Effects of Electroacupuncture on Gastric Migrating Myoelectrical Complex in Dogs

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The aim of this study was to investigate the characteristics of the gastric slow wave during different phases of the migrating myoelectrical complex (MMC) and the effect of electroacupuncture on the MMC. The experiment was performed in eight hound dogs implanted with one pair of bipolar serosal electrodes 2 cm proximal to the pylorus. Gastric myoelectrical activity was recorded for three complete cycles of the MMC in two sessions, one with electroacupuncture at points ST36 and PC6 and the other at sham points. The acupuncture was performed for 30 min in phase I of the second cycle of the MMC. Spectral analysis was performed to compute the frequency and power (amplitude) of the gastric slow wave, whereas blind visual analysis was applied to compute the appearance of spike potentials and the length of each phase of the MMC. It was found that there was a significant difference in the frequency and power of the gastric slow wave during different phases of the MMC ($P < 0.05$). Phase I was characterized with the highest frequency and lowest power of the gastric slow wave, whereas phase III exhibited the highest power in the slow wave. It was also found that in comparison with the sham points, electroacupuncture at the acupoints increased the number of spike bursts. This increase was not significant during the MMC cycle with electroacupuncture ($34.4 \pm 4.1$ vs $27.5 \pm 2.5\%$, $P > 0.05$) but became significant during the cycle after electroacupuncture ($39.8 \pm 3.3\%$ vs $27.5 \pm 2.5\%$, $P < 0.0005$). Similarly, during the MMC cycle after electroacupuncture at the acupoints, there was a significant decrease in the length of phase I ($14.8 \pm 2.2$ vs $46.9 \pm 6.1$ min, $P < 0.003$) and a significant increase in the length of phase II ($75.6 \pm 9.9$ vs $30.6 \pm 4.1$ min, $P < 0.003$) and phase III ($25.8 \pm 0.6$ vs $22.1 \pm 0.7$ min, $P < 0.003$). A similar increase was observed during the MMC cycle with electroacupuncture but was not statistically significant. In conclusion, the gastric slow wave has the highest power during phase III of the MMC, indicating that the antral contraction is characterized not only by the appearance of spikes, but also by the increased power of the slow wave. Electroacupuncture at acupoints of ST36 and PC6 enhances the gastric MMC by reducing the length of phase I and increasing the length of phases II and III.

**KEY WORDS:** gastric slow waves; gastric motility; gastric emptying; electroacupuncture; electrogastrography.

The gastrointestinal migrating myoelectrical complex (MMC) is well characterized by the appearance of gastrointestinal contractions (or spikes superimposed on the gastrointestinal slow waves) (1–3). It is composed of phase I (motor quiescence or slow waves without spikes), phase II (intermittent contractions or slow waves superimposed with intermittent spikes), and phase III (regular contractions or slow waves all superimposed with spikes) (1). It is known that the slow wave determines the maximum frequency and propagation of gastrointestinal contractions (1, 4). Few studies have investigated the characteristics of the gastric slow wave during different phases of the MMC (3, 4). One previous study, using the noninva-
sive technique of electrogastrography, reported an increased amplitude and a decreased frequency of the gastric slow wave during motor activity in fasting state (4). However, this has never been confirmed using internal recordings made directly from the serosa or mucosa of the stomach.

In recent years, more and more studies have evaluated the effects of acupuncture on gastrointestinal functions and disorders. It seems that there is strong evidence to support the regulatory effect of acupuncture on several gastrointestinal functions, including antral and pyloric motility (5, 6), gastric myoelectrical activity (7, 8), and secretion (9) and on digestive disorders such as postvagotomy gastrointestinal atony (10), postoperative dyspepsia (11), morning sickness of early pregnancy (12), motion sickness (13), and chemotherapy-induced emesis (14, 15). Zusani (ST36) and Neiguang (PC6) are the two most commonly used acupoints in treating gastrointestinal diseases (16, 17). The effect of electroacupuncture on the gastric MMC is not clear.

