study was to investigate influence of delayed gastric emptying on postprandial reflux in esophageal pH. Sixty-nine consecutive patients underwent 24 hour (h) esophageal pH monitoring and gastric emptying. In 24 h esophageal pH monitoring, % postprandial reflux pH<4 for 2 h after each meal (% PRT) was extracted from the 24 h pH profile. After solid test meal (1 mCi, Tc99m) was given, gastric emptying was measured with a gamma detector placed transnasally 5 cm below lower esophageal sphincter. % PRT was similar among the 34 normal, 26 delayed and 9 rapid gastric emptying rate patients. Thirty-five with a positive pH study and 34 with a negative had a similar prevalence of gastric emptying disorder. In the positive pH study group, patients with normal gastric emptying had significantly higher % PRT than those with delayed gastric emptying (22.0 vs 12.1%, $P<0.05$). In the same population, patients with a normal %PRT had a significantly higher prevalence of delayed gastric emptying compared with those with a positive % PRT (6/8 vs 9/27, $P<0.05$). In patient with abnormal acid exposure but normal % PRT on 24 h esophageal pH monitoring, gastric emptying may be delayed.

Key words: reflux esophagitis, postprandial reflux, gastric emptying

Introduction

The relationship between esophageal pH evidence and gastric emptying is still controversial, although both tests are generally used in the evaluation for foregut abnormality. Gastroenterologists can consider that gastric distension may explain increased acid exposure. Several authors have concluded that there is no direct link between esophageal pH and gastric emptying findings with radionuclides (Schwizer *et al.*, 1989; Ewer *et al.*, 1994; Benini *et al.*, 1996). However, a delay in gastric emptying is frequently found in patients with gastroesophageal reflux disease (GERD) (Lundell *et al.*, 1994; Benini *et al.*, 1996). At present, delayed gastric emptying seems to play a role in only a minority of GERD patients (Cadiot *et al.*, 1997). On the other hand, evaluation of postprandial reflux is still under investigation and

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delicate for the precise diagnosis of GERD in the literature (Gillen *et al.*, 1994; Mason *et al.*, 1998). It could be postulated that the degree of postprandial reflux is more directly affected by gastric emptying. To clarify the mechanisms of postprandial reflux in patients with GERD, we investigated the interaction between the two standard functional tests for the two neighboring foregut organs.

Patients and Methods

Patients

Sixty-nine consecutive patients with foregut symptoms underwent both 24 hour (h) esophageal pH monitoring and ambulatory gastric emptying test. Patients who had undergone major gastrointestinal surgery were excluded, but 14 patients with antireflux surgery, 5 with cholecystectomy, 1 with splenectomy and 2 with diabetes mellitus were included. The two procedures were carried out intermittently within a week.

Postprandial reflux on ambulatory esophageal pH study

Lower esophageal sphincter (LES) status was manometrically measured in all patients following an overnight fast before ambulatory esophageal pH monitoring. A glass esophageal pH probe (Ingold, Urdorf, Switzerland) was placed through the nose 5 cm above the upper border of the LES. Esophageal pH was recorded on a portable digital data recorder and analyzed as described previously (Synectics Inc, Minneapolis, Minn.) (Jamieson *et al.*, 1992). The % time pH<4 and its positive rate were compared simultaneously with postprandial reflux. Percentage postprandial reflux time pH<4 for 2 hs after each meal (%PRT) was extracted from 24 h pH profile by the following formula.

$$\% \text{ PRT} = \text{postprandial reflux time pH} < 4 / \text{total time of postprandial period} \times 100$$

Normal value of % PRT was determined to be 8.4% as the 95th percentile value of 94 normal volunteers.

Ambulatory gastric emptying test

An ambulatory gamma detection probe (RMD model, Synectics Medical, Watertown, MA) was used for more precise study, in which the probe was placed transnasally 5 cm below the lower border of the LES. Fundic emptying was measured twice, once each in the sitting position and ambulatory upright position as gastric emptying after two solid test meals of Tc 99m-labeled egg sandwiches (1 mCi) were given. The digital data recorder was carried on a belt around the subject's waist (Digitrapper, Synectics Medical). If either of the two gastric emptying studies showed a delay, the patient was regarded as delayed. Thirty healthy volunteers qualified for the study (Ritter *et al.*, 1997). Pathological gastric emptying was set as values outside the 5th and 95th percentile values of healthy volunteers.

