Analysis of Gastrointestinal Sounds in Infants With Pyloric Stenosis Before and After Pyloromyotomy

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ABSTRACT. *Background.* **Although recent advances in computer technology enable us to analyze gastrointestinal sounds data objectively with ease, this clinical application has been investigated in only a few disorders. To investigate one potential role of this approach in pediatric practice, we recorded and analyzed gastrointestinal sounds in infants with hypertrophic pyloric stenosis (HPS), a motility-related disorder that is common in children.**

Methods. **In 15 infants with pyloric stenosis, gastrointestinal sounds were collected with a microphone placed 3 cm below the umbilicus for 60 minutes before pyloromyotomy and at 9 to 12 hours, 20 to 24 hours, 40 to 48 hours, and 112 to 120 hours after the operation. Data were entered into a computer to sum the amplitude of sound signals as a sound index (SI; mV per minute). In 12 infants, gastric emptying was measured immediately before each sound recording, using a marker dilution-double sampling method.**

Results. **Before surgery, the mean SI was 4.6 ± 1.0 mV per minute, significantly less than in healthy controls (31.7 ± 8.4 mV per minute). The SI remained in a similar range until 12 hours after operation, after which it began increasing to reach the normal range by 48 hours after operation (30.0 ± 9.4 mV per minute). Gastric emptying, also low in HPS before pyloromyotomy, increased by 4 to 5 times after surgery. There was a significant positive correlation between SI and gastric emptying. The incidence of postoperative symptoms (such as vomiting) were correlated significantly with SI at 24 hours after surgery.**

Conclusion. **This study found decreased gastrointestinal sounds to be among physical findings suggestive of HPS and a useful indicator of gastric emptying and bowel motility after pyloromyotomy. Computer-assisted analysis of gastrointestinal sounds might be helpful in clinical practice for pediatric patients with some gastrointestinal disorders.** *Pediatrics* **1999;104(5). URL: http://www.pediatrics.org/cgi/content/full/104/5/e60;** ***gastrointestinal sounds, infants, pyloric stenosis, pyloromyotomy.***

ABBREVIATIONS. HPS, hypertrophic pyloric stenosis; SI, sound index.

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Gastrointestinal sounds (bowel sounds) are a physical finding that can be monitored painlessly and easily. Previous studies have found bowel sounds to be decreased or increased in patients with such disorders as appendicitis, mechanical obstruction, and paralytic ileus.[1–3] Drugs, such as carbachol[4] and atropine,[5] can affect gastrointestinal sounds in healthy subjects.

Synchronous monitoring of bowel sounds and gastrointestinal motility has shown the intensity of bowel sounds to be related closely to the gastric phase of migrating motor complex but not to the duodenal phase.[6,7] Erythromycin, which induces strong contractions in the stomach, increase bowel sounds; in contrast, somatostatin induces clusters of contractions in the duodenum but suppress gastric motility, and bowel sounds are decreased.[7] These observations suggest that bowel sounds might be affected greatly by gastric motility. Although the mechanism by which gastric motility increases bowel sounds is not known, the amount of gas emptied from the stomach into the duodenum likely may be a major determinant of bowel sounds.[6,7]

Infantile hypertrophic pyloric stenosis (HPS) is a relatively common disease that primarily affects young infants. In this disorder, pyloric muscle hypertrophy causes functional obstruction of the pyloric canal. Consequently, gastric emptying of milk is disturbed severely, although the antral contractions are increased as to be visible through the abdominal wall.[8] The emptying of gas, as well as milk, is assumed to be delayed in patients with HPS. Therefore, if our above hypothesis is true, bowel sounds in patients with pyloric stenosis would decrease. Furthermore, the decrease in bowel sounds, reflecting stenosis of pylorus, could be useful for diagnosis and evaluation of severity of the illness as one physical finding that has not been paid much attention.

In the present study, we quantified bowel sounds in infants with HPS using computer-assisted analysis and correlated the data with gastric emptying before and after pyloromyotomy.

METHODS

Subjects

A total of 15 infants with pyloric stenosis (12 male and 3 female) were studied. Mean age at pyloromyotomy was 44.4 ± 17.6 days (mean ± standard deviation). The patients were born after 38.6 ± 1.2 weeks of gestation and weighed 3125 ± 128 g at birth. They started having episodes of vomiting 27.2 ± 3.7 days after birth, and their mean body weight on admission was 3737 ± 181 g.

