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Chronic Gastritis Is Not Associated with Gastric Dysrhythmia or Delayed Solid Emptying in Children with Dyspepsia

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To determine if chronic gastritis (CG) is associated with gastric dysrhythmia or delayed solid emptying in children with dyspepsia, 22 patients (7–15 years of age) with dyspepsia and normal gross endoscopies were studied. Antral biopsies were evaluated for chronic gastritis, and immunohistology was performed to determine densities of CD3+, CD20+, CD25+, and tryptase-positive cells. Electrogastrography (EGG) and gastric scintiscan evaluation were performed within 2–7 days of endoscopy. CG and increased immune cell densities were not associated with altered gastric emptying. Mean CD3+ cell counts were positively correlated with the percentage normal slow waves, and patients with a normal EGG had increased CD3+ cell density. In children with dyspepsia, chronic antral inflammation in the setting of a normal gross endoscopy is not associated with EGG abnormalities or delayed solid emptying. Chronic gastritis and gastric dysrhythmia may simply be two separate and distinct mechanisms resulting in the clinical entity of dyspepsia.

KEY WORDS: dyspepsia; electrogastrography; gastric emptying; gastritis.

Recurrent abdominal pain is the most common chronic pain entity in school-age children and young adolescents (1). Cross-sectional studies reveal that at any given time, more than 10% of all school-age children are suffering from recurrent abdominal pain significant enough to interfere with normal daily functioning (2, 3). Dyspepsia refers to pain or discomfort in the upper abdomen. Associated symptoms can include postprandial epigastric fullness, bloating, pressure, early satiety, nausea, and vomiting. Dyspepsia is common in children with recurrent abdominal pain (4). Eighty-one percent of children referred to our institution for evaluation of recurrent or chronic abdominal pain have dyspepsia.

Dyspepsia may result from gastrointestinal mucosal ulceration as well as a host of other etiologies (e.g., hepatobiliary, pancreatic, renal). Patients without an identifiable organic cause are defined as having functional dyspepsia (5). Although histologic inflammation has been implicated in the generation of gastrointestinal pain or discomfort, the relationship between inflammation and clinical presentation and treatment response is not well established in dyspepsia (6). As an example, both chronic gastritis and *Helicobacter pylori*-associated gastritis are present in a significant proportion of asymptomatic adults and symptomatic improvement is inconsistent with *H. pylori* eradication (7–9). Adult patients with functional dyspepsia frequently have motility abnormalities of the stomach and upper small bowel including antral hypomotility and delayed gastric emptying (10–12).

Electrogastrography (EGG) is the technique of obtaining a cutaneous recording of gastric myoelectrical activity

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from abdominal surface electrodes and has been shown to identify dysrhythmic states and to correlate with gastric motility (13). It has been shown that after the age of 4 years, EGG parameters in children and adults are similar and parameters do not differ by age through childhood and adolescence (14, 15). The existence of EGG abnormalities in adults with functional dyspepsia has been established, and relationships between EGG parameters and gastric emptying have been reported (16–18). There are fewer reports evaluating EGG in dyspepsia in children (19–23).

The purpose of this study was to evaluate whether EGG parameters and gastric emptying differ between patients with and those without histologic, chronic, non-specific gastritis or correlate with mucosal densities of mast cells, T lymphocytes, or B lymphocytes. Additionally, we evaluated correlations among EGG parameters, gastric emptying, and symptoms in children with dyspepsia.

MATERIALS AND METHODS

Study Subjects. The study was performed in 22 pediatric patients with functional dyspepsia. Dyspepsia was defined as chronic or recurrent upper abdominal pain or discomfort consistent with published criteria for the diagnosis of functional dyspepsia (5). There were 16 females and 6 males, who ranged in age from 7 to 15 years, with a mean of 10 years. All patients underwent esophagogastroduodenoscopy with biopsies within 1 week of participating in the evaluations in this study. All patients were without gross pathology (including nodularity, erosion, and ulceration) on endoscopic examination and all had the presence of *H. pylori* excluded by histology and rapid urease testing on antral biopsies. Two additional antral biopsies were obtained for histology and were normal in 14 patients. Biopsies from the remaining eight patients revealed chronic, nonspecific gastritis consistent with published histologic criteria (24). Criteria included a monocytic infiltrate with reactive epithelial changes and/or mucin depletion. All patients were without neutrophilic or eosinophilic antral mucosal infiltrates. The study protocol was approved by the Institutional Review Board at Children's Mercy Hospital, and written consent was obtained for all subjects prior to the study.

