Digestive Diseases and Sciences, Vol. 44, No. 7 (July 1999), pp. 1293–1297

Electrogastrography in Gastrostomy-Tube-Fed Children

JANICE B. HEIKENEN, MD, STEVEN L. WERLIN, MD, and CHRISTOPHER W. BROWN, MD

Following gastrostomy tube placement some children develop gagging, retching, vomiting, pain, or irritability during feedings. Conventional medical management is not always successful. It is possible that intolerance of gastrostomy tube feedings reflects an underlying motility disorder of the foregut. The study aim was to determine whether children with gastrostomy tube feeding difficulties demonstrate abnormal gastric electrical control activity as measured by electrogastrography. Cutaneous electrogastrography of interpretable quality was performed in 25 feeding-tolerant and 23 feeding-intolerant children less than 10 years of age. Dominant frequencies, rhythm indices, and postprandial power measurements were recorded during the fasting and postprandial periods. Differences between groups were compared using the Student's *t* test. The groups were similar in method of gastrostomy tube placement, antireflux surgery, neurological impairment, duration of gastrostomy feeding dependence, formula type, volume, and administration. The feeding-tolerant group was significantly older ($P < 0.01$). There were no significant differences between groups in the mean dominant frequencies or rhythm indices. The feeding-intolerant children had a mean postprandial power change that was significantly lower than that of the feeding tolerant group ($P < 0.003$), although overlap was present. Children who are intolerant of gastrostomy tube feeding have an abnormal postprandial power decrease. EGG dominant frequency and rhythm indices are not predictive of gastrostomy feeding tolerance in predominantly neurologically impaired children.

KEY WORDS: electrogastrography; gastrostomy; children; enteral nutrition.

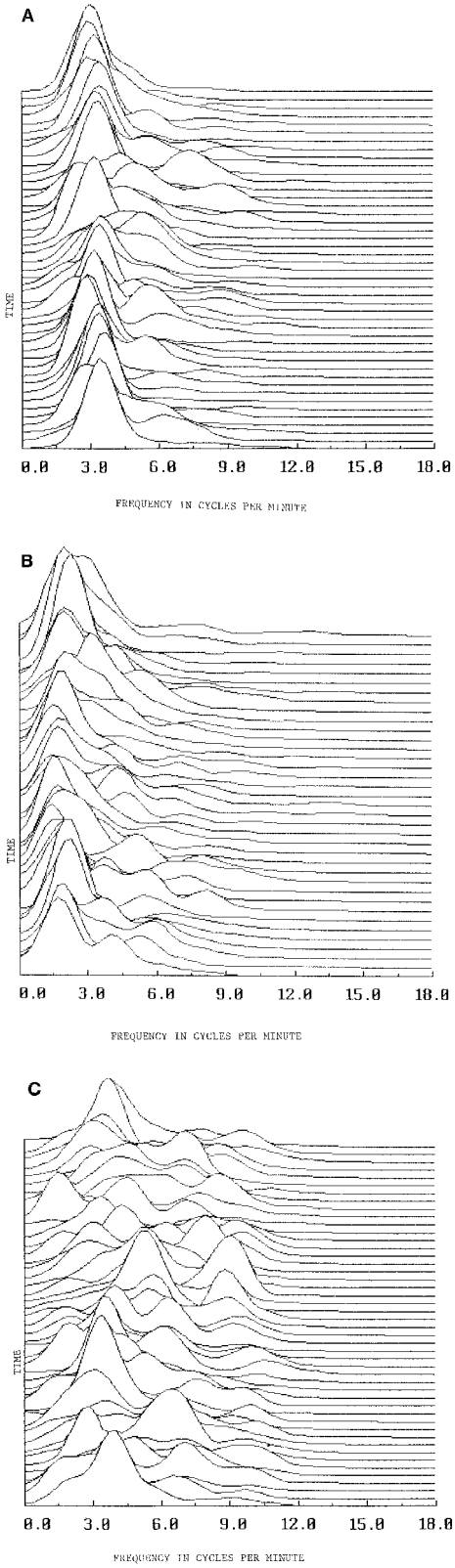
Feeding disorders necessitating long-term supplemental enteral nutrition may require gastrostomy tube feedings (1). Following gastrostomy tube placement some children develop gagging, retching, persistent vomiting, pain or irritability during feedings (2). Although antireflux procedures performed at the time of surgical gastrostomy tube placement have been implicated in subsequent feeding difficulties, not all children who have undergone antireflux procedures have feeding intolerance, just as some children who have feeding difficulties have not had antireflux surgery. It is not known why some children are tolerant and others intolerant of gastrostomy tube feedings. Conventional medical management consisting of changes in formula or its administration, prokinetic agents, and H_2 receptor antagonists often fails (3). Currently available methods for evaluation of feeding intolerance including upper gastrointestinal series and gastric emptying scans, clarify anatomy and function but do not always correlate with symptoms and involve radiation exposure. Antroduodenal manometry evaluates enteric neuromuscular function but is invasive, requires specialized equipment, and is expensive.

