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[Original Articles]

Electrogastrography Versus Gastric Emptying Scintigraphy in Children With Symptoms Suggestive of Gastric Motility Disorders

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ABSTRACT

Background: Cutaneous electrogastrography is a method of recording gastric electrical activity. Abnormalities of the electrogastrogram have been described in a variety of disorders. The purpose of the study was to correlate the electrogastrograms of children with vomiting and dyspepsia with the results of radionucleotide gastric emptying studies.

Methods: Nine patients (5–16 years old) with gastrointestinal symptoms of vomiting and/or abdominal pain were studied. The electrogastrogram was recorded using surface electrodes for 30 minutes in the fasting state and for 120 minutes after a radioisotope-labeled solid meal. Gastric emptying was simultaneously monitored for 120 minutes. The postprandial change in dominant power (power ratio: postprandial/fasting dominant power), percentages of normal slow wave, bradygastria, and tachygastria were recorded and analyzed.

Results: The patients were divided into two groups. The first group (four patients; five studies) had normal gastric emptying, whereas the second group (five patients) had delayed emptying (half-life, >90 minutes). The median power ratio in the first group was 1.69 and in the second group was 2.78; the difference was not statistically significant ($P = 0.90$). The median difference in slow wave percentages in the fasting and postprandial periods was 0.99 in the first group and 0.73 in the second group; again, the difference was not statistically significant ($P = 0.27$).

Conclusions: Although it is a method of assessing gastric myoelectrical activity and gastric motility disorders, electrogastrogram does not correlate with nuclear scintigraphic gastric emptying studies in children.

Patients with gastrointestinal symptoms of nausea, vomiting, abdominal pain, and bloating often have delayed gastric emptying, either secondary to abnormal gastric motor activity such as gastric hypomotility and uncoordinated gastroduodenal contractions, or as a result of mechanical obstruction, for example, from pyloric stenosis.

Different diagnostic techniques and maneuvers have been used for evaluation of upper dyspeptic gastrointestinal symptoms, including endoscopy, nuclear gastric emptying studies, and manometry. Some of these diagnostic measures may expose the developing child to hazardous complications such as radioactivity and perforation, and some may require a hospital setting and even the use of anesthetics. The electrogastrogram (EGG) is a noninvasive technique, easily performed, and inexpensive and has no risk of adverse effects.

The role of cutaneous EGG in motility assessment derives from its ability to capture the electrical signals and identification of gastric contractions from remote external sites (1). Multiple studies have shown that cutaneous EGG is comparable to serosal or mucosal EGG (2–6). Abnormalities in gastric myoelectrical activity had been well established in multiple disorders, including diabetic gastroparesis (7,8) and nonulcer dyspepsia (9–11).

Gastric myoelectrical activity is composed of two types of electrical signals: slow wave activity and superimposed spikes. The slow wave originates in the area of the great curvature of the stomach, adjacent to the junction of the fundus and antrum. The rhythmic variation is characterized by a frequency of 3 cycles per minute (cpm) in humans. Propagation occurs toward the pylorus, with increasing velocity and amplitude (12). Spike potentials (or electrical response activity) constitute another component of gastric myoelectrical activity. The purpose of the present study was to investigate whether the EGG correlates with gastric emptying in children with different gastrointestinal symptoms.

MATERIALS AND METHODS

Patients

The study was performed on nine children (five girls; four boys, age range, 5-16 years, with a median age of 13 years) with gastrointestinal symptoms for which they were scheduled for a solid gastric emptying study. One patient (patient 4) had the studies repeated 6 months later, and therefore 10 paired studies were performed and analyzed. Each patient had at least one of the following symptoms: nausea, vomiting, abdominal pain, or early satiety. The most common symptom was vomiting. The clinical details of the patients are shown in Table 1. All subjects were fasted for 6 hours or more before the study and had taken no medications known to affect gastrointestinal motility during the 3 days before the study. The protocol was approved by the Institutional Review Board at The Cleveland Clinic Foundation.