Study Protocol. After an overnight fast of 8 hr or more, all subjects were studied at the Nuclear Medicine Department in the morning. The study area was separate from other clinical activities in the radiology department and the evaluation was carried out in a quiet room with the patients resting throughout the study. The EGG was recorded for 30 min in a supine position in the fasting state. The subject then sat up and consumed a standard meal labeled with technetium within a 15-min period. The subject then resumed the supine position and the postprandial EGG was recorded for 1 hr while simultaneously monitoring gastric emptying. This length of study has previously been shown to be sufficient to produce reliable results (25). All patients were interviewed to determine the presence of the following symptoms: pain resulting in awakening from sleep, nausea, vomiting, early satiety, bloating, and weight loss. Additionally, the severity (0–4 scale) of symptoms was graded for each of the following symptoms: vomiting, pre- and postprandial nausea, bloating, and pre- and postprandial pain.

Gastric Emptying Test. The standard meal for the gastric emptying test consisted of two whole eggs labeled with $^{99m}T_c$ sulfur-colloid and 120 ml of water. The anterior/posterior images of the stomach were taken by the same operator using a technetium scanner immediately and then every 10 min for 60 min and at 120 min after eating to determine the percentage of gastric retention.

Gastric Myoelectrical Activity. Gastric myoelectrical activity was measured with surface electrogastrography (EGG). Before the placement of electrodes, the epigastric skin where electrodes were to be positioned was shaved, as necessary to remove any hair, cleaned, and abraded with sandy skin preparation jelly (Ommi Prep; Weaver, Aurora, CO) to reduce the impedance. Two silver–silver chloride EGG electrodes (DNA, Dayton, OH) were placed on the abdominal skin. One electrode was positioned at the midpoint between the xiphoid process and the umbilicus. The second electrode was placed midsternal on the subject's left side, just below the lower rib and above the level of the first electrode. A reference electrode was placed in the lower quadrant close to the left costal margin. The electrodes were connected to a portable battery-operated recorder (Synectics Medical, Irving, TX) with low and high cutoff frequencies of 1 and 18 cpm, respectively. On-line digitization was done at a sampling frequency of 4 Hz and digitized samples were stored on the recorder. All recordings were made in a quiet room and the subject was asked not to talk and to remain as still as possible during the recording to avoid motion artifacts.

At the end of the recording, the EGG data stored on the recorder were downloaded to an IBM 586 personal computer for data analysis. After the EGG segments with motion artifacts were identified by visual analysis and removed using the locally developed program, the following parameters were computed from the EGG data using spectral analysis methods: (i) EGG dominant frequency, which was defined as the frequency at which the power spectrum of an EGG recording had a peak power in the range of 0.5 to 9 cpm; (ii) EGG dominant power, which was defined as the power at the dominant frequency in the power spectrum of the EGG recording; (iii) change of postprandial EGG dominant power (δP), which was defined as the difference between the EGG dominant power after and that before the test meal; and (iv) the percentage of normal slow waves and percentage of dysrhythmias, which were defined as the percentages of time during which regular 2- to 4-cpm slow waves and electrical dysrhythmias, respectively, were present over the entire observation period. A dysrhythmic episode required a frequency either >4 or <2 cpm and had to be recorded for ≥ 2 min with the normal signal simultaneously absent.

Mucosal Inflammatory Cells. For immunohistologic evaluation, serial 3-μm paraffin sections were air dried and heat-fixed on slides. The sections were deparaffinized with xylene and iodine and rehydrated in a graded series of alcohol. Sections for CD25 and CD3 were treated with Antigen Retrieval Solution (Dako No. S1700; Dako, Carpinteria, CA, USA) in a steamer at 90–95°C for 20 min and then cooled for 15 min. Sections for CD20 and tryptase were not pretreated. Sections were stained on an automated Dako Autostainer 3400 using Dako's LSAB+ kit with streptoavidin conjugated to horseradish peroxidase. For CD25 color signals were amplified by DakoCytomation CSA II. Antibodies used were CD25 monoclonal mouse anti-human CD25, clone ACT, Dako; CD3 monoclonal mouse anti-human CD3, clone F7.2.38, Dako; CD20 monoclonal mouse anti-human CD20cy, Clone L26, Dako; and tryptase monoclonal mouse anti-human mast cell tryptase, clone AA1, Dako.