Electrogastrography (EGG) is an effective and noninvasive method for measuring gastric myoelectri-

Manuscript received August 31, 1998; accepted February 20, 1999.

From the Division of Gastroenterology, Department of Pediatrics, The Medical College of Wisconsin, Milwaukee, Wisconsin.

Address for reprint requests: Dr. Steven L. Werlin, Department of Pediatrics, The Medical College of WI, 8701 Watertown Plank Road, Milwaukee, Wisconsin 53226.



cal activity (4, 5). Studies have shown that the gastric electrical activity recorded from surface electrodes accurately reflects the electrical control activity as measured by mucosal and serosal electrodes in humans (4, 6). Cutaneous electrodes are placed on the abdomen over the gastric antrum, and an electrical tracing is recorded. The myoelectric activity of the stomach normally generates a slow wave that modulates gastric motor activity at approximately 3 cycles per minute (7). Variation in the frequency of the slow wave from its normal rate between 2.5 and 3.5 cpm results in rhythmic variations referred to as bradygastria, tachygastria, or mixed dysrhythmia (Figure 1). These gastric electrical dysrhythmias are associated with intestinal dysmotility and symptoms of nausea, vomiting, abdominal pain, and bloating (5, 8, 9). Since intolerance of gastrostomy tube feedings may reflect an underlying gastric motility disorder, we investigated whether abnormal gastric myoelectrical activity as measured by EGG is present in children who are gastrostomy tube feeding intolerant.

MATERIALS AND METHODS

Patients. Forty-eight gastrostomy tube feeding-dependent children less than 10 years of age, recruited from the Comprehensive Gastrostomy Tube Feeding Clinic at The Children's Hospital of Wisconsin, were categorized as feeding tolerant or intolerant based on their current feeding history. Feeding intolerance was defined as gagging, retching, vomiting, or postprandial discomfort requiring prokinetic medication and/or dietary manipulation requiring longer than 1 hr for administration of a gastrostomy tube feeding. Feeding-tolerant children tolerated gastrostomy tube bolus feedings in less than 30 min without symptoms or prokinetic agents.

Electrogastrography. Gastric myoelectrical activity was measured using surface electrogastrography (RedTech GIPC, Calabasas, California). All subjects were fasted at least 3 hr prior to the study and prokinetic agents withheld 48 hr prior to EGG. Three silver–silver chloride electrodes (Blue Sensor, Medicotest) were applied over the epigastrium after cleansing with 70% isopropyl alcohol. Following a 30-min baseline recording, the child's regularly scheduled gastrostomy tube feeding was administered to induce postprandial activity. A 30-min postprandial recording was obtained, during which the child remained in the same posture as during the baseline recording. The electrical signal was amplified, digitized, and stored on the hard drive of a lap-top computer for later off-line analysis.

Data Analysis. The EGG signal was band pass filtered (low of 1 cpm, high of 9 cpm) and visually edited for motion

Fig 1. Running spectral frequency plots of electrogastrograms recorded in gastrostomy tube fed children showing A: normal gastric electrical control activity at 3.5 Hz, B: bradygastria at 2.3 Hz, C: mixed dysrhythmia.

Table 1. Patient Results

	Patient				Gastrostomy tube		
Group	N	Gender	Age (yr)	CNS disease	Surgical	PEG	Nissen
Feeding tolerant	25	16M	3.7 ± 1.8*	18	12	13	12
Feeding intolerant	23	11M	2.2 ± 1.3*	18	11	12	10

* Statistically significant, $P < 0.01$.

artifacts. Study patients with uninterpretable EGGs were excluded from analysis. The dominant frequency in cycles per minute, rhythm index, and power in decibels were obtained for the fasting and postprandial periods. Normogastria was defined as 2.5–3.5 cpm, bradygastria less than 2.5 cpm, and tachygastria greater than 3.5 cpm. The rhythm index is the percentage of time during which these three gastric rhythms are observed during the EGG. The relative value difference between fasting and postprandial dominant power is referred to as the power change. Demographic information was tabulated for each child and included age, gender, diagnosis, method of gastrostomy tube placement, duration of gastrostomy tube feeding dependence, antireflux procedures, medications, symptoms of feeding difficulties, and information related to enteral formulation and administration. The Student's t test was used to compare differences between the feeding-tolerant and -intolerant groups. Statistical significance was assigned for $P < 0.05$.

