0002-9270/97/9209-1527$03.00/0
THE AMERICAN JOURNAL OF GASTROENTEROLOGY

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Vol. 92, No. 9, 1997
Printed in U.S.A.

Electrical Stimulation of Acupuncture Points Enhances Gastric Myoelectrical Activity in Humans

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Objective: **Acupuncture is known to enhance gastric motility. Electrical acustimulation has been shown to reduce gastric tachyarrhymia in vection-induced motion sickness. The aim of this study was to investigate the effect of electrical stimulation of acupuncture points on gastric myoelectrical activity in healthy humans.** ***Methods:*** **Nine healthy native Chinese were studied. Gastric myoelectrical activity was recorded using surface electrogastrography (EGG). The EGG recording was made in the fasting state, in a study period during which acupuncture points were electrically stimulated continuously, and in a recovery period after stimulation. The percentage of regular slow waves was assessed by computing the percentage of 2 to 4 cycles per minute slow waves in the EGG.** ***Results:*** **Electrical stimulation significantly increased the percentage of regular slow waves, which was sustained in the recovery period. The increase of the regular slow wave activity resulted from the normalization of arrhythmia.** ***Conclusion:*** **Electrical stimulation of acupuncture points may enhance the regularity of gastric myoelectrical activity and may be an option for treatment of gastric dysrhythmia.**

INTRODUCTION

Gastric myoelectrical activity is associated with gastric motility and can be measured cutaneously (1, 2). Electrogastrography is the technique to obtain a cutaneous recording of gastric myoelectrical activity from abdominal surface electrodes (2). Previous studies have shown that the cutaneous electrogastrogram (EGG) is an accurate measurement of the gastric slow wave (3–7). The contraction-related spike or second potentials are reflected in the EGG as an increase in amplitude (3, 8). Numerous studies have shown the association of abnormalities in gastric myoelectrical activity or in the EGG with gastric motility disorders and gastrointestinal symptoms (9–20).

Acupuncture has been used to treat gastrointestinal symptoms in oriental countries for many years. The most commonly used acupuncture points in treating gastrointestinal symptoms are the Neiguan and Zusanli points (21). Dundee *et al.* reported that acupuncture at the Neiguan point in patients who underwent gynecological surgery had a significant antiemetic effect on postoperative nausea and vomiting, and it could also decrease cisplatin-associated nausea and vomiting in cancer patients (22–24). Hu *et al.* electrically stimulated the Neiguan point using cutaneous electrodes, which they called electrical acustimulation, and recorded severity of symptoms of motion sickness (25). The result of their study showed that electrical acustimulation reduced the severity of symptoms of motion sickness and appeared to decrease gastric tachyarrhythmia (25). Studies published in Chinese literature reported improvement of gastrointestinal motility and symptoms with acupuncture (26).

Based on the promising effect of acupuncture on gastrointestinal motility and symptoms, we hypothesized that acupuncture might enhance gastric myoelectrical activity.

MATERIALS AND METHODS

Study subjects

The study was performed on nine healthy native Chinese subjects (five males, four females; ages, 31–67 yr; mean age, 45 yr). All subjects were fasted for 6 h or more before the study and had taken no medications with known effect on gastrointestinal motility during the 3 days before the study.

Electrogastrogram

Surface electrogastrography was applied to record gastric myoelectrical activity. Before the placement of electrodes, the abdominal skin of recording sites was cleaned with sandy skin-prep jelly (OMNI PREP, Weaver & Co., Aurora, CO) to reduce the impedance. The skin was rubbed until pinkish. The hair, if present, was shaved. Three silver/silver chloride ECG electrodes (SNAP, Lombard, IL) were placed on the abdominal skin. Two epigastric electrodes (one over the antrum and the other over the corpus) were connected to yield a bipolar EGG signal. The other electrode, placed on the left costal margin) was used as a reference. The EGG signal was amplified using a portable EGG recorder (Digitrapper EGG, Synectics Medical, Inc., Irving, TX) with low

Received Nov. 8, 1996; accepted May 5, 1997.

and high cutoff frequencies of 1 and 18 cycles per minute (cpm), respectively. On-line digitization with a sampling frequency of 1 Hz was performed using an analog/digital converter installed on the recorder, and digitized samples were stored on the recorder.