Lamina propria CD25-, CD3-, CD20-, and tryptase-positive cells were enumerated by counting the cells within a 1 × 1-mm grid in 5 high-power fields. The mean of the obtained value was expressed as number of cells per square millimeter. All assessments were performed by a single pathologist blinded to clinical history, EGG, and gastric emptying.

Statistical Analysis. Delayed gastric emptying was defined as gastric retention >70% at 1 hr or >50% at 2 hr. The EGG was defined as abnormal if the percentage of normal slow waves (2–4 cpm) was ≤70% or if the preprandial power exceeded the postprandial power ($\delta P < 0$). These were based on norms previously established by the authors (Z.L. and R.W.M.). Differences in means for each EGG parameter were compared between patients with normal vs. delayed emptying by Student's t test and two-factor ANOVA for repeated measures. Disease severity scores were compared between normal and delayed emptying and between normal and abnormal EGG parameters, respectively, by the Mann–Whitney U test. Cross-tabulations were created for normal vs. delayed emptying and normal vs. abnormal EGG parameters, respectively, with symptom frequency and significance determined by Fisher's exact test. Pearson correlation coefficients were determined for emptying rates and EGG parameters as well as both emptying rates and EGG parameters, respectively, with symptom severity scores. Cross-tabulations were created for gastritis vs. normal biopsies with normal vs. abnormal EGGs and normal vs. delayed emptying, respectively, and significance was determined by the Fischer's exact test. Differences in measurements for gastric emptying and EGG parameters were evaluated for gastritis vs. normal biopsies by Student's t test. Pearson correlation coefficients were determined for cell densities and emptying rates and EGG parameters, respectively. Differences in cell densities were evaluated for normal vs. delayed emptying and for normal vs. abnormal percentage normal slow waves, respectively, by Student's t test. A P value <0.05 was considered to be significant. This value was adjusted using the Bonferroni correction when multiple t tests were performed.

RESULTS

The mean gastric emptying was 34% (range, 12–68%) at 1 hr and 61% (range, 23–96%) at 2 hr. Emptying was delayed at 1 hr in 50% (11/22) of the patients and at 2 hr in 36% (8/22) of the patients. All patients with delayed emptying noted at 2 hr were also delayed at 1 hr. Gastric emptying at 2 hr was highly correlated with gastric emptying at 1 hr ($r = 0.912$, $P < 0.001$).

Overall, an abnormal EGG was found in 64% (14/22) of the patients. The percentage of time with a normal 2- to 4-cpm frequency was abnormally low in 55% (12/22) in the preprandial period. In 10 of these 12 patients, the primary dysrhythmia was bradygastria. The percentage of time with a normal 2- to 4-cpm frequency was abnormally low in 32% (7/22) in the postprandial period. In six of these seven patients, the primary dysrhythmia was bradygastria. Bradygastria was more pronounced in the preprandial period as opposed to the postprandial period (28 vs. 16%, $P < 0.05$). A decrease in power from the preprandial to the postprandial period was found in 23% (5/22) of the patients.

The gastric emptying study showed delayed emptying in 50% of patients with gastritis and in 50% of patients with normal antral biopsies. Electrogastrographic recordings were abnormal in 38% of patients with gastritis and in 79% of patients with normal antral biopsies ($P = 0.081$). Gastric emptying and EGG parameters for patients with and without gastritis, respectively, are shown in Table 1.

Mean lamina propria CD3+ cell densities averaged 21.5/mm^2 (range, 8.4 to 42/mm^2) and peak CD3+ densities averaged 27.4/mm^2 (range, 11 to 52/mm^2). CD20+ and CD25+ cells were unusual, with average mean densities of 0.04 and 0.03/mm^2, respectively. Mean lamina propria tryptase-positive cells averaged 2.0/mm^2 (range, 0 to 5.2/mm^2) and peak tryptase-positive cells averaged 3.4/mm^2 (range, 0 to 8/mm^2). There was no significant correlation between CD3+ cell density and gastric emptying, nor did CD3+ cell densities differ between patients with normal versus delayed emptying at 1 or 2 hr, respectively. In the preprandial period, both the mean and the peak CD3+ densities were significantly correlated with the

TABLE 1. GASTRIC EMPTYING AND ELECTROGASTROGRAPHIC FINDINGS IN PATIENTS WITH NORMAL ANTRAL BIOPSIES VS. CHRONIC, NONSPECIFIC GASTRITIS (MEAN ± SD)