Patient	Age (yr)	Sex	Signs and symptoms	Diagnosis
1	12	F	Abdominal pain and poor weight gain	EGE
2	16	F	Abdominal pain and weight loss	Gastritis
3	14	M	Abdominal pain and weight loss	EGE
4	5	F	Vomiting and abdominal pain	EGE
5	12	F	Vomiting and abdominal pain	EGE
6	13	M	Vomiting and failure to thrive	EGE
7	16	M	Vomiting and weight loss	EGE vs Crohn's disease
8	8	F	Abdominal pain and constipation	Pseudo-obstruction
9	13	M	Vomiting and abdominal pain	GER, EGE

EGE, eosinophilic gastroenteritis; GER, gastroesophageal reflux.

TABLE 1. *Patients' characteristics*EGE, eosinophilic gastroenteritis; GER, gastroesophageal reflux.

Electrogastrogram

Cutaneous EGG was performed to record gastric myoelectrical activity. Before the placement of the electrodes, gastric ultrasonography was performed by a pediatric radiologist to localize the great curvature of the stomach for electrode placement. The skin was lightly abraded with a sandy skin preparation paste (Weaver & Co., Aurora, CO, U.S.A.) to reduce impedance, followed by the application of an "electro" cream (Signa creme; Parker, Orange, NJ, U.S.A.) to improve conduction. Three silver-silver prejellied electrocardiogram electrodes (Conmed Corp., Utica, NY, U.S.A.) were placed over the ultrasonographically determined electrode sites. Two epigastric electrodes were connected to yield a bipolar EGG signal, and a third electrode was placed over the left flank region as a reference grounding electrode. The EGG signal was recorded and amplified (PC Polygraf HR; Synectics Medical, Inc., Shoreview, MN, U.S.A.) with low and high cutoff frequencies of 0.5 and 15 cpm, respectively. Electrogastrography recording was performed for 30 minutes during a fasting state and for 2 hours after the meal.

Gastric Emptying

The standard test meal for determining gastric emptying consisted of two scrambled eggs mixed with technetium sulfur colloid with two pieces of toast and 4 oz of orange juice. For patient 1, who was allergic to egg, the technetium was mixed with a mashed banana. After ingestion of the radioisotope-labeled meal, the patients were asked to lie supine under the gamma camera for 2 hours, during which images of the stomach were taken every 15 minutes. The half-life ($T_{1/2}$) of gastric emptying was calculated. Normal gastric emptying was defined as $T_{1/2}$ in a range of 60 to 90 minutes, and delayed emptying was defined as $T_{1/2}$ of more than 90 minutes.

Study Protocol

Scintigraphic gastric emptying studies and EGGs were performed simultaneously. After at least 6 hours' fasting, EGG recording was performed for 30 minutes while the patient was lying supine and in the fasted state. Then, the patient was asked to ingest the isotope-labeled test meal within 6 to 12 minutes for the gastric emptying study. The patient then resumed a supine position and simultaneous recording of the EGG and gastric emptying were performed for 2 hours. A member of the Child Life Team at Cleveland Clinic Foundation was present during the study period for all patients to help maintain the patient's cooperation during the study.

Data Analysis

The EGG data were obtained and analyzed with a computer program (Polygram UGI, ver. 6.4; Medtronics Inc., Minneapolis, MN, U.S.A.). The following parameters were computed for each patient: 1) The dominant electrical frequency (DF) and the percentage of DF in the defined normal frequency range (2.4-3.7 cpm), the bradygastria range (0.5-2.4 cpm), and the tachygastria range (3.7-9 cpm) were recorded. Nine to 15 cpm were deleted as artifact and separated from tachygastria, because they were assumed to arise from the duodenum or the lung. 2) The dominant frequency instability coefficient (DFIC), which is a measure of how much the DF changes over the course of the recording period, and 3) the electrical power (amplitude) were also analyzed. Because the absolute value of the power is influenced by many factors (such as the thickness of the abdominal wall of the patient, skin preparation and conductance, and position of the electrodes) (13,14), only the postprandial-to-fasting power ratio was analyzed. The data were obtained by running spectrum analysis.

