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## [Original Studies]

**Electrogastrography and Gastric Emptying Scintigraphy Are Complementary for Assessment of Dyspepsia**

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**Abstract**

We have tried to correlate abnormalities in electrogastrography (EGG) and gastric emptying (GE) with symptom severity in patients with functional dyspepsia. Seventy-two patients with functional dyspepsia underwent EGG, GE, and symptom severity quantitation. EGGs were assessed for dominant frequency (DF), percentage of time of DF in the 2 to 4 cpm range, and postprandial-fasting DF power ratio. Solid-phase GE scintigraphy was assessed for 2-hour percentage retention. Symptoms of upper abdominal discomfort, early satiety, postprandial abdominal distension, nausea, vomiting, and anorexia were graded as none (0), mild (1), moderate (2), and severe (3); the sum represented a total symptom score. The EGG was abnormal in 11 of 22 (50%) patients with delayed GE compared with 11 of 50 (22%) with normal GE ( $p < 0.025$ ). The total symptom scores were higher in patients with both delayed GE and abnormal EGG compared with patients with normal GE and EGG, normal GE and abnormal EGG, and delayed GE and normal EGG. We conclude that EGG abnormalities are more common in dyspeptic patients with delayed GE. Patients with both delayed GE and abnormal EGG have more severe symptoms. Our results suggest that EGG and GE complement each other in correlating symptoms to gastric dysmotility.

Dyspeptic symptoms, that is chronic or recurrent upper abdominal symptoms, occur in 14% to 20% of the population (1,2). Abnormal gastric motility has been found in up to 50% of patients with functional dyspepsia (3). Although gastric emptying scintigraphy is frequently used to evaluate dyspeptic patients for impaired gastric motor function, symptoms of upper gastrointestinal motor dysfunction have not been well correlated with gastric emptying results (4,5). Electrogastrography (EGG) measures gastric myoelectrical activity and provides information on the frequency and relative amplitude of antral contractions (6). EGG abnormalities have been found in patients with gastroparesis and nonulcer dyspepsia (7,8), but the clinical utility of EGG in evaluating patients with symptoms of upper gastrointestinal motor dysfunction, or dyspepsia, has not been established. Nor is the relationship of abnormalities in EGG to gastric emptying results in symptomatic patients at all clear.

We tried to (a) determine the frequency of EGG and gastric emptying abnormalities in patients with unexplained dyspepsia, and (b) correlate abnormalities in EGG and gastric emptying with symptom severity.

**METHODS****Patient Study Group**

Patients with dyspeptic symptoms and negative upper endoscopy or upper gastrointestinal radiographic series were included in this study. Patients were generally enrolled from those undergoing gastric emptying (GE) scintigraphy for clinical assessment of their symptoms. Inclusion criteria were (a) chronic or recurrent symptoms of dyspepsia for at least 3 months; (b) a negative upper endoscopy and upper gastrointestinal barium study within 3 months before the study; and (c) performance of GE scintigraphy and EGG at Temple University Hospital. Medicines that affect gastrointestinal motor function were stopped for at least 3 days before performance of gastric emptying scintigraphy or EGG. Patients were excluded if they were taking a prokinetic agent or narcotic analgesic within 3 days of the EGG or GE or had undergone previous gastric resection. Patients were excluded if the endoscopy revealed ulcers or erosions anywhere in the esophagus, stomach, or duodenum. A hiatal hernia was not a cause for exclusion.

**Gastric Emptying Scintigraphy**

Gastric GE scintigraphy was performed in the morning after an overnight fast as previously described (9,10). A technetium-99m ( $^{99m}\text{Tc}$ ) sulfur colloid (500  $\mu\text{Ci}$ )-labeled egg sandwich (two scrambled eggs and two pieces of toasted bread; 282 kcal; 32% protein, 46% carbohydrate, 22% fat) was used to measure solid-phase gastric emptying. This was given with 300 ml of water. Technetium counts were imaged using a 140 KeV photopeak with a 20% window. With the patient standing upright, images were acquired in both the anterior and posterior positions for 1 minute every 20 minutes for 120 minutes using a large field of view gamma camera (General Electric Medical Systems, Model 535, Milwaukee, WI) interfaced to a NuLear Mac computer (Scientific Imaging, Denver, CO).