Electrical stimulation of acupuncture points

Electrical stimulation of acupuncture points was performed on the subjects using acupuncture needles. Two acupuncture needles were inserted into the subject's wrists at the Neiguan points on the pericardial meridian. These points are located about 3 cm from the distant palmer crease between the palmaris longus and flexor carpi radialis tendons. Another two acupuncture needles were inserted into the subject's legs at the Zusanli points. These points are located about 10 cm below the patella and 2 cm breadth from the anterior crest of the tibia. The electrodes were connected to a 9-V battery-powered electrical acupuncture instrument (Model D-860; Shanghai Huayi Medical Instrument Factory, Shanghai, China). The stimulation signal was a series of periodic pulses, which were composed of a 2-ms biphasic pulse varying from 10 to 20 V into a 1000 Ω dummy load. The mode of operation was a constant rate of 18 series per minute.

Study protocol

After a fast of 6 h or more, the EGG recording was made for 30 min in the baseline before electrical stimulation of acupuncture points, 30 min during electrical stimulation, and 30 min after electrical stimulation. All recordings were made in a quiet environment. The subject was in a supine position and was asked not to talk and to remain as still as possible during the recording to avoid motion artifacts. After electrical stimulation, the needles were removed. At the end of the study, the recording device was disconnected, and the electrodes were removed.

Data analysis

At the end of the study, the EGG data stored on the recorder were downloaded to an IBM 486 personal computer. All data were subjected to computerized spectral analysis using programs previously developed in our laboratory (27). The following parameters were computed from the EGG by using spectral analysis and statistical analysis methods.

Percentage of normal 2 to 4 cpm slow waves. The percentage of normal 2 to 4 cpm gastric slow waves, which reflects the regularity of gastric myoelectrical activity, was defined as the percentage of time during which normal 2 to 4 cpm slow waves were present over the entire observation period. It was computed using the adaptive running spectral analysis method (28). Each EGG recording was divided into blocks of 1 min without overlapping. The power spectrum of each 1-min EGG was calculated and examined to see whether the peak power was within the range of 2–4 cpm. The 1-min EGG was called normal if the dominant power was within the 2–4 cpm range. Otherwise, it was called dysrhythmia.

Percentage of dysrhythmia. The percentage of gastric dysrhythmia was defined as the percentage of time during which normal 2 to 4 cpm slow waves were absent over the entire observation period. It was computed using the same method with the percentage of normal gastric slow waves. If the peak power was outside the range of 2 to 4 cpm, it was called dysrhythmia. If it was within the range of 0.5 to 2 cpm, it was called bradygastria, and if it was within the range of 4 to 9 cpm, it was called tachygastria. The remaining percentage was called the percentage of arrhythmia (absence of a dominant peak in the power spectrum).

EGG dominant frequency and power. The frequency at which the EGG power spectrum has a peak power in the range of 0.5 to 9.0 cpm was defined as the EGG dominant frequency. The dominant frequency of the EGG has been shown to be equal to the frequency of the gastric slow wave measured from the implanted serosal electrodes (7). It was computed using the smoothed power spectral analysis method (27). The smoothed power spectral analysis was used to produce an averaged power spectrum of the EGG during each recording period including (a) 30 min in the baseline before electrical stimulation, (b) 30 min during electrical stimulation, and (c) 30 min recovery after electrical stimulation.

The power at the dominant frequency in the power spectrum of the EGG was defined as the EGG dominant power.

Statistical analysis

All data were presented as mean ± SEM. Student's *t* test was used to investigate the difference of the EGG parameters before, during, and after acupuncture. A finding of $p < 0.05$ was considered to be significant.

