Effect of electric acupoint stimulation on gastrointestinal hormones and motility among geriatric postoperative patients with gastrointestinal tumors

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Abstract

OBJECTIVE: To evaluate the effects of electric acupoint stimulation on gastrointestinal hormones and motility among geriatric postoperative patients with gastrointestinal tumors, and to explore an efficient and noninvasive method for postoperative recovery of bowel functions.

METHODS: Forty patients were randomly and evenly assigned into a regular nursing care group (RNC) and an acupoint electric stimulation group (AES). Patients in the RNC group received regular nursing care and patients in the AES group received regular nursing care plus electric stimulation of acupoints. The serum levels of gastrin (GAS), motilin (MOT), and cholecystokinin (CCK), and an electrogastrogram (EGG) of all the patients were evaluated on the first, third, and fifth day after surgery. The time to first flatus after surgery and the number of patients with side effects such as abdominal pain, abdominal distention, and diarrhea were recorded.

RESULTS: There were significant differences between the two groups in GAS, MOT, EGG, time to first flatus, abdominal pain, abdominal distention, and diarrhea ($P < 0.05$).

CONCLUSION: Electric stimulation on acupoints could increase levels of GAS and MOT, promote the recovery of gastrointestinal functions, and decrease complications among postoperative senile patients with gastrointestinal tumors.

Key words: Electric stimulation therapy; Aged; Gastrointestinal stromal tumors; Gastrointestinal hormones; Gastrointestinal motility; Point ST36 (Zusanli); Point ST37 (Shangjuxu)

INTRODUCTION

A common complication from gastrointestinal tumor surgery includes gastrointestinal paralysis, which inhibits gastrointestinal function and results in difficult flatus and defecation. Paralysis can result from anesthesia, surgical trauma, or postoperative analgesia pump use. Abdominal distension will not only cause discomfort, but may also delay incision healing because of dia-
phragm lifting and increased abdominal cavity pressure. Early movement on the bed is encouraged to promote gastrointestinal function recovery. However, geriatric patients are often weaker and see limited effects from movement. We aimed to explore an efficient and noninvasive method to help recover gastrointestinal function and reduce postoperative complications among geriatric patients using acupuncture. Acupuncture plus electric stimulation was used on the Zusanli (ST 36) and Shangjixu (ST 37) acupoints and the therapeutic effects were evaluated on gastrointestinal hormones and motility.

MATERIALS AND METHODS

Patients and groups

Forty geriatric patients with gastrointestinal tumors receiving surgeries between January 2009 and December 2010 were enrolled in the study. All patients gave informed consent and the trial was approved by the Ethics Committee of Shanghai Pulmonary Hospital. The inclusion criteria were: (a) age older than 60 years; (b) receiving abdominal surgery because of gastrointestinal tumor; (c) surgical time longer than 2 h; (d) signing of the informed consent. The exclusion criteria were: (a) poor compliance; (b) drop out for other reasons; and (c) poor general health.

The patients were randomly assigned by drawing lots into a regular nursing care group [RNC: 10 male, 10 female, aged 60-84 years, average (70 ± 7) years, 10 patients with gastric cancer, 7 patients with colon cancer, and 3 patients with rectal cancer] and an acupoint electric stimulation group [AES: 14 male, 6 female, aged 60-88 years, average (70 ± 7) years, 7 patients with gastric cancer, 10 patients with colon cancer, and 3 patients with rectal cancer]. General data of the two groups were compared and no statistically significant differences were founded (Table 1).

Methods

In the RNC group, patients were given routine nursing care: fasting, antibiotics, gastrointestinal decompression, nutritional support, and correcting water and electrolyte imbalances. After surgery, conditions of patients were monitored and early movement was encouraged. In addition to routine nursing care in the AES group, patients received electric stimulation on acupoints Zusanli (ST 36) and Shangjixu (ST 37) from the first day to the seventh day after surgery. A G6805-II pulse acupuncture apparatus (disperse-dense wave, disperse 30 Hz, dense 100 Hz, 6-15 V, Shanghai Medical Instrument Technology Co., Ltd., Shanghai, China) was employed, and slight local muscle quivering was induced. Each session lasted for 20 min, and the treatment was given once daily.

