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Effect of Meal and Intravenous Erythromycin on Manometric and Electrogastrographic Measurements of Gastric Motor and Electrical Activity

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Electrogastrography (EGG) measures, on the skin surface, the myoelectrical activity attributable to gastric smooth muscle cells. The physiological significance of signal amplitude and variation has not been clearly established. The increased signal amplitude after eating a meal may be related to increased contractile activity or to gastric distension. This study investigates the effect of increased gastric motor activity, unaccompanied by gastric distension, on the EGG recording and compares it to the effect of a meal. Nine children (3 months to 15 years old), were assessed by antroduodenal manometry for chronic intestinal pseudoobstruction ($N = 5$), chronic vomiting ($N = 2$), and abdominal distension ($N = 2$). Synchronized EGG recording was performed simultaneously. During the study, four children were given a meal and five were given intravenous erythromycin 3 mg/kg over 1 hr. The ratio of the antral motor index (MI = number of waves × sum of amplitudes) determined 1 hr before a meal (or erythromycin) to that determined 1 hr after a meal (or during intravenous erythromycin) was calculated. The ratio of the running total spectrum power of the electrical signal at the same times was also calculated. Antral MI increased after a meal [MI ratio (mean ± SE) 5.33 ± 2.2] and after intravenous erythromycin (MI ratio: 9.36 ± 2.6). The amplitude of the electrical activity also increased after the meal [power ratio (mean ± SE) 3.01 ± 0.65] and after intravenous erythromycin (power ratio: 1.23 ± 0.39), but the increase was greater after the meal ($P <$ 0.05 vs intravenous erythromycin). No correlation was found between antral MI ratio and running total spectrum power ratio. In conclusion, the increased amplitude of the gastric electrical activity recorded by the EGG after a meal seems to be only partly due to the increase in antral motor activity. The increase in power is also related to gastric distension.

KEY WORDS: electrogastrography; erythromycin; manometry; children.

Electrogastrography (EGG) is a noninvasive technique for recording the myoelectrical activity of gastric smooth muscle cells using electrodes placed on the skin surface. Recent advances have improved the measurement and analysis of the EGG. Spectral analysis of the signal identifies two components of the surface electrical signal: frequency and power [which is related to the amplitude of the signal (1)]. Numerous studies have demonstrated that frequency is related to the gastric slow waves recorded by serosal or mucosal electrodes (2, 3). Conversely, the physiolog-

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ical significance of the power (or amplitude) and its fluctuations has not been clearly established. The increase in the amplitude of the signal observed after a meal may be due to increased contractile activity (4, 5) or to gastric distension (2).

This study investigates the effect on the EGG recording of increasing the gastric motor activity in the absence of gastric distension and compares this to the effect of a meal.

MATERIALS AND METHODS

Patients and Study Protocol. Nine children (median age 5.5 years, range 3 months to 15 years) were included in the study. They underwent antroduodenal manometric assessment for chronic intestinal pseudoobstruction syndrome (N = 5), chronic vomiting (N = 2), or abdominal distension (N = 2). Synchronized EGG recording was performed simultaneously. During the study, four children received a meal and five received an infusion of erythromycin (3 mg/kg in 1 hr) to induce phase III activity, because this had not been recorded during the first 3 hr of antroduodenal manometry.

Methods. Antroduodenal manometry was performed using a low-compliance perfused system (Arndorfer) connected to pressure transducers (Statham P23ID) and to a polygraph recorder (Gould ES2000). A six-lumen polyvinyl catheter was inserted into the antroduodenum on the day preceding the recording, using fluoroscopic visualization and a vascular guidewire. Recording was performed on fasting patients for at least 3 hr to record at least one period of phase III activity. If such a period was recorded, the patient was allowed to have a meal (200 ml of formula for infants, 300–450 kcal for older children). If no such period had been recorded during the first 3 hr, the patient was given intravenous erythromycin (3 mg/kg in 1 hr) to induce phase III-like activity, following the routine protocol we use in our unit.

The recordings were analyzed visually and the antral motor index (sum of amplitudes × number of waves) was calculated for the times 60 min before the meal or erythromycin infusion and 60 min after the meal or during erythromycin infusion. The ratio of the running total spectrum power determined 60 min before the meal or erythromycin infusion to that measured 60 min after the meal or during erythromycin infusion was calculated.

Synchronized electrogastrographic recording was simultaneously performed using a 96-kb portable EGG recorder (Synectics MedicalAB, Stockholm, Sweden). All recordings were made at sampling frequencies of 4 Hz and analyzed using software developed by Synectics (ElectroGastrogram version 6.40, Gastrosoft Inc., Synectics Medical).

Two silver–silver chloride bipolar surface electrodes (Red Dot, 3M) were placed on the cleaned skin over the gastric antrum. One electrode was placed on the patient's ventral midline, halfway between xiphoid process and umbilicus, and the other immediately below the left costal margin in the midclavicular line. A third skin electrode, used as the reference lead, was placed so as to form an equilateral triangle.