Images were recalled from computer disc and analyzed to determine gastric emptying by constructing time-activity curves for the stomach. The gastric region of interest was drawn manually. The geometric mean of radioactive counts was used to correct for attenuation (geometric mean counts = square root [anterior counts  $\times$  posterior counts]) and the counts were corrected for decay (10). The corrected  $^{99m}\text{Tc}$  counts in the gastric region of interest were plotted against time. GE was defined to be delayed if more than 50% remained in the stomach after 2 hours (Table 1) (10).

Variable	Normal values
EGG <sup>a</sup>	
Dominant frequency	
Fasting	2.34–3.47 cpm
Postprandial	2.55–3.67 cpm
Percentage of time of dominant frequency in 2–4 cpm range	
Fasting	$\geq 65\%$
Postprandial	$\geq 70\%$
Power ratio	$> 1$
Ratio of postprandial-fasting power of dominant frequency	
GE scintigraphy <sup>b</sup>	
Solid phase with $\text{Tc}^{99m}$ -labeled egg	
Percentage retention at 2 hours	$\leq 50\%$

<sup>a</sup>Normal values obtained from a prior study in normal subjects: Parkman HP, Harris AD, Miller MA, Fisher RS. Influence of age, gender, and menstrual cycle on the normal electrogastrogram. *Am J Gastroenterol* 1996;91:127–33.

<sup>b</sup>Normal values obtained from a prior study in normal subjects: Maurer AH, Knight LC, Charkes ND, et al. Comparison of left anterior oblique and geometric mean gastric emptying. *J Nucl Med* 1991;32:2176–80.

TABLE 1. Normal values for electrogastrography (EGG) and gastric emptying (GE) scintigraphy

#### Electrogastrography Recording

Electrogas EGG was performed as previously described (11), usually on the day after the GE test. Recording of the cutaneous EGG began in the morning after an overnight fast. The abdominal skin surface for each recording site was carefully abraded until slightly erythematous (Buf-Puf Regular; 3M Personal Care Products, St. Paul, MN). If abdominal hair was present, this was removed with a razor. Three surface electrodes (Cleartrace electrodes; Medtronic Andover Medical, Inc., Haverhill, MA) were placed on the abdominal surface overlying the stomach. Gastric myoelectric activity was recorded using a Synectics microDigitrapper (Synectics Medical, Irving, TX). Two active electrodes were used: One was placed on the midline of the abdomen, halfway between the umbilicus and the xyphoid process; the other was placed on the patient's left side, about 1 cm below the bottom rib and one quarter of the distance from the ventral midline. One reference electrode was placed on the left lower abdomen, below the umbilicus with similar distances between each active electrode and the reference electrode. The sampling frequency for digital recording was set at 4 Hz. During recording, patients sat in a comfortable chair and were instructed not to talk or move during the study. EGGs were recorded for 60 minutes in the fasting condition. Patients then ingested a standard test meal consisting of two scrambled eggs with two pieces of toasted bread and 200 ml of water (282 cal; 32% protein, 46% carbohydrate, 22% fat). Patients were instructed to consume the meal in approximately 5 minutes. Postprandial EGGs were obtained for another 60 minutes.

After completion of the study, recorded myoelectric activity was downloaded from the microDigitrapper to a computer (NEC Powermate SX/251). The recording was inspected for motion artifacts (large amplitude deflections); the time periods containing these motion artifacts were deleted before computer analysis. The EGGs were analyzed using computer software (Multigram 6.10D3P4; Synectics Medical) that used fast Fourier transform (FFT) and running

spectral analysis. Running spectral analysis was used for 60-minute fasting and 60-minute postprandial periods. Each running spectrum was 4 minutes 16 seconds long, with the next spectrum advancing 1 minute, giving 3 minutes 16 seconds of overlap between consecutive spectra. Frequencies of each spectrum were interpreted using FFT and classified as follows: bradygastria, 0.5 to 2 cpm; normal rhythm, 2 to 4 cpm; tachygastria, 4 to 9 cpm; and duodenal-respiratory rhythm, 9 to 15 cpm (6,7,11). The use of a 4-Hz sampling frequency and 4 minute 16 second spectra for the FFT gives a frequency resolution of 0.23 cpm.