Before pyloromyotomy, their serum sodium, potassium, and chloride concentrations were 136.1 ± 0.5 mEq/L (mean ± standard error), 4.1 ± 0.2 mEq/L, and 97.1 ± 1.9 mEq/L, respectively. In 3 subjects, the serum chloride level was <96 mEq/L. The blood pH level was 7.54 ± 0.02 and was >7.45 in 11 subjects. Base excess was 2.82 ± 1.39. Total protein concentration in serum was 5.8 ± 0.1 g/dL, and was >5.1 g/dL in all subjects.

In all subjects, Ramstedt's pyloromyotomy was performed. In brief, the abdomen was opened through a transverse skin incision high over the liver. After thickened pylorus was delivered into the wound, an incision was made through the serosa and partially through the circular muscle. The circular muscle then was spread with a pylorus spreader on the submucosal base.

Six healthy infants (38.8 ± 15.6 days of age) were used as controls.

Methods

Recording of Bowel Sounds

Bowel sounds were recorded and analyzed by a previously reported method.[6,7] A condenser microphone sound sensor (handmade and provided by Nihon Kohden, Co, Maebashi, Japan) was attached with electrocardiograph adhesive tapes (Adhesive collar 20; Nihon Kohden) to the abdominal surface, 3 cm below the umbilicus. Signals were amplified and transferred to an audio cassette deck (T-03SR; Pioneer, Tokyo; frequency range: 20–18 kHz) over 60 minutes when fasted and were stored for later analysis. These analog signals were processed by a personal computer (Power Mac 520; Apple Japan, Tokyo; RAM: 12 MB) after AD conversion (MacLab/2e; Bioresearch Center, Nagoya, Japan) at a sampling frequency of 1000 Hz. An 80-Hz analog high pass filter was used to suppress 20 to 50 Hz signals of cardiovascular origin. To reduce further the unavoidable noise, we used a triggering function (with persistence of signals acquisition for 20 milliseconds after the last signal >100 mV). During data acquisition, sounds were monitored continuously through an audio headphone (Model HP-50S; Yamaha, Tokyo), confirming computer signals representing bowel sounds. Figure 1 illustrates the signal morphology recorded by this system (Fig 1). Three-minute bins were used to calculate the sound index (SI), as the sum of absolute signal amplitudes expressed as volts per minute. Only data obtained while subjects were sleeping quietly were used. When the valid recording time was <20 minutes in any recording session, the data were excluded.

Measurement of Gastric Emptying

In 12 of 15 infants, gastric emptying was measured using a marker dilution double-sampling method, reported previously by George and Siegel et al.,[9,10] with a slight modification. In brief, after washing out the stomach twice with 20 mL of distilled water through a nasogastric tube, gastric contents were aspirated as completely as possible. Thirty minutes later, 0.24 mg/L of phenol red (7 mL/kg) was given via the tube over 1 minute. The gastric content was mixed by withdrawing and reinserting with a syringe. Then, the subject was placed in the prone position, and samples were taken 30 minutes and 60 minutes after a test meal; at these times, 2.0-mL samples were removed before and after administration of 4.0 mL of 2.4 mg/L phenol red. The concentration of phenol red in each sample was measured by spectrophotometry at a wavelength of 550 μm. The volume of test solution and gastric secretion, emptied through the pylorus within 30 and 60 minutes of the intragastric instillation of phenol red was calculated using equations described previously by Siegel et al.[10]

Postoperative Symptom Index

The postoperative symptom index was defined based on the symptom from 24 hours to 120 hours after surgery as follows: grade 0, never vomited or had no gastric retention; grade 1, vomited an average of <0.5 times per day; grade 2, vomited 0.5 to 1 time per day or had mild gastric retention that did not cause any delay in the feeding schedule; and grade 3, vomited >1 time per day or had gastric retention causing a delay in the feeding schedule.

Protocol

Gastrointestinal sounds were recorded for 60 minutes at least 3 hours after the previous meal on the day before pyloromyotoy and at 9 to 12, 20 to 24, 40 to 48, and 108 to 120 hours after pyloromyotomy. Immediately before sound recording, gastric emptying was measured in each subject except at 108 to 120 hours after operation. Feeding of milk was started 24 hours after pyloromyotomy in all patients.

Data Analysis

Data are expressed as the mean ± standard error, unless otherwise mentioned. Statistical analysis was performed by analysis of variance using the Stat View program version 4. A P value of <.05 was regarded as significant.