TABLE 1. ANTRAL MOTOR INDEX AND RUNNING TOTAL SPECTRUM POWER RATIOS IN PATIENTS RECEIVING A MEAL OR ERYTHROMYCIN*

Patient	*Antral motor index ratio*	*Running total spectrum power ratio*	
1	10.8	2.29	
2	7.03	2.61	
3	1.3	2.19	
4	2.21	4.95	
Mean ± SE	5.33 ± 2.2	3.01 ± 0.65	
5	13.8	2.39	
6	15.3	0.52	
7	11.1	0.73	p = 0.04
8	4.22	0.53	
9	2.4	1.99	
Mean ± SE	9.36 ± 2.6	1.23 ± 0.39	

*Patients 1–4 were given a meal. Antral motor index and running total spectrum power ratios were determined 1 hr before the meal and 1 hr after the meal. Patients 5–9 received erythromycin. Antral motor index and running total spectrum power ratios were determined 1 hr before erythromycin and during the infusion.

The power of the signal was calculated by running spectral analysis. Since the absolute value of the power is influenced by many factors (such as skin resistance and electrode location), we calculated the ratio of the running total spectrum power determined 60 min before the meal or erythromycin infusion to that measured 60 min after the meal or during erythromycin infusion.

Ethical Considerations. All the children underwent the routine clinical tests used in our unit to investigate their clinical conditions. Informed consent was obtained from the parents, most of whom were present during the study.

Statistical Analysis. Statistical analysis was performed to investigate the differences between the EGG power and motor index ratios in the two groups of children. An unpaired Student's t test was used to assess the statistical significance, with a threshold of $P < 0.05$. Data are reported as mean ± SE.

RESULTS

The antral motor index ratios were 9.36 ± 2.6 (mean ± SE) during erythromycin infusion and 5.33 ± 2.2 after a meal, indicating that the antral motor index rose in both situations (Table 1). The post/pre ratio of the running total spectrum power was significantly higher in the children who had a meal (3.01 ± 0.65) than in those who were stimulated by erythromycin (1.23 ± 0.39, $P = 0.04$), indicating that motor activity increased in both cases, but that the increase in amplitude was greater after the meal than during erythromycin administration (Table 1). No correlation was found between antral motor index ratio and running total spectrum power ratio.

DISCUSSION

Gastric myoelectrical activity can be measured by EGG using surface electrodes. Although the frequency of the skin surface signal is closely correlated to the frequency recorded by internal electrodes, the significance of the amplitude of this signal remains unclear despite intensive investigations in recent years. A postprandial increase in amplitude has been reported in numerous studies in adults and in children (6–9), but its significance is controversial. Some authors believe that it is related to the increased contractility of the stomach after the meal (1, 4, 8, 10), whereas others have reported a major effect of gastric distension (2, 6, 11). The present study shows that the electrical response of gastric smooth muscle, recorded by electrodes on the skin, differs depending on how the antral motor activity is stimulated.

No correlation was found between the increase in the antral motor index and in the power ratio, suggesting that the increase in the amplitude of the electrical signal is not linked to antral motor activity and does not reflect directly the motility. Furthermore, despite comparable increases in the antral motor index obtained after stimulation with erythromycin and after a meal, the increase in power induced after a meal was greater than that induced by erythromycin stimulation, suggesting that the gastric distension resulting from the meal makes an important contribution to the increase in power.

The EGG recordings performed in our patients parallel those reported in the literature for normal children (7, 8) and in chronic intestinal pseudoobstruction syndrome (12).

Low-dosage erythromycin is a powerful prokinetic agent, with a motilin-agonist activity on the antroduodenum. The infusion of erythromycin (3 mg/kg) induced phase III-like activity in the antroduodenum, with strong, regular 3-per-minute antral contractions (13). This drug is used during motility testing in children to induce phase III activity if this fails to occur spontaneously. The 1-hr infusion time is the most effective, with the greatest effect on gastric antral contractions even in children with motility disorders. Di Lorenzo et al showed a 4.7-fold increase in the antral motor index after 3 mg/kg intravenous erythromycin (13).

To the best of our knowledge, no electrical data had previously been reported for children following erythromycin stimulation. Our findings mirrored those of Chen et al, who showed an increase in power in adults after erythromycin infusion (6 mg/kg intravenously) (14). The differing electrical responses in the two groups of children studied could be attributable to the underlying disease, if the electrical responses were abnormal in the erythromycin-stimulated group. We cannot exclude this possibility, but we clearly demonstrated that the increases in antral motor activity were similar after erythromycin and after a meal in both groups of children, regardless of the underlying disease.

Brown et al suggested that the postprandial distended stomach lies in closer proximity to surface electrodes than the fasting stomach, resulting in increased EGG amplitude (11). This was confirmed by Mintchev et al, who performed studies in dogs that clearly demonstrated the role of gastric distension in increasing the amplitude of the electrical signal on the skin surface corresponding to increased gastric activity after inflating the stomach with a balloon and blocking its mechanical activity with atropine and glucagon (2). Conversely, other authors have suggested that because the cutaneous EGG is the summation of all internal electrical events, periods of greater gastric mechanical activity are reflected by greater electrical power due to spike activity (1, 4, 10). These authors have studied the correlations between electrical activity and motor activity during various periods, but without one-to-one correspondence of single events (10). However, the same authors have clearly demonstrated that gastric distension has an influence on the amplitude of the signal by comparing electrical activity during fasting, after ingesting water, and after a meal (15). These findings suggest that both gastric motor activity and gastric distension affect the power of skin electrode recordings of the gastric electrical activity. Moreover, due to the chaotic and asynchronous appearance of gastric electrical spike activity, which is responsible for the motor response, variations of the skin surface recordings of power do not accurately reflect spike activity (16).

In the light of the findings of this study, we conclude, like other authors, that gastric distension and motor activity both contribute to the increase in EGG amplitude, the greater contribution being attributable to gastric distension.

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