RESULTS

All nine patients successfully completed both the gastric emptying and EGG studies, producing 10 sets of data. Based on the results of gastric emptying studies, patients were divided into two groups: the first group (four patients, five studies; patients 1-4*; 4* denotes the patient who had the studies repeated 6 months later) had normal gastric emptying times, whereas the second group (five patients, 5-9) had delayed gastric emptying.

Using Wilcoxon's rank sum test, patients with normal gastric emptying had a median power ratio of 1.69, with interquartile range of 1.31 to 3.15, whereas patients with delayed gastric emptying had a median power ratio of 2.78 with an interquartile range of 1.25 to 2.95. There was no statistically significant difference in median power ratio (P = 0.90) between patients with normal gastric emptying and patients with delayed gastric emptying. Four of 5 patients with delayed gastric emptying had an increase in dominant power ratio; 3 of those had a ratio higher than 2.5. We also noted that the patient with the longest $T_{1/2}$ (patient 9), had the lowest dominant power ratio (0.86), whereas the patient with the fastest emptying (patient 1), had the highest dominant power ratio among the patients with normal gastric emptying.

Patient 4 had the studies repeated 6 months later for evaluation of persistent symptoms in spite of treatment with prednisone and cisapride for a presumed diagnosis of eosinophilic gastroenteritis. The second study on patient 4* showed improvement in slow wave percentage in the preprandial period and an increase in postprandial tachygastria in comparison with the first study before treatment. Patient 3 also had postprandial tachygastria. Both patients with postprandial tachygastria had normal gastric emptying.

Analysis of other EGG parameters, such as slow wave percentages, tachygastria, and bradygastria, in the pre-and postprandial periods were not significantly different between the two groups. The median difference of the slow wave percentages in postprandial-to-fasting state was 0.99, with an interquartile range of 0.63 to 1.45 in patients with normal gastric emptying, whereas the median difference in patients with delayed gastric emptying was 0.73, with interquartile range of 1.15 to 1.75. The difference was not statistically significant (P = 0.27)

The percentages of bradygastria, tachygastria, and gastric arrhythmias are best reflected by DFIC. In all patients with delayed gastric emptying, DFIC decreased in the postprandial period. Data are shown in Table 2.

Patient	Fasting (% at 3 cpm)	Postprandial (% at 3 cpm)	Fasting (% DFIC)	Postprandial (% DFIC)	Dominant power ratio	GE $T_{1/2}$ (min)
1	53.3	44.0	39	32	4.48	58
2	57.9	71.8	33	31	1.84	70
3	81.5	41.7	20	30	1.57	83
4	44.4	76.7	25	17	1.64	82
4*	88.9	82.5	17	17	1.81	75
5	37.0	95.7	36	8	1.25	148
6	81.3	93.3	14	17	5.59	110
7	81.5	93.8	11	9	2.95	155
8	30.8	53.8	37	31	2.78	97
9	37.0	50.6	36	28	0.85	270

4* denotes values of repeated studies on patient 4. cpm, cycle per minute; DFIC, dominant frequency instability coefficient; GE, gastric emptying.

TABLE 2. *Running spectrum showing percentage activity and half-life of gastric emptying*4* denotes values of repeated studies on patient 4. cpm, cycle per minute; DFIC, dominant frequency instability coefficient; GE, gastric emptying.