The following parameters, derived from the computer analysis of the EGG signal, were determined for each electrogastrogram (6,7,11). (a) Dominant slow-wave frequency in both the fasting and postprandial periods: These were calculated by averaging the FFT results (power as a function of frequency) for running spectra during the fasting or postprandial period, respectively. The dominant frequency represents the frequency with the highest power. (b) Percentage of time the dominant frequency was in bradygastria (0.5-2 cpm), normal rhythm (2-4 cpm), tachygastria (4-9 cpm), and duodenal-respiratory range (9-15 cpm) for both the fasting and postprandial periods: This was performed by determining a single dominant frequency for each 4-minute 16-second running spectra and calculating their percentage of distribution among the four frequency intervals (bradygastria, normal rhythm, tachygastria, and duodenal-respiratory) for each fasting and postprandial period. (c) Power ratio, the ratio of postprandial to fasting power of the dominant frequency: Normal parameters for these values were obtained in a previous study from Temple University Hospital using the same EGG recording techniques in healthy persons (11). These are shown in Table 1. An abnormal EGG was defined as an EGG with any one of the parameters outside the normal ranges.

#### Symptom Assessment

Each patient completed a detailed questionnaire just before undergoing EGG. This questionnaire assessed demographic information, gastrointestinal symptoms, medical history, surgical history, and medications. The symptoms occurring during the 1 week before the EGG were assessed for symptom severity. Symptoms of dyspepsia and upper gastrointestinal motor dysfunction (that is, upper abdominal discomfort, early satiety, postprandial abdominal distension, nausea, vomiting, and anorexia) were graded by the patient as none (0), mild (1), moderate (2), or severe (3) (12,13). A total symptom score was calculated as the sum of these six individual symptom scores, with a maximum total being 18.

#### Statistical Analysis

Results are reported as means  $\pm$  SEM. Analysis of variance and Student's *t* test were performed as appropriate to determine significant differences. The chi-square test was used to test for differences in proportions (14). Statistical calculations were performed with a Macintosh Plus computer and statistical software (Stat Works; Cricket Software, Philadelphia, PA). A *p* value less than 0.05 was considered significant.

### RESULTS

#### Study Group

The study group consisted of 72 patients with dyspeptic symptoms. There were 60 female and 12 male patients with a mean age of  $40.4 \pm 15.5$  (mean  $\pm$  SD) years (range: 16-82 years). Four patients had diabetes mellitus. The symptom scoring (mean  $\pm$  SD) of the entire group of 72 patients revealed upper abdominal pain ( $1.7 \pm 1.2$ ), early satiety ( $1.7 \pm 1.1$ ), nausea ( $1.6 \pm 1.1$ ), abdominal distension or bloating ( $1.3 \pm 1.1$ ), anorexia ( $0.8 \pm 1.1$ ), and vomiting ( $0.8 \pm 1.2$ ). Symptoms of gastroesophageal reflux such as heartburn ( $0.9 \pm 1.1$ ) and regurgitation ( $0.8 \pm 1.0$ ) were present in some of the patients, but if present, they were milder than dyspeptic symptoms.

#### Gastric Emptying Test and Electrogastrography Results

Of the 72 patients with unexplained dyspepsia studied, 22 patients (31%) had abnormal GE tests results and 22 patients (31%) had abnormal EGGs. Overall, 33 patients (45%) had abnormalities in either the EGG or GE. The EGG was abnormal in 11 of 22 patients (50%) with delayed gastric emptying compared with only 11 of 50 patients (22%) with normal gastric emptying ( $p < 0.025$  by chi-square analysis). Thus EGG abnormalities occurred in dyspeptic patients with either delayed or normal gastric emptying, although they were more common in patients with delayed gastric emptying. It should be noted that only one half the patients with delayed gastric emptying had an abnormal EGG result. The use of the EGG for predicting delayed GE in this study population was associated with a sensitivity of 50% (11/22), a specificity of 78% (39/50), a positive predictive accuracy of 50% (11/22), and a negative predictive accuracy of 78% (39/50).