Ethical Considerations

This study was approved by the Human Investigation Committee (Department of Pediatrics) at Gunma University School of Medicine on February 15, 1996. Informed consent was obtained from the parents of each subject.

RESULTS

Before surgery, mean SI was 4.5 ± 1.0 mV per minute, being significantly less than in age-matched healthy controls (31.7 ± 8.4 mV per minute; P = .0013). SI was still low at 12 hours after surgery but increased thereafter (P = .0002; Fig 2). SI entered the normal range by 48 hours after operation. The mean amplitude of sound signals did not change with time, suggesting that the increase in SI should attribute to an increase in number of sound events, not to an increase in amplitude of signals (Fig 3).

Gastric emptying before surgery was 1.8 ± 1.5 mL and 5.4 ± 2.2 mL for 30 minutes and 60 minutes, respectively. Gastric emptying for both 30 minutes and 60 minutes started to increase by 12 hours after surgery (P = .006 and P = .0006, respectively; Fig 4). Gastric emptying for 60 minutes at 24 hours after surgery was 18.7 ± 2.3 mL, which is ~82% of the given volume. As shown in Fig 5, SI and gastric emptying were correlated positively (P = .018).

Postoperative symptom index showed a significant negative correlation with SI at 24 hours after surgery (Fig 6). There was also a trend that patients with greater SI had a lower symptom index at 48 hours after pyloromyotomy, but the difference was

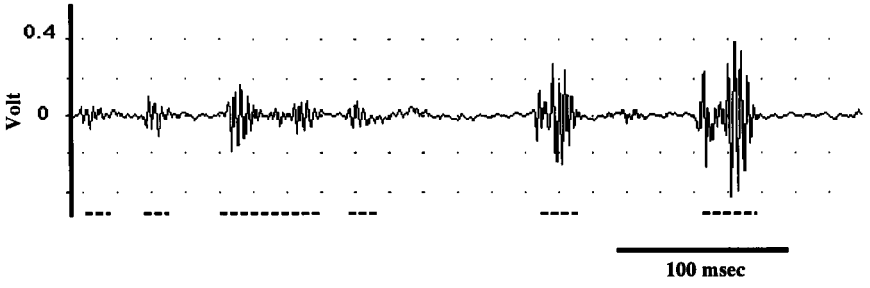

Fig 1. Representative record of gastrointestinal sounds before filtering. Broken underlines indicate gastrointestinal sounds.

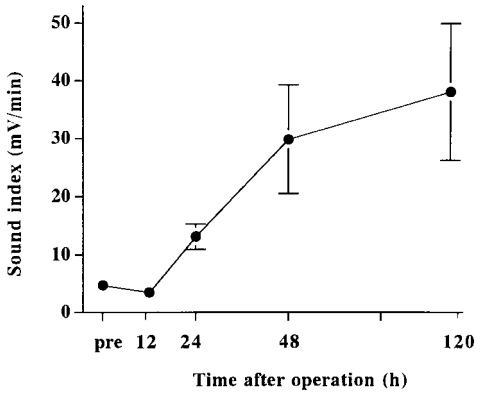

Fig 2. SI and after pyloromyotomy. SI increased after operation (P = .0002).

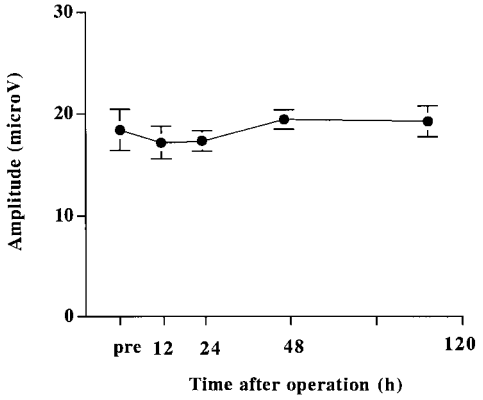

Fig 3. Mean amplitude of sound signals before and after pyloromyotomy. Sound amplitude did not change with time.