Statistical analysis

Data show mean $\pm$ standard deviation. Statistical analysis was done by one-way analysis of

Table 1 Esophageal acid exposure according to ambulatory fundic emptying findings

Number of patients	Fundic emptying			ANOVA
	normal 34	delayed 26	rapid 9	
Esophageal pH				
% time pH <4	3.99 ± 5.38	5.16 ± 6.42	4.56 ± 4.61	N.S.
Positive rate	47.1 (16/34)	53.8 (14/26)	55.6 (5/9)	N.S.
% PRT	11.6 ± 14.0	7.73 ± 9.46	12.7 ± 12.9	N.S.
Positive rate	41.2 (14/34)	38.5 (10/26)	55.6 (5/9)	N.S.

variance (ANOVA), Student's t and Fisher's exact tests using the SPSS statistical software package (SPSS Inc., Chicago, IL). A value of less than 0.05 was considered statistically significant.

Results

Sixty-nine cases were classified as 34 normal, 26 delayed, and 9 rapid gastric emptying (Table 1). The % time pH<4 of the normal, delayed and rapid emptying groups were 3.99 ± 5.38 , 5.16 ± 6.42 and 4.56 ± 4.61 , respectively, showing no significant difference between them ($p=0.73$). The % PRT was also similar in all three groups (11.6 ± 14.0 , 7.73 ± 9.46 , 12.7 ± 12.9 , $p=0.51$). Further, both the positive rate of esophageal pH and that of % PRT were also similar among the three groups according to the findings of gastric emptying (Table 1).

With regard to esophageal pH status, two populations were identified, 35 patients with a positive pH study and 34 patients with negative values. The prevalence of delay in gastric emptying in the pH study negative and positive groups was 12 (35.3%) and 14 patients (40.0%), respectively (Table 2). Patients are also divided into another two populations, 40 with a negative and 29 with a positive % PRT. The prevalence of delay in gastric emptying in these two groups was 16 (40.0%) and 10 patients (34.5%), respectively. There was no significant difference in these gastric emptying findings according to esophageal pH status (Fisher's exact test).

We further classified the two esophageal pH negative and positive groups into two groups each according to delay in gastric emptying with groups 1, 2, 3, and 4, composed of 22, 12, 21 and 14 patients, respectively. Table 3 shows the background characteristics, showing no significant differences especially in sphincter events in esophageal manometry findings. The % PRT was also compared among the four groups as shown in Fig. 1. Groups 1 and 2, which were pH study negative, showed similar % PRT despite a delay in gastric emptying (2.11 ± 3.50 , $2.62 \pm 5.00\%$, $p=0.875$). With regard to groups 3 and 4, which were pH study positive, group 3 with no delay in gastric emptying had significantly higher % PRT than patients with delay in group 4 (22.0 ± 12.8 , $12.1 \pm 10.8\%$, $p=0.022$). There was also a significant difference in % PRT positive rate between groups 3 and 4 (90%, 57%, $p=0.039$).

In the esophageal pH positive population, there were two other groups, 8 patients who were % PRT negative and 27 who were positive. As shown in Fig. 2, the patients with negative % PRT had a significantly higher prevalence of delayed gastric emptying compared with those with positive % PRT (6/8 vs. 8/27, $p=0.039$).

Table 2 Prevalence of fundic emptying abnormality according to ambulatory esophageal pH monitoring findings

	Esophageal pH			
	% time pH <4		%PRT	
	negative	positive	negative	positive
	N.S.		N.S.	
Fundic Emptying				
Normal (%)	18 (52.9)	16 (45.7)	20 (50.0)	14 (48.3)
Delayed (%)	12 (35.3)	14 (40.0)	16 (40.0)	10 (34.5)
Rapid (%)	4 (11.8)	5 (14.3)	4 (10.0)	5 (17.2)
Total	34	35	40	29

Table 3 Patient characteristics classified into four groups by esophageal pH and fundic emptying findings

Groups	1	2	3	4
Esophageal pH	negative		positive	
Fundic emptying	no delay	delayed	no delay	delayed
no. of cases	22	12	21	14
mean age	48.6	43.4	52.7	48.3
sex (male/female)	12/10	7/5	9/12	8/6
manometry on average				
LESP (mmHg)	11.4	7.8	13.1	11.8
overall length (cm)	2.8	2.3	2.5	2.6
abd. length (cm)	1.5	1.2	1.3	1.2
diabetes mellitus	0	0	1	1