The 11 abnormal results of EGGs in patients with delayed GE consisted of 4 with a decreased postprandial-fasting power ratio ( $< 1$ ), 1 with a decreased fasting percentage time in a 2- to 4-cpm pattern, and 6 with multiple abnormalities in the EGG. The 11 abnormal results of EGGs in patients with normal GE consisted of 5 with decreased postprandial-fasting power ratio ( $< 1$ ), 1 with fasting tachygastria, 1 with postprandial tachygastria, 2 with postprandial bradygastria, and 2 with multiple abnormalities. There was no correlation between the specific type of EGG abnormality and the presence or absence of delayed GE. Interestingly, however, there was a higher incidence of

multiple EGG abnormalities in patients with delayed gastric emptying (6 of 11 abnormal EGGs) than when the GE result was normal (2 of 11 abnormal EGGs).

#### Relationship of Symptoms to Gastric Emptying and Electrogastrography Abnormalities

The correlation between the total symptom score and the percentage retention at 2 hours on the GE scan is shown in Figure 1. There was a trend ( $r = 0.217$ ,  $p = 0.077$ ) for the total symptom score to correlate with GE as expressed as the absolute percentage of gastric retention at 2 hours. The GE results were then divided into two groups composed of normal and delayed GE (see Fig. 2). In patients with delayed GE, there was a significantly greater symptom severity, with a mean total symptom score of  $9.6 \pm 0.7$  (SEM) compared with patients with normal GE, who had a mean total symptom score of  $7.3 \pm 0.5$  ( $p = 0.011$  by Student's  $t$  test). The three individual symptoms—upper abdominal discomfort ( $p = 0.006$ ), early satiety ( $p = 0.007$ ), and postprandial distension ( $p = 0.043$ )—were each significantly greater in patients with delayed GE compared with patients with normal GE, whereas symptoms of nausea ( $p = 0.318$ ), vomiting ( $p = 0.339$ ), and anorexia ( $p = 0.409$ ) were not significantly different.

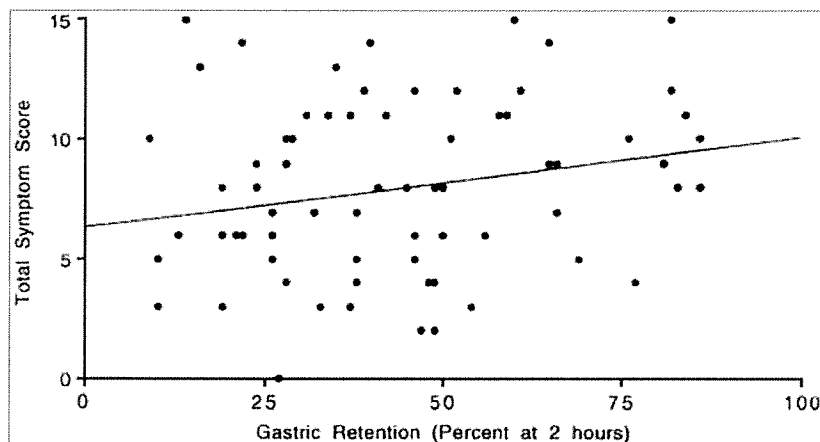


FIG. 1. Correlation of total symptom score with percentage retention at 2 hours on gastric emptying scintigraphy. The total symptom score represents the sum of the individual symptom scores for upper abdominal discomfort, early satiety, postprandial abdominal distension, nausea, vomiting, and anorexia graded individually by the patient as none (0), mild (1), moderate (2), and severe (3). There was a trend for the total symptom score to correlate with percentage retention. The line shown is the regression line characterizing the point distribution ( $r = 0.217$ ,  $p = 0.077$ ).