Ethical Considerations. Project approval was granted by the Human Research Review Committee of The Medical College of Wisconsin and the Research and Publications Committee/Human Rights Review Board of Children's Hospital of Wisconsin. Informed consent was obtained from the parents or guardians of all study participants.

RESULTS

Electrogastrograms were performed in 25 gastrostomy tube feeding-tolerant and 23 feeding-intolerant children. Three children had EGGs that were uninterpretable due to excessive motion artifact or poor signal quality and were excluded from study results. Demographic information is summarized in Table 1. The groups were similar in methods of gastrostomy tube placement and numbers of patients having undergone antireflux surgery. Two children in each group had surgical gastrostomy tube placement without an antireflux procedure. One child in the feeding intolerant group and two in the feeding tolerant group had subsequent antireflux surgery following PEG placement. The age range was 0.4–9 years in the feeding-tolerant group and 0.7–5 years in the feeding-intolerant group. The children in the feeding-tolerant group were significantly older ($P < 0.01$), although the duration of gastrostomy tube dependence was similar. The majority of children in both groups were globally neurologically impaired with only a slightly higher percentage in the feeding intolerant group (78%) than the feeding tolerant group (72%).

All children received more than 50% of their caloric requirements from gastrostomy tube feedings. Except for four children in the feeding-tolerant group who received some oral feedings, the remainder of the study children were exclusively gastrostomy tube fed. Of the feeding-tolerant children, 84% were exclusively fed by bolus technique, compared with 39% of the feeding intolerant children. The remainder utilized either a continuous drip or combination of bolus and drip feeding methods. Information related to gastrostomy tube feedings is summarized in Table 2. The groups were similar in formula type, volume, and administration time (NS).

The distribution of EGG results is summarized in Table 3. There was no statistically significant difference in the mean dominant frequency between the groups. During the fasting period, 53.7% of the feeding tolerant and 55.4% of the feeding intolerant patients demonstrated dysrhythmia (NS). During the postprandial period, 52.9% of the feeding tolerant

Table 2. Gastrostomy Tube Feedings

	Formula type				
Group	Cow's milk protein	Soy protein	Elemental	Volume given (oz)	Feeding duration (hr)
Feeding tolerant	24	1	0	6.5	0.4
Feeding intolerant	19	3	1	5.1	0.6

TABLE 3. EGG RESULTS*

Group	Dominant frequency (cpm)		Rhythm indices (%)						Power change (dB)
			Bradygastria		Normogastria		Tachygastria		
	NPO	PP	NPO	PP	NPO	PP	NPO	PP	
Feeding tolerant	3.5	3.7	12.4	10.5	45.9	46.7	41.3	42.4	+0.97†
Feeding intolerant	3.7	3.7	13.1	13.0	44.5	43.0	42.3	44.1	−0.38†

* NPO = fasted; PP = postprandial.
† Statistically significant, $P < 0.003$.

and 57.4% of the feeding intolerant patients demonstrated dysrhythmia (NS). The prevalence of dysrhythmia was not different in the children who had received a Nissen fundoplication and those who had not. The mean postprandial change in power in the feeding tolerant and intolerant children was 0.97 and −0.38, respectively ($P < 0.003$). However, there was overlap between the groups, as demonstrated in Figure 2.

DISCUSSION

The mean dominant frequencies and rhythm indices did not significantly differ between groups and did not differentiate children with feeding intolerance. Normogastria is present more than 70% of the time in normal children 2 months of age or older (10). We found that both feeding-tolerant and -intolerant children had far less normogastria at 46% and 44%, respectively. As this was observed in both groups, it is possible that the lower than normal percentage of normogastria reflects either a change in antral propagation of slow waves due to disruption of the gastric pacemaker by gastrostomy tube placement, or the underlying pathology that required gastrostomy tube placement. The association between children with central nervous system disorders and foregut dysmotility has been reported (9). It is understandable that the enteric nervous system could be abnormally modulated by the central nervous system or, likewise involved by the same process, with resultant disordered motility. Both groups of children had a higher percentage of neurological impairment, which might contribute to the abnormally low percentage of normogastria observed. This abnormal finding does not explain gastrostomy tube feeding intolerance, as both groups were similarly abnormal with no statistically significant difference between them.