Discussion

Ambulatory esophageal pH monitoring has been established for the diagnosis and treatment of GERD owing to its accuracy and utility (Jamiesen *et al.*, 1992). However, it is not still sufficient in the evaluation of symptomatic patients with GERD. Evaluation of reflux during supine period is considered helpful (DeMeester *et al.*, 1976; Dhiman *et al.*, 1996), but it has been reported that upright reflux is more significant than supine (Branicki *et al.*, 1982; DeCsestecker *et al.*, 1987). Gillen *et al.* (1994) indicated that the development of esophagitis was most closely correlated with postprandial reflux. Against this, exclusion of meal periods can eliminate meal-time pH variability without affecting postprandial acid exposure and improve the diagnosis of GERD (Wo *et al.*, 1994). However, postprandial reflux is a dynamic indicator of sphincter competency and increases as the structural sphincter characteristics deteriorate (Mason *et al.*, 1998). The present results show that postprandial pH study therefore contributes to our understanding of not only sphincter competency but also to the degree of gastric emptying as a gastric motility disorder.

At present, most commonly used and reliable technique is gastric emptying with radionuclides, in evaluation of gastric motility although details of the mechanism of gastric emptying are still under investigation. Recently, ambulatory gastric emptying with an intraluminal gamma counter probe has been developed as a more precise measurement

Fig. 1. Comparison of % PRT among the four groups classified by 24 h esophageal pH monitoring and gastric emptying findings. Bars show mean % PRT level (group 1: 2.11, group 2: 2.62, group 3: 22.0, group 4: 12.1). Significant difference is seen between groups 3 and 4 (*a: $p=0.022$ by Mann-Whitney U test, *b: $p=0.039$ by Fisher's exact test).

Fig. 2. Prevalence of delay in gastric emptying according to % PRT findings in the patients with positive esophageal pH study. Significant difference is seen between prevalence in % PRT positive and negative groups (*: $p=0.039$ by Fisher's exact test).

(Akkermans *et al.*, 1994). We previously evaluated the reliability and reproducibility of ambulatory intraluminal measurement and found it to be more close to daily life and accurate means of detecting radionuclides (Ritter *et al.*, 1997).

The relationship between gastric emptying and GER is still controversial although delayed gastric emptying is likely to increase the degree of esophageal exposure to acid. Generally speaking, it is considered that gastric emptying is significantly delayed in patients suffering from reflux symptoms (Lundell *et al.*, 1994; Benini *et al.*, 1996). Nevertheless, some investigators have found no relationship between esophageal pH events and gastric emptying (Schwizer *et al.*, 1989; Ewer *et al.*, 1994; Benini *et al.*, 1996). Our data showed that patients without a delay in gastric emptying have significantly higher % PRT than those with a delay, although they have similar LES manometry findings to patients with positive esophageal pH results. We concluded that normal postprandial reflux on 24 h esophageal pH profile is obviously related to delayed gastric emptying in patients with GERD. Presumably, retained food in the stomach works as a potent buffer against gastric acid (Schwizer *et al.*, 1989). It is probable that neutral reflux may occur due to gastric distension during the meal period. To better understand the relationship between esophageal pH events and gastric emptying, it is necessary to monitor gastric pH and gastric emptying simultaneously. In fact, Stein *et al.* reported that delayed gastric emptying was suggested by prolonged postprandial alkalization in the gastric pH record (Stein *et al.*, 1994). Delay in gastric emptying might relieve GER if the gastric acid is neutralized by food. New technique, impedance method, for measurement of neutral reflux to the esophagus, which may be more frequent in GERD patients with normal postprandial reflux on profile, should be investigated (Wenzl *et al.*, 2002). Moreover, such neutral reflux must be distinguished from duodenogastric reflux, given that mixed reflux with duodenal juice is more harmful to the esophagus than gastric juice alone (Kaur *et al.*, 1995).

Our results indicate that delayed gastric emptying can be predicted with 75% accuracy by normal postprandial reflux in patients with a positive esophageal pH study. When normal postprandial acid exposure is seen in spite of abnormal acid exposure in ambulatory esophageal pH monitoring, the possibility of a delay in gastric emptying should be taken into account. This also means that postprandial reflux is a useful parameter in surveying gastric dysmotility in patients with GERD. On the other hand, we previously reported that increased postprandial reflux, evaluated by the same parameter, suggests volume-induced sphincter shortening and incompetency in patient with GERD (Mason *et al.*, 1998). Therefore, measurement of % PRT is beneficial to patients with GERD in terms of therapy for not only GERD but also gastric dysmotility.

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