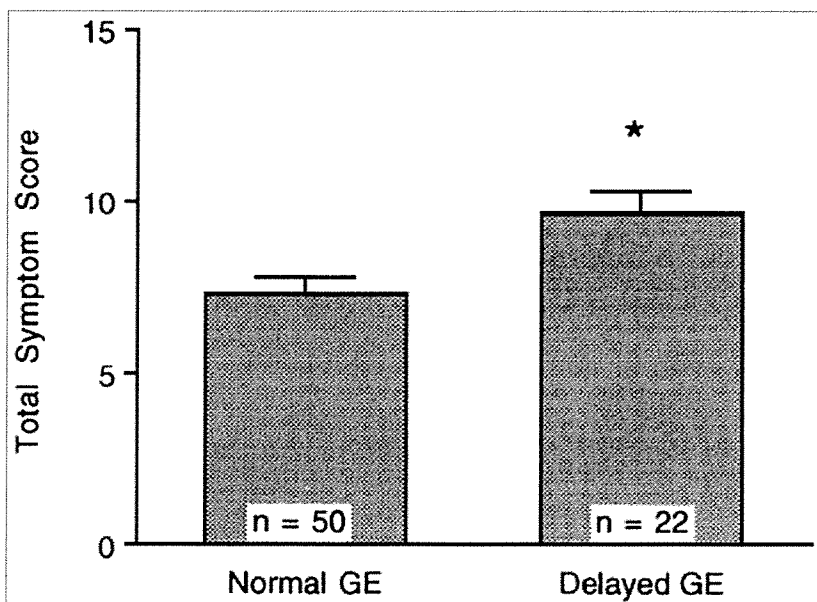


FIG. 2. Stratification of total symptom score by the result of the gastric emptying (GE) scintigraphy. GE was divided into normal and abnormal results. GE was defined to be delayed if more than 50% remained in the stomach after 2 hours. In the patients with delayed GE, there was a significant increase in symptom severity, with a mean total symptom score of 9.6, compared with patients with normal GE, who had a mean total symptom score of 7.3 ( $p = 0.011$ ).

The EGG results were also divided into two groups composed of normal and abnormal EGG. In patients with an abnormal EGG result, there was also a significantly greater symptom severity with a mean total symptom score of  $9.4 \pm 0.8$  compared with patients with a normal EGG result, having a mean total symptom score of  $7.4 \pm 0.5$  (Fig. 3). The individual symptoms of upper abdominal discomfort ( $p = 0.036$ ) and anorexia ( $p = 0.048$ ) were each significantly greater in patients with abnormal EGGs compared with patients with a normal EGG result, whereas nausea ( $p = 0.445$ ),

vomiting ( $p = 0.210$ ), early satiety ( $p = 0.137$ ), and abdominal distension ( $p = 0.334$ ) were not significantly different.

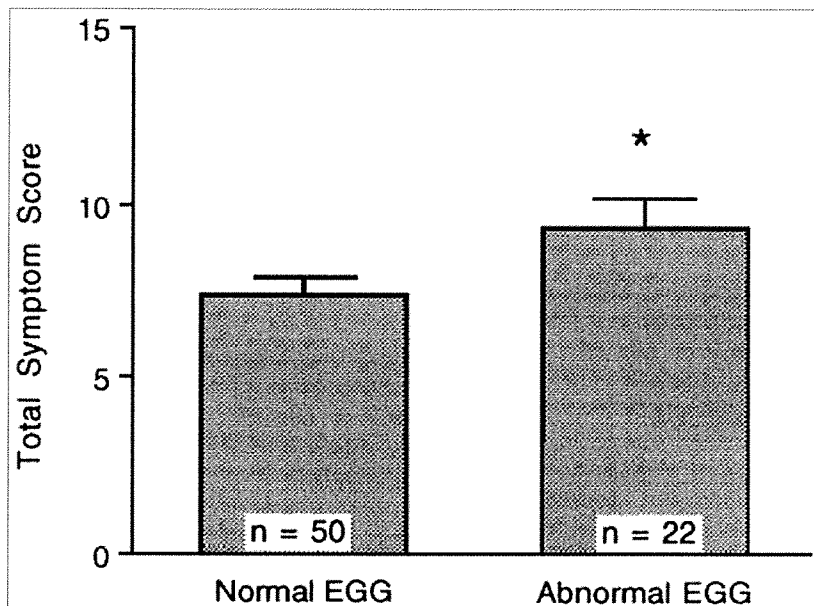


FIG. 3. Stratification of total symptom score by the result of the electrogastrography (EGG). In the patients with an abnormal EGG, there was also a significantly greater symptom severity, with a mean total symptom score of 9.4, compared with patients with normal EGG, having a mean total symptom score of 7.3 ( $p = 0.030$ ).