	Normal (n = *14*)	*Gastritis* (n = *8*)	P *value*
Gastric emptying (%)			
1 hr	34.9 ± 15.7	31.4 ± 9.0	0.159
2 hr	60.4 ± 18.2	62.1 ± 18.8	0.774
% normal 2- to 4-cpm waves			
Preprandial	63.6 ± 14.3	80.3 ± 17.7	0.414
Postprandial	78.8 ± 14.6	76.0 ± 11.1	0.608
% bradygastria			
Preprandial	31.9 ± 17.9	18.9 ± 17.0	0.562
Postprandial	15.2 ± 9.5	18.6 ± 13.3	0.535
% tachygastria			
Preprandial	4.4 ± 7.3	0.88 ± 2.5	0.013
Postprandial	6.0 ± 13.3	5.4 ± 5.84	0.881
δ power	3.6 ± 4.1	0.74 ± 3.3	0.086

percentage normal slow waves ($r = 0.486$, $P = 0.02$ and $r = 0.500$, $P < 0.02$, respectively). There was a significant negative correlation between mean and peak CD3+ densities and the percentage bradygastria ($r = -0.479$, $P = 0.02$, and $r = -0.509$, $P < 0.02$, respectively). All other EGG parameters were not significantly correlated with CD3+ cell densities. CD3+ cell density did not differ between patients with normal versus delayed emptying at 1 or 2 hr. CD3+ mean and peak densities were significantly increased in patients with a normal percentage slow waves in the preprandial state (27.4 vs. 15.5, $P = 0.009$, and 35.4 vs. 19.4, $P = 0.003$, respectively) but not in the postprandial state. Mean and peak mast cell densities did not correlate with gastric emptying or EGG parameters nor did they differ significantly between patients with normal versus delayed emptying or normal versus abnormal EGG studies, respectively.

Overall, delayed gastric emptying or an abnormal EGG was found in 77% (17/22) of the patients. An abnormal EGG was seen in 55% of patients with normal 1-hr gastric emptying vs. 73% of patients with delayed 1-hr gastric emptying ($P > 0.05$). Electrogastrographic findings in patients with normal vs. delayed gastric emptying are shown in Table 2. Delayed 1-hr gastric emptying was seen in 38% of patients with a normal EGG vs. 57% of patients with an abnormal EGG ($P > 0.05$). Predictability did not improve when only patients with normal biopsies were considered. Gastric emptying did not differ between patients with positive vs. negative δ power or between patients with a normal vs. an abnormal percentage of time with a 2- to 4-cpm frequency for either the preprandial or the postprandial period, respectively. There was a significant decrease in the percentage bradygastria in both normal and delayed emptiers noted in the postprandial period ($P < 0.002$) but this decrease did not differ between the two groups. Gastric emptying at 1 hr was significantly correlated with percentage bradygastria in the preprandial period ($r = 0.452$, $P = 0.035$) and a tendency toward a negative correlation with the percentage normal 2- to 4-cpm in the preprandial period ($r = -0.420$, $P = 0.051$).

There were no significant differences in symptom frequency or symptom severity in patients with normal vs. delayed emptying or between patients with normal vs. abnormal EGGs. There was a trend toward increased pain severity in patients with delayed 1-hr gastric emptying ($P = 0.065$).

TABLE 2. ELECTROGASTROGRAPHIC FINDINGS IN PATIENTS WITH NORMAL 1-HR GASTRIC EMPTYING VS. THOSE WITH DELAYED 1-HR GASTRIC EMPTYING (MEAN ± SD)

	Normal emptying (n = *11*)	*Delayed emptying* (n = *11*)
% Normal 2- to 4-cpm waves		
Preprandial	70.0 ± 20.1	69.4 ± 14.8
Postprandial	79.0 ± 9.8	76.5 ± 16.4
% bradygastria		
Preprandial	26.8 ± 21.5	27.5 ± 15.6
Postprandial	17.0 ± 8.7	15.9 ± 13.0
% tachygastria		
Preprandial	3.2 ± 7.3	3.1 ± 5.1
Postprandial	4.0 ± 4.9	7.5 ± 15.0
δ power	2.2 ± 3.9	2.9 ± 4.2

*$P > 0.10$ for all parameters.

