Clinical utility of electrogastrography and the water load test in patients with upper gastrointestinal symptoms

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Abstract

We assessed gastric myoelectric functioning in patients with various gastrointestinal symptoms and to determine the utility of electrogastrography in differentiating specific disease entities. Electrogastrography with a water load was performed in 101 patients with reflux disease, 55 patients with active gastric ulcer, 59 patients with functional dyspepsia, and 30 controls. Upper gastrointestinal symptoms were assessed in each patient. Electrogastrography was abnormal in 41 (40.6%) patients with reflux disease, 31 (56.4%) patients with active gastric ulcer, and 26 (44.1%) patients with functional dyspepsia (P=NS). Water load tolerance was greater in controls than any patient group (all P<0.05). Symptoms predicted abnormal electrogastrography in reflux patients with satiety (OR=2.9; P<0.05) and in dyspeptic patients with nausea (OR=3.1; P<0.05). Although electrogastrography is helpful in differentiating subgroups of patients with nausea or satiety, it cannot directly differentiate disease states such as reflux disease, gastric ulcer, and functional dyspepsia.

Key words: electrogastrography, gastric myoelectrical activity, gastrointestinal symptom

Introduction

Functional dyspepsia (FD) is common and is often defined as episodic or persistent upper abdominal symptoms related to eating (Barbara et al., 1989). Dyspeptic symptoms include vague epigastric or periumbilical discomfort, early satiety, postprandial fullness, bloating, regurgitation, nausea, and vomiting (Drossman, 1999). A number of abnormalities of gastric physiology have been described in FD (Barbara et al., 1989; Jebbink et al., 1995; Gilja et al., 1996). Abnormal gastric myoelectric activities have been found in patients with FD (Lin et al., 1998) and in patients with unexplained nausea and vomiting (Koch and Stern, 1996). Normalization of gastric dysrhythmias has been associated with an improvement in dyspeptic symptoms (Koch et al., 1989; Riezzo et al., 1995). It has been suggested that gastric motor disorders in these patients may be pathophysiologically related to gastric myoelectric
dysrhythmias (Kim et al., 1988; Chen et al., 1995; Hasler et al., 1995).

Electrogastrography (EGG) allows the cutaneous measurement of gastric myoelectric activity and provides information on the frequency and relative amplitude of antral contractions (Smout et al., 1980; Chen and McCallum, 1993). These activities originate from the gastric pacemaker located in the mid portion of the stomach which fires at 3 cycles per min (cpm) with aboral propagation of spike bursts to the pylorus (Chen and McCallum, 1993). Since its first application in the 1920s (Alverez, 1922), numerous studies have demonstrated a close association of cutaneously monitored electric abnormalities with gastrointestinal motility disorders (Chen and McCallum, 1991). The water load test is a standardized test to induce gastric distension and to evoke gastric motility responses without the complex hormonal response of a caloric test meal. EGG with water load test has been validated as being reliable and reproducible (Koch et al., 2000).

In this study, we aimed at assessing gastric myoelectric functioning with a water load in patients with gastroesophageal reflux disease (GERD), gastric ulcer (s), FD as well as healthy controls by using EGG, and to evaluate the utility of EGG in differentiating these patients with different disease entities. We also aimed to examine the role of EGG in predicting individual gastrointestinal symptom.

**Materials and Methods**

**Patients**

Consecutive patients were identified and enrolled from the Gastroenterology Clinic of Tzuchi Medical Center (Hualien, Taiwan). The patients included 101 with GERD, 55 with active gastric ulcer disease (GU), and 59 with FD, as well as 30 asymptomatic controls. The diagnosis of GERD was based on symptoms and endoscopic findings. Patients were included who presented endoscopic evidence of reflux esophagitis (Lundell et al., 1999). FD patients were diagnosed using Rome criteria (Talley et al., 1999), and all had a normal esophagogastroduodenoscopy (EGD) and a normal abdominal ultrasound. Patients with active GU were confirmed by EGD. Patients were excluded if they had a history of gastric, intestinal, or colonic resection. Other exclusions were pregnancy and malignancy. Subjects were also excluded if they were infected with *Helicobacter pylori*. *H. pylori* status was determined by biopsy for histology or rapid urease testing or via $^{13}$C-urea breath testing. Patients were considered infected if any test for the presence of *H. pylori* was positive. Drugs such as anticholinergics, cholinergics, antispasmodics, and antiemetics were held for 48 hours before the EGG tests. Studies were accomplished with subjects’ written informed consent, in accordance with the Helsinki Declaration.