RESULTS

A significant difference was found in the EGGs before and during electrical stimulation of acupuncture points. The percentage of the 2 to 4 cpm slow waves during electrical stimulation was found to be significantly higher than that in the baseline (74.8 ± 6.9% *vs* 64.8 ± 10.1%, $p < 0.05$, see Fig. 1). This increase was sustained during the 30 min after electrical stimulation (74.3 ± 3.3% *vs* 74.8 ± 6.9%, $p > 0.05$).

It was further found that the increase in the percentage of 2 to 4 cpm waves resulted from normalization of arrhythmia. The percentage of arrhythmia was 26.9 ± 8.5% in the baseline period, 10.8 ± 3.6% during electrical stimulation ($p < 0.02$ in comparison with baseline), and 12.3 ± 3.6% after electrical stimulation ($p < 0.05$ in comparison with baseline), as shown in Figure 2. The percentages of bradygastria and tachygastria were not affected significantly by electrical stimulation on acupuncture points.

The EGG dominant power was slightly increased during electrical stimulation but was not statistically significant

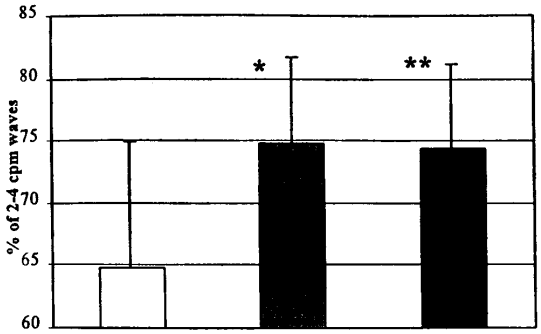

FIG. 1. Effect of electrical stimulation on percentage of 2 to 4 cpm slow waves in Chinese subject. Open bar, baseline; lightly shaded bar, during electrical stimulation; darkly shaded bar, recovery. * $p < 0.02$ compared with baseline; ** $p < 0.05$ compared with baseline.

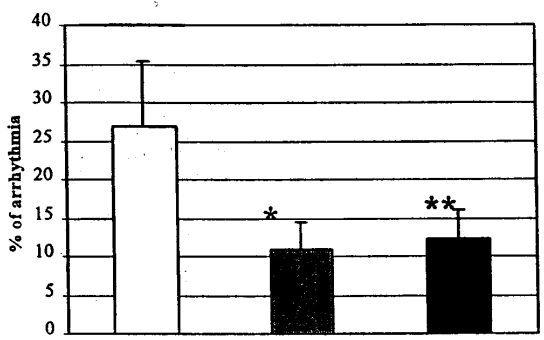

FIG. 2. Effect of electrical stimulation on percentage of arrhythmia. Open bar, baseline; lightly shaded bar, during electrical stimulation; darkly shaded bar, recovery. * $p < 0.05$ compared with baseline; ** $p < 0.05$ compared with during electrical stimulation.

(baseline, 31.4 ± 2.1 dB; during electrical stimulation, 32.8 ± 1.17 dB; and after electrical stimulation, 31.4 ± 1.2 dB).

DISCUSSION

In this paper, we have found that (a) electrical stimulation of acupuncture points increased the percentage of regular 2 to 4 cpm gastric slow wave, and (b) this increase was attributed to the normalization of gastric arrhythmia.

Noninvasive surface electrogastrography was used in this study to investigate gastric myoelectrical activity. Although the cutaneous recording of gastric myoelectrical activity is somewhat contaminated by noise and interferences from other organs of the human body, numerous studies have shown that the EGG is an accurate measurement of the gastric slow waves when it is appropriately recorded and analyzed. Spectra analysis methods are able to separate the gastric signal from noise and interferences. The main EGG parameter used in this paper was the percentage of regular 2 to 4 cpm gastric slow waves. It has been shown to accurately reflect the regularity of the gastric slow waves (7).