DISCUSSION

Gastric motor and/or myoelectrical abnormalities appear to be common in pediatric patients with functional dyspepsia, with one or the other being abnormal in 77% of patients in this study. A delay in gastric emptying was seen in 50% of these patients at 1 hr postprandial. Pediatric patients with functional dyspepsia have previously been shown to have delayed emptying by ultrasound, with delayed emptying occurring in 68% of patients (19, 21). These are similar to the 60% prevalence of delayed solid emptying reported in adults with functional dyspepsia (16). In the current study, there was no advantage to extending the gastric emptying study from 1 to 2-hr in duration. Gastric emptying at 2 hr was highly correlated with 1-hr emptying, and there were no patients with delayed emptying at 2 hr that were not also delayed at 1 hr. Three patients delayed at 1 hr had a normal emptying rate at 2 hr. The ability of the 1-hr emptying to predict 2-hr emptying has previously been shown to be suspect in pediatric liquid emptying studies (26). In adults, 4-hr emptying studies have been found to be superior to 2-hr studies with a standardized meal utilizing egg substitute, superior to a liquid meal (27, 28). Four-hour studies have not been evaluated in pediatric functional dyspepsia. Patient compliance with a more prolonged evaluation may be a concern in this age group.

An abnormal EGG was seen in 64% of the patients in this study. There was an abnormally low percentage of normal 2- to 4-cpm slow waves in 55% of patients in the preprandial period and in 32% of patients in the postprandial period and the δ power was negative in 23% of the patients. EGG abnormalities have previously been reported in 52% of pediatric patients with functional dyspepsia (23). Pediatric functional dyspepsia has previously been associated with a decrease in the percentage normal 2–4 cpm in both the fasting and the fed states (19, 22), an increase in tachygastria in both the fasting and the fed states (21, 23), and a decrease in the postprandial/preprandial power ratio (21) compared to controls. In contrast, the

primary dysrhythmia in the current study was bradygastria, which was more prevalent in the preprandial period. An abnormally decreased percentage normal 2–4 cpm has been reported in 36–66% of adults with functional dyspepsia (16–17).

Animal studies have clearly implicated low-grade inflammation as an etiology for altered motility and/or afferent nerve function of the gut in irritable bowel syndrome (IBS) (29). Increased CD3+ cells in the lamina propria have been reported in both IBS patients with nonspecific microscopic inflammation and those with normal histology (30). Additionally, persistence of chronic inflammatory cells is associated with the development of postinfectious IBS (31). There is a paucity of similar studies of chronic inflammation for dyspepsia. The effects of other forms of inflammation (including *H. pylori*-associated gastritis, celiac disease, and allergic enteropathy) on gastric electrical and mechanical function have been studied. Lin *et al.*, reported *H. pylori* colonization to be associated with an abnormal EGG, which normalized in 83% of patients following *H. pylori* eradication (32). It also appears that *H. pylori* affects accommodation but not gastric emptying (33–35). Celiac disease has been associated with delayed gastric emptying of solids which normalized on a gluten-free diet (36). Abnormalities in gastric emptying and electrogastrography have been reported with allergic gastrointestinal inflammation (37, 38). The gastric dysmotility associated with gastrointestinal allergy has been shown to be eosinophil dependent in a mouse model (39). These forms of inflammation differ from chronic gastritis in that they all have mixed inflammatory cell infiltrates.

It is a usual practice to obtain mucosal biopsies (regardless of gross appearance) during endoscopy evaluation of abdominal complaints in children, as histologic correlation with gross appearance is poor (40). Histologic gastritis appears to be a common finding in children with gastrointestinal complaints (41, 42). However, the significance of chronic, nonspecific gastritis is not known. There are few data on the presence of gastritis in asymptomatic children. What data are available would suggest that, in contrast to adults, gastritis is not common in asymptomatic children (7, 43). Chronic gastritis would have the potential to result in dyspeptic symptoms by a variety of mechanisms, including disturbances of electrical rhythm, delayed emptying, impaired accommodation, and hypersensitivity to distension. In the current study, we evaluated relationships between chronic inflammation and EGG and solid emptying.

Fink *et al.* found a correlation between slowing of gastric emptying and increased severity of gastritis in adults with gastroesophageal reflux (44). In the current study, we found no association between the presence of gastritis and the gastric emptying rate. Likewise, we found no relationship between emptying and mucosal CD3+ or mast cell densities. Mast cells were evaluated as a potential cofounder, as they would not be apparent on routine biopsies, are increased in patients with IBS, and have been associated with gastric hypersensitivity (45–47). All patients in this study would have correlated with lower gastritis severity in the adult study, i.e., chronic gastritis. Chronic gastritis in children does not predict the presence of abnormally delayed gastric emptying.