**Symptomatic assessments**

The patients were questioned with regard to the presence and severity of nausea, vomiting, heartburn, belching, satiety, fullness, and bloating at the beginning of the study (Chen et al., 2005). The symptoms were scored using a 10-point scale from 0 when the symptom was absent to 9 when the symptom was worst.
Electrogastrography (EGG) with water load test

All patients were fasted overnight. The EGG signal was recorded using standard Ag/AgCl cutaneous electrodes. One electrode was positioned in the mid-clavicular line 2 inches below the left costochondral margin. Another electrode was located at the mid-point between the umbilicus and the xiphoid process. The reference electrode was placed on a line formed by the previous electrodes and a line from right mid-clavicular line to a point 2 inches below the right costochondral margin. Electrode sites were prepared by rubbing with an abrasive paste, followed by application of an electroconductive gel. An EGG recorder and software analysis (3 CPM company, Crystal Bay, NV, U.S.A.) was utilized to record the EGG signal. Overall power spectra were computed for 15 minutes at baseline, and 30 minutes after ingestion of the water load. The water was cold (23°C) and ingested over a period of 5 min until the subjects felt full. Frequencies of interest recorded in the EGG were 1.0–2.5 cpm (1–2.5 cpm = bradygastria), 2.5–3.75 cpm (normal range), 3.75–10.0 cpm (3.75–10 cpm = tachygastria), and 10–15 cpm (10–15 cpm = duodenal or respiratory frequency). In addition, the digitized file was analyzed using Fourier transformation, running spectral analysis (RSA) with Fourier transformation, and calculation of the percentage distribution of power in the four frequency ranges described above (Koch et al., 2000). The EGG was interpreted as normal or abnormal on the basis of the raw EGG recording and the running spectral plot. The study was considered abnormal if 2.5–3.75 cpm activity was seen <70% of the study period (Chen and McCallum, 1992).

Statistical analysis

Results were expressed as the mean ± SEM or as percentages. Statistical significance was assessed by analysis of variance (ANOVA) and χ² test as appropriate. Correlation for presence of individual symptom with normal or abnormal EGG was assessed using logistic regression analysis. The α level was set at 0.05 for all statistical analysis.

Results

The clinical features of the different patient groups are shown in Table 1. Of the 101 GERD patients, 41 (40.6%) had an abnormal EGG, 31 of 55 patients (56.4%) with GU had abnormal EGG, while 26 of 59 FD patients (44.1%) had abnormal EGG findings (P=NS). One healthy control also was found to have an abnormal EGG. All of the patient groups ingested less water until full than controls (Fig. 1), but there was no difference in the amount of water ingestion among the patient groups. FD patients with abnormal EGG findings ingested less water until full than those with normal EGG results (383 ± 26 ml vs. 452 ± 26 ml; P=0.045), but this difference did not occur in other patient groups (Fig. 2).

Figure 3 shows the severity of gastrointestinal symptoms in all patient groups. FD patients had higher scale results for early satiety (P=0.006) and belching (P=0.01) than patients with GU, and more bloating (P=0.005) than GERD patients. Not surprisingly, GERD patients had more heartburn than the other groups. GERD patients also manifested more belching than patients with GU (P=0.001). In addition, FD patients with abnormal EGG results had higher nausea scores than those with normal EGG (P=0.03) (Fig. 4A). GERD patients with abnormal EGG
findings had more profound satiety than those with normal EGG ($P=0.01$) (Fig. 4B). In addition, we found individual symptoms statistically predicted abnormal EGG in GERD with early satiety (odds ratio = 2.9; $P<0.05$) and in FD with nausea (odds ratio = 3.1; $P<0.05$) (Table 2).

As shown in Fig. 5, patients with GU had significantly higher percent of 3.75–10 cpm activity

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic features of all subjects</th>
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<tr>
<td></td>
<td>GERD</td>
</tr>
<tr>
<td>No. of cases</td>
<td>101</td>
</tr>
<tr>
<td>Age (mean ± SEM) (yr)</td>
<td>48.9 ± 1.6</td>
</tr>
<tr>
<td>Female (no. of cases)</td>
<td>49</td>
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<tr>
<td>Body mass index</td>
<td>23.4 ± 0.4</td>
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GERD, gastroesophageal reflux disease; GU, gastric ulceration disorder; FD, functional dyspepsia.
EGG and gastrointestinal symptoms

Fig. 3. Symptom profile in all patient groups. FD patients had higher scale for early satiety (*P=0.006) and belching (++P=0.01) than patients with GU, and higher scale for bloating (**P=0.005) than GERD patients. GERD patients had higher scale for heartburn among the groups (***P=0.001), and had greater scale for belching that patients with GU (+P=0.001). GERD, gastroesophageal reflux disease; GU, gastric ulcer disease; FD, functional dyspepsia.