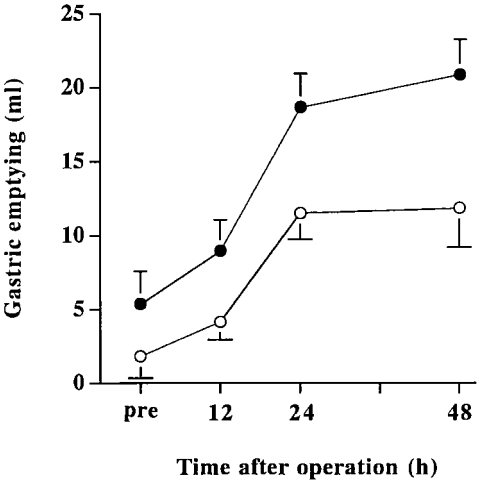

Fig 4. Gastric emptying for 30 minutes (open circles) and for 60 minutes (closed circles) before and after pyloromyotomy. Gastric emptying for both 30 minutes (P = .006) and 60 minutes (P = .0006) increased after operation.

not statistically significant. At no time did gastric emptying for 30 minutes or 60 minutes correlate significantly with the symptom index ($P > .05$).

DISCUSSION

This study showed that the amount of gastrointestinal sound, or SI, was decreased in patients with pyloric stenosis before surgery; the mean SI was

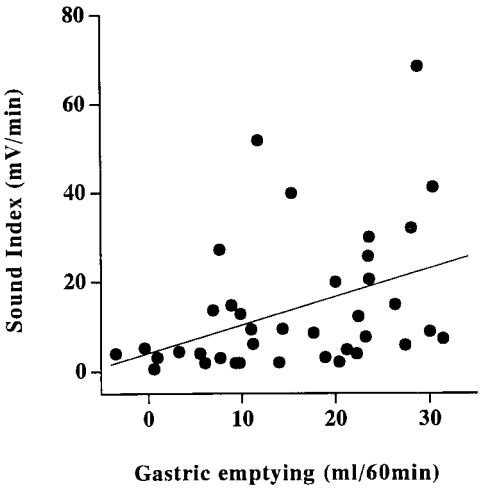

Fig 5. The relationship between SI and gastric emptying (P = .018; R^2 = .149).

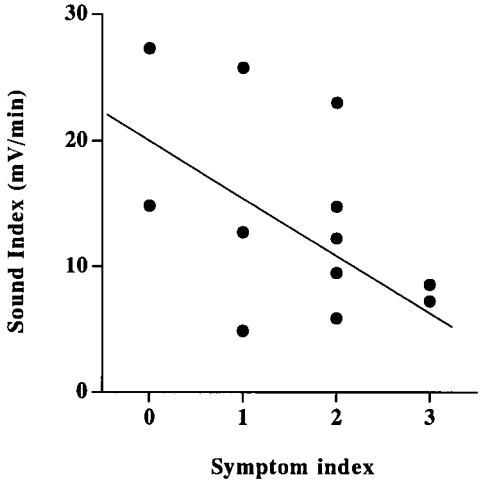

Fig 6. Relationship between SI at 24 hours after surgery and postoperative symptom index (P = .035; R^2 = .373).

approximately six times less than in controls. Gastrointestinal sounds were correlated positively with gastric emptying. These results support the hypothesis that gastrointestinal sounds, which reflect the amount of intraintestinal gas that was emptied from the stomach, are decreased in patients with HPS.

The present results also showed that gastrointestinal sounds increased after pyloromyotomy, correlating with the return of gastric emptying except for the first 24 hours when gastric emptying reached the plateau level, but SI remained at less than half of the subsequent level.

Benson et al[11] have demonstrated by manometry that small intestinal motility was abnormal after major abdominal surgery. Some characteristics of migrating motor complexes remained abnormal for ~48 hours after operation. The median time for the initial occurrence of phase 2 activity after operation was 40 hours. In the same study, gastrointestinal sounds were monitored by stethoscope, and these remained absent for >20 hours in all subjects. Approximately 60 hours were required for bowel sounds to return in 50% of subjects.

Because gastrointestinal sounds may reflect both

the amount of gas emptied from the stomach and small bowel motility, as mentioned above, the discrepancy between gastrointestinal sounds and gastric emptying during the first 24 hours after operation might involve the more gradual normalization of the bowel motility component after surgery. Gastrointestinal sounds, therefore, are a good indicator of the return of gastric emptying as well as bowel motility after pyloromyotomy and can be useful in deciding when to resume feeding postoperatively in each patient. In agreement with this impression, SI at 24 hours after surgery was correlated significantly with the postoperative symptom index.

CONCLUSION

In summary, our study indicates that, although the specificity of this finding is still unknown, gastrointestinal sounds are decreased in infants with HPS before pyloromyotomy and reflect gastric emptying and bowel motility after corrective surgery. Computer-assisted analysis of gastrointestinal sounds deserves additional investigation in other motility disorders in children.

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