Patients were further subdivided into groups based on the results of both the EGG and GE test (Table 2). Symptom scores were significantly higher in patients with combined delayed GE and abnormal EGG, with a mean total symptom score of  $11.1 \pm 1.0$  compared with patients with normal GE and EGG ( $7.2 \pm 0.6$ ), normal GE and abnormal EGG ( $7.6 \pm 1.1$ ), and delayed GE and normal EGG ( $8.1 \pm 0.8$ ) (Fig. 4). Thus, when both the EGG and GE scintigraphy were abnormal, the symptom scores were higher than when only one of these tests was abnormal or when both were normal. The individual symptoms of early satiety ( $p = 0.045$ ) and upper abdominal discomfort ( $p = 0.018$ ) were significantly higher in this subgroup of patients with delayed GE and abnormal EGGs by analysis of variance (see Table 2).

Variable	Normal GE, normal EGG	Normal GE, abnormal EGG	Delayed GE, normal EGG	Delayed GE, abnormal EGG	p <sup>a</sup>
Number of patients	39	11	11	11	
Sex (% female)	79	91	62	91	
Duration of symptoms (years)	$4.8 \pm 5.7$	$1.4 \pm 1.5$	$2.5 \pm 2.4$	$2.8 \pm 2.6$	0.107
Weight loss in the last 6 months (pounds)	$9.5 \pm 14.6$	$15.6 \pm 12.6$	$7.7 \pm 10.5$	$17.2 \pm 14.5$	0.232
Nausea score	$1.6 \pm 1.1$	$1.4 \pm 1.0$	$1.5 \pm 1.0$	$2.2 \pm 1.0$	0.282
Vomiting score	$0.9 \pm 1.2$	$1.0 \pm 1.3$	$0.1 \pm 0.3$	$1.2 \pm 1.3$	0.112
Anorexia score	$0.7 \pm 1.1$	$1.0 \pm 1.3$	$0.5 \pm 0.9$	$1.5 \pm 1.2$	0.179
Early satiety score	$1.4 \pm 1.1$	$1.5 \pm 0.4$	$2.0 \pm 1.0$	$2.4 \pm 0.7$	0.045
Postprandial abdominal distension	$1.2 \pm 1.2$	$1.0 \pm 1.3$	$2.1 \pm 0.8$	$1.3 \pm 0.9$	0.101
Upper abdominal pain	$1.4 \pm 1.2$	$1.6 \pm 0.4$	$1.9 \pm 1.1$	$2.6 \pm 0.7$	0.018
Total symptom score	$7.2 \pm 3.6$	$7.6 \pm 3.6$	$8.1 \pm 2.6$	$11.1 \pm 3.2$	0.014
GE (% retention)	$32.0 \pm 12.0$	$32.0 \pm 15.0$	$66.0 \pm 12.0$	$72.0 \pm 11.0$	

<sup>a</sup>Expressed as means  $\pm$  SD.

<sup>b</sup>Analysis of variance.

TABLE 2. Parameters stratified by results<sup>a</sup> of gastric emptying (GE) scintigraphy and electrogastrography (EGG)

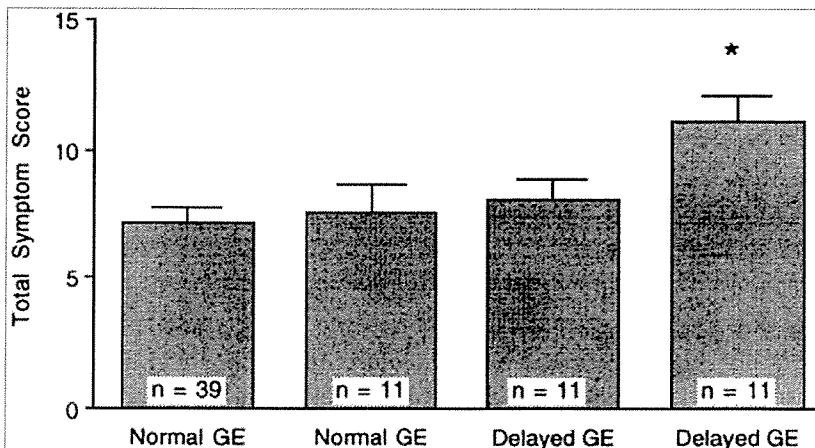


FIG. 4. Stratification of total symptom score by the results of both the electrogastrography (EGG) and the gastric emptying (GE) scintigraphy. Patients were subdivided into groups based on the results of both the EGG and GE tests. Symptom scores were significantly higher in patients with both delayed GE and abnormal EGG (a mean total symptom



score of 11.1) compared with patients with normal GE and EGG, normal GE and abnormal EGG, and delayed GE and normal EGG ( $p = 0.014$  by analysis of variance).