DISCUSSION

Although cutaneous EGG is a noninvasive and safe study, its use as a diagnostic test in children is limited, because there are no data that provide normal values in healthy children, which makes the interpretation of EGG difficult and the correlation of the results with clinical scenarios even more difficult. Because control data were not available for the purpose of the study, we assumed that normal gastric myoelectrical activity in children was similar to that in adults. Chen et al. (15) studied the pattern of gastric myoelectrical activity in human subjects of different ages and concluded that age-matched control subjects are necessary for the interpretation of EGG data for neonates and infants, whereas EGG parameters in children and adults are similar. Pfaffenbach et al. (16) reported the results of a

running spectrum analysis of EGG recordings performed on 40 healthy adult patients with an age range of 19 to 90 years and determined that the dominant electrical frequency was higher in the postprandial than in the preprandial period. The postprandial DFIC was lower, and the electrical power increased after the meal, with a postprandial-to-fasting power ratio of 2.4. In our study, all patients except one (patient 9) had an increase in the postprandial-to-fasting power ratio. There was no significant difference in the power ratio in patients with normal or delayed gastric emptying.

In several other studies (6,17-19) in adult patients, investigators attempted to study the correlation between EGG and gastroparesis. Chen et al. (19) studied 97 adult patients with symptoms suggestive of gastroparesis by using both gastric emptying scintigraphy and EGG. In their study, patients with delayed gastric emptying showed a significantly lower percentage of normal gastric slow waves and a significantly reduced increase in the dominant power ratio in the postprandial state. Thirty-five percent of their patients with a normal EGG study had delayed gastric emptying. Our results showed that four of five patients with delayed gastric emptying had an increase in the postprandial dominant power and an increase in the postprandial slow wave percentage. Of interest, the only patient who had a power ratio less than 1 had the most severe delay in gastric emptying, with a $T_{1/2}$ of 270 minutes. This may indicate that gastric emptying should be significantly delayed to reflect changes in the EGG. Three of four patients with normal gastric emptying had a decrease in slow wave percentage in the postprandial period. None of our patients with delayed gastric emptying had postprandial tachygastria, whereas two patients with normal gastric emptying had postprandial tachygastria (patients 3 and 4*). This observation may indicate that there is a gastric dysrhythmic pattern associated with nonspecific upper gastrointestinal symptoms in patients with normal gastric emptying. Tachygastria has been related to gastric retention (20), nausea and vomiting (21), and motion sickness (22). There is no characteristic pattern of EGG in patients with normal gastric emptying.

It is known that several factors may affect the results of gastric emptying as well as the EGG recording. These factors include the test meal, the body position of the patient, the patient's mood, and the recording environment. We tried to eliminate most of these variables by performing both the EGG and the gastric emptying scan simultaneously. Because different meals may have a different effect on the gastric motility and EGG (23), all patients had a uniform test meal except for one (patient 1) who had multiple food allergies and received the radioisotope mixed with mashed banana. The EGG electrodes were placed sonographically, because blind placement of electrodes by reference to the umbilicus was unreliable in detecting gastric electrical activity (16). In our study, we measured and analyzed the ultrasonographically determined electrode positions in relation to the umbilicus and xiphoid process, and we tried to apply the calculations that had been used in adults to localize the antrum (16,24,25). We concluded that there was no uniform measurement among our patients to predict the position of the gastric antrum, and our conclusion is therefore in agreement with other studies that EGG electrode sites are best determined ultrasonographically.

The results of our study showed that EGG is technically feasible in pediatric patients. Our results were different from those reported by Chen et al. (19), which may be because of the small size of our study sample and/or the specific disease entity; seven of the nine patients had eosinophilic gastroenteritis.

Although EGG failed to predict gastric emptying in our study patients, several other studies have documented the usefulness of EGG as a diagnostic study in multiple and different diseases in adult patients. This study opens up the field for further studies and research on EGG in children to establish normal values of EGG parameters in healthy children, who are not simply small adults.

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Key Words: Electrogastrography; Gastric emptying; Gastric motility; Gastric myoelectrical activity

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IMAGE GALLERY

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Table 1

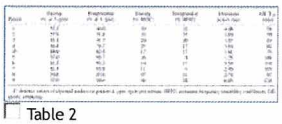

Table 2

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