The percentage of 2 to 4 cpm slow waves in healthy Chinese subjects observed in this study was substantially lower than that in healthy European-Americans as reported in the literature (29–31). The healthy European-Americans usually show an average of 80 to 90% of 2 to 4 cpm slow waves in the EGG. Although the underlying cause is unknown, a number of previously published studies may be related to this observation. In a previous study by Hu *et al.* (25), it was found that in the fasting state Chinese subjects had 20% of tachyarrhythmia, whereas European-American subjects had only 6% of tachyarrhythmia. The percentage of tachyarrhythmia defined by Hu *et al.* was the ratio between the summed power in the frequency range of 4 to 9 cpm and the total power of the EGG in the whole frequency range. Although statistical analysis of the difference was not provided and the definition was different from this paper, their study did indicate that gastric myoelectrical activity in Chinese was more dysrhythmic. It is known that Chinese have a higher infection rate of *H. pylori* than Caucasians. A recent preliminary study (32) showed that patients with *H. pylori* infection have a lower percentage of regular 2 to 4 cpm slow waves and that the eradication of *H. pylori* increases this percentage. Whether the observed lower percentage of regular 2 to 4 cpm slow waves in Chinese was caused by the infection of *H. pylori* is unknown and may deserve further investigation. Studies published by Stern *et al.* (33, 34) showed that vection provoked significantly increased nausea responses in Chinese subjects when compared with African-American and European-American subjects. It was reported that vection-induced nausea is caused by gastric myoelectrical dysrhythmia (35, 36).

This study demonstrated that electrical stimulation of acupuncture points increases the regularity of gastric slow waves by normalizing gastric arrhythmia. This result is in agreement with previous findings by Hu *et al.* who reported that tachyarrhythmia during drum rotation in the acustimulation group was significantly less than that in the control group (25). They also reported that electrical acustimulation is effective in both Chinese subjects and European-American subjects. Our data are also consistent with the studies of Dundee *et al.*, who reported that acupuncture could reduce nausea and vomiting induced by cancer chemotherapy.

The significant improvement in the regularity of the gastric slow wave observed in this study suggests that electrical stimulation of the acupuncture points may be a new therapeutic approach for the treatment of patients with gastric motility disorders. Gastric dysrhythmias are frequently observed in patients with gastric motility disorders (4, 10–12, 18, 20). It is well known that gastric myoelectrical activity controls the frequency and propagation of gastric contractions. Therefore, irregular gastric slow waves may lead to gastric hypomotility or uncoordinated or gastric contractions, yielding delayed emptying of the stomach and/or gastrointestinal symptoms of nausea, vomiting, etc. Prokinetic agents such as cisapride have been used to treat patients with gastric motility disorders. More studies are

needed to investigate systematically the effect of electrical stimulation of the acupuncture points on gastric motility, gastric emptying, and gastrointestinal symptoms.

Acupuncture has been in practice in China for over 2000 yr. Numerous research studies have been performed to investigate the mechanism of acupuncture. It has been reported that the channels and collaterals may be special bioelectrical pathways from acupuncture points to specific organs. That is, electrical stimulation at the acupuncture points related to the stomach is effectively delivered to the stomach (37). Our recent study in dogs has also proven this (unpublished data). Electrical stimulus artifacts were more clearly observed in the recording electrodes implanted on the serosal surface of the stomach and small intestine when electrical stimulation was applied via the Zusanli points, which is far away from the gastrointestinal tract, than via the electrodes placed 5 cm away from the recording electrodes. The effect of acupuncture on gastrointestinal hormones, vagal nerves, and the central nervous system have also been reported. However, the exact mechanism for the improvement of the gastric slow wave observed in this study is unknown.

In summary, electrical stimulation of acupuncture points may enhance the regularity of gastric myoelectrical activity and may be an option for treatment of patients with gastric dysrhythmia.

ACKNOWLEDGMENT

The authors thank Regina Randall for her preparation of the manuscript.

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