Fig. 4. The symptom severity in FD and GERD patients according to the results of EGG tests. A. FD patients with abnormal EGG had greater score for nausea than those with normal EGG (*P=0.03). B. GERD patients with abnormal EGG had greater score for early satiety than those with normal EGG (**P=0.01). FD, functional dyspepsia; GERD, gastroesophageal reflux disease.
by 11–20 min after water ingestion as compared to controls \((P=0.01)\). However, there were no statistically significant differences in any other EGG variables among the patient groups.

**Discussion**

This study shows that gastric dysrhythmias are detected through EGG in patients with a variety of disorders such as GERD, GU, and FD; furthermore, stomach fullness in response to a water load is altered in all patient groups compared to healthy controls.

We have demonstrated that about 40% of patients with FD have an abnormal EGG, which is in agreement with previously published observations (Leahy *et al.*, 1999; Jones *et al.*, 2003). FD patients with abnormal EGG findings also had significantly lower water ingestion tolerance and more nausea compared with controls. In addition, the presence of nausea in FD patients was observed to correlate with abnormal EGG data. This is in agreement with Camilleri *et al.* (1998)
who have reported that nausea and vomiting are the most common symptoms associated with disturbed EGG (Camilleri et al., 1998). These findings would suggest that altered perception to gastric fullness may coincide with disturbed gastric electrical activities which may account for the dyspeptic symptoms. However, conflicting results have been reported by Jones et al. (2003) who found a poor correlation between an abnormal drink test and disturbed EGG (Jones et al., 2003). In the current study, we noted that 60% of FD patients have normal EGG with the water load test. Additionally, these subjects with normal EGG consumed less water compared to control subjects. This indicates the possibility that other underlying mechanisms such as visceral hypersensitivity may explain the symptoms.

Many patients with gastric ulceration have upper abdominal discomfort, and some patients may have considerable dyspeptic symptoms associated with acute gastric ulcers. We have shown that above 50% of patients with gastric ulcer disease have abnormal EGG. In addition, compared with healthy controls, there was a statistically significant increase in tachygastria after water ingestion in these patients. Our findings are similar to those of a previous study done by Geldof et al. (1989) who reported that abnormal EGG was found in patients with an active gastric ulcer (Geldof et al., 1989). Also, these patients had significantly less water ingestion compared with controls. The altered gastric neuromuscular response to the water load and perception to fullness may contribute to concomitant dyspeptic symptoms experienced by these patients.

In this study, patients with reflux disease were discriminated from controls both by the presence of abnormal EGG and by lower tolerance for water loading, although two groups did not differ in quantitative analysis of the EGG in any power range. The results could be in accordance with our recent study which has shown gastric dysrhythmias in 10–40% of GERD patients (Chen et al., 2004). This abnormality is more notable in those with concomitant dyspeptic symptoms (GERD+) (Chen et al., 2004). In this study, we attempted to determine the capability of EGG in differentiate reflux patients with individual dyspeptic symptoms. Of interest, GERD patients with abnormal EGG appear to experience significantly more satiety than those with normal EGG. The presence of satiety also correlated well with abnormal EGG findings in GERD patients. This finding would suggest that the EGG may be useful in differentiating reflux patients with and without satiety. However, EGG was not particularly helpful in delineating meaningful GERD subgroups with other dyspeptic symptoms.

There are some important clinical implications arising from this study. With EGG evidence of abnormal gastric myoelectric activity, it is possible identify a subgroup of FD patients with nausea as well as with less water load toleration, and a subgroup of reflux patients with satiety. In these subgroups of patients with GERD or FD, EGG may not only help distinguish patient heterogeneity in clinical practice but might also provide a useful objective marker of treatment effect. Although we have demonstrated that three groups of patients had significantly greater gastric dysrhythmias and increased sensitivity to gastric distension by the water load, there were no differences in the prevalence of gastric dysrhythmias or any other EGG variable among GERD, GU, and FD. These findings may reflect the fact that gastrointestinal symptoms in these patients may be pathophysiologically related to gastric myoelectric dysrhythmias regardless of the associated major clinical diagnosis. Whether this disturbance is caused by primary visceral
pathology or by more central mechanisms, perhaps in association with psychological disturbances, cannot be elucidated from these data.

In conclusion, our study reemphasizes the noninvasive role of EGG and water load testing in assessing the gastrointestinal motility in patients with a variety of gastrointestinal symptoms such as GERD, GU, and FD. Although EGG could help differentiate subgroups of patients with nausea or satiety occurring in association with various major diagnostic categories, EGG does not directly differentiate GERD vs. GU vs. functional dyspepsia.

References