It is well known that the role of the gastric MMC is to clear the stomach of residual food, secretions, and cellular debris (18). Abnormality in the gastric MMC has been found in a number of clinical settings, such as diabetic and postvagotomy gastroparesis (19), pyloroplasty (20), and scleroderma (21). The absence of phase III contractions has been found in conditions of bacterial overgrowth, scleroderma, diabetic and idiopathic gastroparesis, unexplained nausea and vomiting, and intestinal pseudoobstruction (22). It has been reported that erythymcin, which speeds up gastric emptying in diabetic gastroparesis (23), could enhance antral phase III activity both in humans and dogs (24). It is unclear whether acupuncture has any prokinetic effects on the stomach.

The aims of this study were to investigate the characteristics of the gastric slow wave during different phases of the MMC and to explore the effect of electroacupuncture on the gastric MMC in dogs.

**MATERIALS AND METHODS**

**Subjects.** Eight healthy female hound dogs (14.4–22.6 kg) were studied. The anesthesia was induced with Penta-thal (sodium thiopental 5 mg/kg, intravenous, Abbot Laboratories, North Chicago, Illinois 60064) and maintained on IsoFlo (isoflurane 1.5%, inhalation anaesthesia, Abbot). One pairs of 28-gauge cardiac pacing wires (A&E Medical, Farmingdale, New Jersey) were implanted on the serosal surface of the stomach 2 cm above the pylorus. The two electrodes in the pair were 1 cm apart. The electrodes were sutured to the gastric serosa in the seromuscular layer of the stomach. The wires were brought out through the anterior abdominal wall, channeled subcutaneously along the right side of the trunk, and placed outside the skin for the attachment to the recording device. The study was initiated 10 days or more after surgery. A Pavlov sling was used to position the dog comfortably and obtain minimal movement during the studies. The animal committee of the VA Hospital, Oklahoma City, Oklahoma approved the protocol.

**Study Protocol.** Each dog was studied in the fasting state in two sessions on two different days in a randomized order after complete recovery from surgery. Gastric myoelectrical activity was recorded for three complete consecutive cycles of the MMC in each session. Electroacupuncture was applied at points ST36 and PC6 for 30 min starting from phase I of the second cycle of the MMC in the study session. In the control session, sham points were used. The study in each session lasted about 6 hr.

**Electroacupuncture.** The location of ST36 (Zusanli) was at the proximal one fifth of cranial lateral surface of the rear leg, distal to the head of the tibia in a depression between the muscles of the cranial tibia and the long digital extensor. Point PC6 was located in the groove caudal to the flexor carpi radialis and cranial to the superficial digital flexor muscles, approximately 3 cm proximal to the carpus (25). The sham point paired with ST36 was 4 cm lateral to ST36, and the sham point paired with PC6 was located 3 cm perpendicularly below the PC6.

After the insertion of the acupuncture needle into the acupoints or shampoints, the handle of the needles was immediately connected to the 6-V battery-powered electroacupuncture instrument (Electrotherapeutic Apparatus, model 6806, Shanghai, China). The stimulation signal was composed of a series of periodic pulses with a frequency of 14 cpn, a pulse width of 0.5 msec, and a strength of 10–20 mA.

**Recording and Analysis of Gastric Myoelectrical Activity.** Gastric myoelectrical activity was recorded from the serosal electrodes during the entire study using a multichannel recorder (Aqknowledge III, EOG 100A, Biopac Systems, Inc. Santa Barbara, California). All signals were displayed on a computer monitor and saved on a hard disk by an IBM-compatible 486 PC. The low and high cutoff frequencies of the amplifier were 0.05 and 35 Hz, respectively. Before data storage, the signal was low-pass-filtered again by software with a cutoff frequency of 10 Hz and sampled at 20 Hz. Spikes were clearly observable with this cutoff frequency. For the analysis of gastric slow waves, the signal was further lowpass filtered with a cutoff frequency of 1 Hz and resampled at 2 Hz. In order to avoid biased results, the myoelectrical recordings were coded and blindly analyzed to compute the percentage of slow waves superimposed with spikes and the length of each phase of the MMC. The dominant frequency and power of the gastric slow wave in different phases of the MMC were obtained using spectrum analysis. The dominant frequency and power were computed from the power spectral density that is the squared magnitude of the Fourier transform of the infinite data sequence with appropriate statistical averaging by the method of periodogram (26).

The definitions of the different phases of the MMC was defined as follows: phase I—the recording showed slow waves but no plateaus or spikes; phase II—the slow waves