## DISCUSSION

Functional dyspepsia, characterized by abdominal pain or discomfort, early satiety, nausea, and upper abdominal distension or bloating (15,16) represents a heterogeneous group of disorders. Motility abnormalities of the stomach and upper small bowel (3,17-19) or delayed GE, usually of the solid phase of the test meal, have been described in many patients with unexplained dyspeptic symptoms (3,20). In our study, 31% of patients had abnormal GE and 31% had an abnormal EGG result. By both GE scintigraphy and EGG, abnormal gastric motor function was found in 33 of 72 (45%) patients. Thus EGG and GE testing complement each other in demonstrating gastric motor dysfunction in patients with functional dyspepsia.

A variety of EGG findings have been reported in dyspeptic patients in this and prior studies (8,21,22), and these include inotropic dysfunction (decreased postprandial-fasting power ratio) and chronotropic dysfunction (gastric dysrhythmias: bradygastrias and tachygastrias), or a normal EGG (8,23). Thus the EGG provides information about the potential mechanism underlying abnormal gastric motor function. The EGG abnormalities found in functional dyspepsia are similar to those that occur in gastroparesis; these findings may reflect patients having primarily dysmotility-like dyspepsia (15,16), because the main symptoms were intermittent nausea, vomiting, and bloating.

Discordance between the EGG and GE results was demonstrated in our study and others, with an abnormal EGG in some patients with normal GE and a normal EGG in some patients with delayed GE (8,24,25). The positive predictive accuracy of an abnormal EGG for delayed GE in this study was 50%, whereas the negative predictive accuracy of a normal EGG predicting normal GE was 78%. One might have expected a higher correlation between the EGG results and GE because they are both measures of gastric motility. This discordance may in part be related to the fact that the EGG and GE studies were performed on different days. Chen et al. (26) reported a higher correlation between GE and EGG when they were recorded simultaneously. Simultaneous recording of GE and EGG, however, may result in motion artifact in the EGG signal, preventing reliable interpretation. Thus they were performed separately for our study. A second potential explanation for the discordance might be regional specialization in the stomach. For example, the EGG mainly represents antral motility, whereas GE scintigraphy reflects overall postprandial gastric motor function (3). Fundic dysfunction, pyloric abnormalities, and duodenal motility disorders may delay GE and produce symptoms that may not be reflected in the EGG. Finally, we studied symptomatic patients with either delayed or normal GE; this is similar to the situation commonly faced by the clinician with a symptomatic patient. Studies demonstrating a high correlation between EGG and GE scintigraphy have often compared symptomatic patients with delayed GE to younger normal asymptomatic controls (7,27). This may be the explanation for the 87% sensitivity rate reported in a previous study of diabetic gastroparesis (27).

In our study, 39 of 72 patients (54%) had normal GE and EGG results, suggesting normal gastric motor function in the majority of dyspeptic patients. Augmented visceral afferent sensation, rather than dysmotility, may be a major mechanism for symptom production in dyspepsia (28,29). Use of a gastric barostat may help to determine whether augmented visceral nociception is the mechanism of symptom production in the subgroup of patients with normal EGG and normal GE. Future studies will also determine whether classifying patients according to EGG, GE, and possibly barostat results will provide prognostic information regarding the appropriate medication. Currently, however, in the typical dyspeptic patient, an EGG is not needed for initial evaluation for patients and in those who respond to empiric therapy for dyspepsia with either gastric acid secretory suppression or a prokinetic agent. In patients not responding to empiric treatment, determining whether a patient does indeed have a gastric motility disorder with gastric emptying scintigraphy and electrogastrography may help direct further medical therapy.