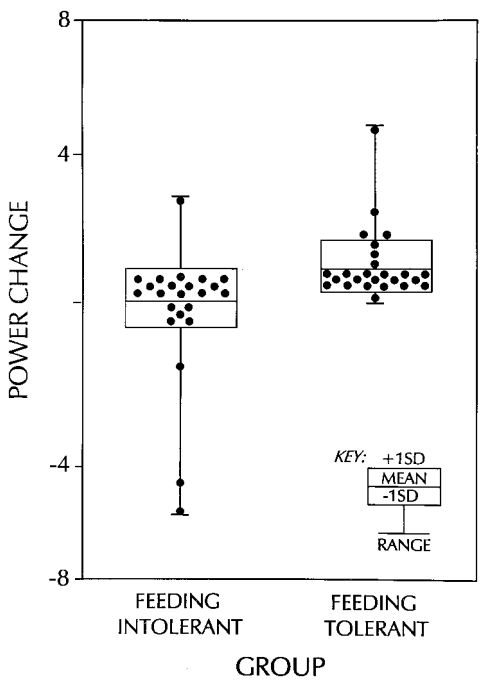


Fig 2. Scatterplot of postprandial power change by group.

Although the length of time since gastrostomy tube placement was similar in the two groups, the tube-feeding-tolerant children were significantly older. Following birth, the percentage of normal gastric slow waves increases from 26.6% in premature infants to 88.9% in adults (9). The developmental maturation of myoelectrical activity based on chronological age might result in the absence of feeding difficulties observed in the feeding-tolerant children. The maturational development of EGG dominant power is not known, and the effect of age discrepancy between groups in this respect is difficult to assess.

The feeding intolerant children demonstrated a clearly abnormal postprandial power response. The absolute power value is related to factors such as abdominal wall thickness and electrode position. Due to these variables, the absolute power value cannot be used comparatively. However, the relative change in power is of great clinical significance and is useful for

comparison purposes (11). EGG dominant power reflects dominant amplitude, and the postprandial increase in power is attributed to the strength of gastric contractions or gastric displacement due to distension and normally increases following a meal. Feeding volume and administration times that could affect power changes differed due to age and individual needs but were not statistically significant. A decrease of postprandial EGG power is always abnormal and attributable to a decrease in the amplitude or frequency of the gastric slow wave (10). Decreased power is frequently present in patients with gastroparesis. A persistent decrease in power after a meal has never been reported in normal subjects (10). Thus, the abnormal postprandial power response demonstrated in the gastrostomy tube feeding-intolerant group reflects an underlying gastric motility disorder. Due to the overlap in the power change between patients in both groups, it was not able to differentiate between feeding tolerant and intolerance.

We conclude that children who are intolerant of gastrostomy tube feedings have an abnormal postprandial power response that contributes to feeding intolerance. EGG rhythm indices are abnormal but do not differentiate between feeding tolerance and intolerance in a largely neurologically impaired pediatric population who are fed via gastrostomy tube.

REFERENCES

1. Marin OE, Glassman MS, Schoen BT, Caplan DB: Safety and efficacy of percutaneous endoscopic gastrostomy in children. Am J Gastroenterol 89:357–361, 1994
2. Caulfield M: Percutaneous endoscopic gastrostomy placement in children. Gastrointest Endosc Clin North Am 4:79–193, 1994
3. Launay V, Gottrand F, Turck D, Michaud L, Ategbo S, Farriaux JP: Percutaneous endoscopic gastrostomy in children: Influence on gastroesophageal reflux. Pediatrics 97:726–728, 1996
4. Mintchev MP, Kingma JY, Bowes KL: Accuracy of cutaneous recordings of gastric electrical activity. Gastroenterology 104:1273–1280, 1993
5. Cucchiara S: Electrogastrography. *In* Pediatric Gastrointestinal Motility Disorders. P Hyman, C Di Lorenzo (eds). New York, Academy Professional Information Services, 1994, pp 305–312
6. Milla PJ: Electrogastrography in childhood. *In* JZ, Chen, RW McCallum (eds). Electrogastrography Principles and Applications. New York, Raven Press, 1994, pp 379–395
7. Chen JDZ, McCallum RW: Clinical applications of electrogastrography. Am J Gastroenterol 88:1324–1336, 1993
8. Chen JDZ, Lin A, Pan J, McCallum RW: Abnormal gastric myoelectrical activity and delayed gastric emptying in patients with symptoms suggestive of gastroparesis. Dig Dis Sci 41:1538–1545, 1996
9. Ravelli AM, Milla PJ: Vomiting and gastroesophageal motor activity in children with disorders of the central nervous system. J Pediatr Gastroenterol Nutr 26:56–63, 1998
10. Chen JDZ, Co E, Liang J, Pan J, Sutphen J, Torres-Pinedo RB, Orr WC: Patterns of gastric myoelectrical activity in human subjects of different ages. Am J Physiol 272:1022–1027, 1997
11. Chen JZ, McCallum RW: Electrogastrographic parameters and their clinical significance. *In* Electrogastrography Principles and Applications. JZ Chen, RW McCallum (eds). New York, Raven Press, 1994, pp 45–73