There was a trend toward gastritis being associated with a lesser power increase from the preprandial to the postprandial state ($P = 0.09$) Gastritis, however, was not associated with dysrhythmia. Mucosal CD3+ cell density was significantly correlated with the percentage normal slow waves and negatively correlated with the percentage bradygastria. Likewise, CD3+ mean and peak densities were significantly greater in patients with normal gastric rhythms. The significant decrease in the percentage bradygastria from the preprandial to the postprandial period in this patient group was nearly entirely the result of a decrease in patients with normal biopsies. The mean percentage bradygastria decreased from 18.9 to 18.6% in patients with gastritis and from 31.9 to 15.2% in patients with normal biopsies. There appear to be differences in EGG recordings from patients with normal gastric mucosal as opposed to patients with gastritis in both the preprandial period and with regard to changes that occur with feeding. The association of gastritis with normal EGG may simply be an indication that chronic nonspecific gastritis and dysrhythmia are two separate and distinct mechanisms resulting in the clinical entity of dyspepsia.

There are few previous studies which have evaluated EGG recordings simultaneously with gastric emptying studies in pediatric patients. Barbar *et al.* reported EGG findings in four patients with normal scintiscans versus five patients with delayed emptying and found no significant differences in the median power ratio or in the median difference in slow wave percentages in the fasting and postprandial periods (20). Riezzo *et al.* evaluated EGG with gastric emptying measured by ultrasound and found no correlation between the power ratio and the $t_{1/2}$ for gastric emptying (21). Lin *et al.* evaluated EGG with solid gastric emptying in adults with functional dyspepsia and found that 80% of patients with an abnormal EGG had delayed gastric emptying (16). In the current study, 57% of pediatric patients with an abnormal EGG had delayed gastric emptying, however, this was not statistically different from patients with a normal EGG. Chen *et al.* evaluated adults with symptoms of gastroparesis and found that delayed gastric emptying was significantly associated with a decrease in the percentage normal 2- to 4-cpm slow

waves and a significantly lower increase in the dominant power in the postprandial EGG (δP) (18). An abnormally low percentage normal 2–4 cpm predicted delayed emptying with 78% accuracy and the power change predicted delayed emptying with 75% accuracy. All patients abnormal for both parameters had delayed emptying. This contrasts with the findings in the current pediatric study. We found no significant differences in the means for EGG parameters between patients with normal compared to delayed emptying. Surprisingly, the gastric emptying rate was positively correlated with the preprandial percentage bradygastria, with a trend toward a significant negative correlation with the percentage normal 2- to 4-cpm slow waves in the preprandial period. Overall, we found the EGG to predict gastric emptying (normal vs. abnormal) with an accuracy of 59%. There was one patient with normal emptying despite a decreased percentage normal 2- to 4-cpm slow waves and a postprandial decrease in dominant power. In contrast to adults, it appears that in pediatric patients with functional dyspepsia, EGG findings cannot predict gastric emptying. Also, correlations with percentage slow wave parameters for bradygastria and normal 2- to 4-cpm waves trend in opposite directions in pediatric dyspepsia compared to adult dyspepsia.

Previous pediatric studies evaluating EGG findings in relationship to symptoms have revealed conflicting results. Chen *et al.* found an inverse correlation between the postprandial increase in dominant power and the symptoms score, while Riezzo *et al.* found no correlation between the power ratio and symptom scores (21, 22). We found no significant correlations between EGG parameters and symptoms in the current study. In adults, studies evaluating the relationship between symptoms and gastric emptying have revealed conflicting results. Talley *et al.* found no significant relationship between gastric emptying (as measured by ^{13}C octanoic acid breath test) and symptom frequency or severity (48). Stanghellini *et al.* evaluated gastric emptying (by radioisotope method) in adults with functional dyspepsia and found delayed emptying in 33.5% (49). Delayed emptying was particularly associated with the presence of postprandial fullness, nausea, and vomiting and the absence of severe epigastric pain. In contrast, we found no difference in symptom frequency or severity between pediatric patients with normal emptying compared to delayed emptiers, however, the trend was toward increased pain severity in patients with delayed emptying. This would suggest that delayed emptying may contribute to patient's symptomatology.

In conclusion, gastric myoelectric and emptying abnormalities are common in children with functional dyspepsia. Although EGG recordings appear to differ in some ways between patients with and those without gastritis, chronic gastritis is not associated with abnormalities of gastric electrical rhythm or solid emptying. Relationships between chronic gastritis and accommodation or sensitivity to distension remain to be elucidated. Lastly, relationships among EGG recordings, gastric emptying, and symptoms in children appear to differ from previous reports in adults and this needs to be considered when attempting to extrapolate the published adult experience to children.

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