We did not find that symptoms correlated well with gastric emptying results alone, an observation reported previously in diabetic gastroparesis (12,24,30-33) and idiopathic gastroparesis (34). In other studies in dyspeptic patients in whom delayed GE is present (approximately 30-40% of the cases), there is also a poor relationship between the delay in emptying and dyspeptic symptoms (21,35,36), except for possibly abdominal fullness or distension and vomiting (35,36). In our study, the total symptom score tended to correlate with the absolute degree of gastric stasis, but significance was reached only when patients were classified as either normal GE or delayed GE. Delayed GE was associated primarily with the symptoms of upper abdominal discomfort, early satiety, and postprandial abdominal distension. Similar findings have been reported by Jian et al. (5) in which treatment with cisapride significantly decreased GE and improved symptoms of epigastric pressure, bloating, and prolonged digestion with a borderline improvement in early satiety and nausea and vomiting. Other scintigraphic parameters, such as antral distension (37,38), abnormal intragastric distribution of food (38), and altered amplitude of antral contractions as measured by dynamic antral scintigraphy (20) may also be useful to evaluate dyspeptic patients.

That the combination of delayed GE combined with an abnormal EGG was associated with increased severity of symptoms, primarily early satiety and upper abdominal discomfort, was of particular interest. Several studies have suggested that dyspeptic symptoms in patients with gastroparesis and nonulcer dyspepsia correlate better with EGG abnormalities than with GE abnormalities (21,24). Improvement in symptoms with treatment also correlates better with improvement in the EGG than in GE (24). Studies in dyspeptic patients suggest that factors other than abnormalities of either the GE or EGG may also be involved (36). Our study suggests that the combination of both the EGG and GE

results is useful in correlating symptoms to gastric dysmotility.

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Key Words: Dyspepsia; Gastric emptying scintigraphy; Electrogastrography

IMAGE GALLERY

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Variable	Normal values
<b>EGG*</b>	
Dominant frequency	
Fasting	2.34-3.47 cpm
Postprandial	2.55-3.67 cpm
Percentage of time of dominant frequency in 2-4 cpm range	
Fasting	≥ 60%
Postprandial	≥ 70%
Power ratio	≥ 1
Ratio of postprandial:fasting power of dominant frequency	
GE scintigraphy†	
Solid phase with Tc <sup>99m</sup> -labeled egg	
Percentage retention at 2 hours	≤ 50%

\*Normal values obtained from a prior study in normal subjects: Parkman HP, Harris AD, Miller MA, Fisher RS. Influence of age, gender, and menstrual cycle on the normal electrogastrogram. *Am J Gastroenterol* 1996;91:127-33.

†Normal values obtained from a prior study in normal subjects: Maurer AH, Knight LG, Chakras ND, et al. Comparison of left anterior oblique and geometric mean gastric emptying. *J Nucl Med* 1991;32:2176-80.

**Fig. 1**

**Fig. 2**

**Table 1**

**Table 2**

Variable	Normal GE	Normal EGG	Delayed GE	Delayed EGG	p
Total Symptom Score	7.5 ± 1.2	7.6 ± 1.1	10.5 ± 1.3	11.2 ± 1.4	< 0.001
Abdominal Pain	2.1 ± 0.4	2.2 ± 0.3	3.5 ± 0.5	3.8 ± 0.6	< 0.001
Postprandial Fullness	1.8 ± 0.3	1.9 ± 0.2	2.8 ± 0.4	3.1 ± 0.5	< 0.001
Early Satiety	1.5 ± 0.2	1.6 ± 0.2	2.5 ± 0.3	2.8 ± 0.4	< 0.001
Bloating	1.2 ± 0.2	1.3 ± 0.2	2.2 ± 0.3	2.5 ± 0.4	< 0.001
Regurgitation	0.8 ± 0.1	0.9 ± 0.1	1.5 ± 0.2	1.8 ± 0.2	< 0.001
Nausea	0.5 ± 0.1	0.6 ± 0.1	1.2 ± 0.2	1.5 ± 0.2	< 0.001
Heartburn	0.3 ± 0.1	0.4 ± 0.1	0.8 ± 0.1	1.0 ± 0.1	< 0.001
Indigestion	0.2 ± 0.1	0.3 ± 0.1	0.7 ± 0.1	0.9 ± 0.1	< 0.001

**Fig. 4**

[Back to Top](#)