Gastrin (GAS), motilin (MOT), and cholecystokinin (CCK) monitoring

On the morning of the day of surgery, and the first, third, and fifth day after surgery, fasting serum GAS, MOT, and CCK of patients were tested with radioimmunoassay and enzyme-linked immunosorbent assay using 2 ml of venous blood. The GAS kit was obtained from the Northern Biotechnology Institute (Beijing, China). The MOT and CCK kits were provided by Adlitteram Diagnostic laboratories, Inc. (San Diego, CA, USA). Instructions of the kits were strictly followed.

Electrogastrogram

The electrogastrogram (EGG) was performed on the early morning of the day of surgery, and the first, third, and fifth day after surgery. An EEGG-2D8-type double-lead smart gastrointestinal electrogastrogram instrument produced by the Institute of Electric Technology Kelly Optoelectrics Technology Co., Ltd., was used (Hefei, China). The midpoint of the line connecting the xiphoid and umbilicus was considered the 0 point,

<table>
<thead>
<tr>
<th>Item</th>
<th>RNC (n = 20)</th>
<th>AES (n = 20)</th>
<th>Total (n = 40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60-70</td>
<td>12 (30.0)</td>
<td>9 (22.5)</td>
</tr>
<tr>
<td></td>
<td>70-80</td>
<td>6 (15.0)</td>
<td>9 (22.5)</td>
</tr>
<tr>
<td></td>
<td>80-90</td>
<td>2 (5.0)</td>
<td>2 (5.0)</td>
</tr>
<tr>
<td>Sex</td>
<td>Female</td>
<td>10 (25.0)</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>10 (25.0)</td>
<td>14 (35.0)</td>
</tr>
<tr>
<td>Disease</td>
<td>Gastric cancer</td>
<td>10 (25.0)</td>
<td>7 (17.5)</td>
</tr>
<tr>
<td></td>
<td>Colon cancer</td>
<td>7 (17.5)</td>
<td>10 (25.0)</td>
</tr>
<tr>
<td></td>
<td>Rectal cancer</td>
<td>3 (7.5)</td>
<td>3 (7.5)</td>
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<tr>
<td>Course of disease (years)</td>
<td>1-2</td>
<td>19 (47.5)</td>
<td>19 (47.5)</td>
</tr>
<tr>
<td></td>
<td>3-4</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td></td>
<td>≥5</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

Notes: patients received regular nursing care and electric stimulation on acupoints Zusanli (ST 36) and Shangjixu (ST 37) from the first day to the seventh day after surgery. Each session lasted for 20 min, and the treatment was given once daily. RNC: regular nursing care group; AES: acupoint electric stimulation group.
and the first lead was placed 4 cm left and 1 cm above the 0 point (gastric body). The second lead was placed 4 cm right of the 0 point (antrum). The reference electrode was placed on the inside of the right wrist and the grounding electrode was placed on the inside of the right ankle.

The number of cases with postoperative gastrointestinal disorders such as abdominal pain, diarrhea (defecation frequency significantly greater than normal daily frequency, loose stool over 200 g daily containing undigested food or pus), and abdominal distension were recorded according to the diagnostic criteria.¹

Statistical analysis
Data are expressed as the mean ± standard deviation (±). The SPSS 15.0 statistical software (SPSS, Chicago, IL, USA) was used for data homogeneity of variance analysis. When variance was homogenous, the paired t test method and two-sample t test were used for further analysis. When variance was heterogeneous, the Tamhane test was used. Enumerated data were analyzed by χ² test. P < 0.05 was considered statistically significant.

RESULTS

Comparison of GAS, MOT, and CCK between two groups
As shown in Figure 1, there were no significant differences in serum GAS levels on the morning of surgery and the first day after surgery between the two groups (P > 0.05). However, there were significant differences in serum GAS levels on the third and fifth day after surgery between the two groups (P < 0.05).

As shown in Figure 2, there were no significant differences in serum MOT levels on the morning of surgery, and the first and fifth day after surgery between the two groups (P > 0.05), but there was a significant difference in serum MOT levels on the third day after surgery between the two groups (P < 0.05).

As shown in Figure 3, there were no significant differences in serum CCK levels on the morning of surgery, and the first, third, and fifth day after surgery between the two groups (P > 0.05).

REFERENCE

¹ Hou LL et al. / Clinical Study

Figure 1 Comparison of gastrin before and after surgery in two groups
Patients received regular nursing care and electric stimulation on acupoints Zusanli (ST 36) and Shangjuxu (ST 37) from the first day to the seventh day after surgery. Each session lasted for 20 min, and the treatment was given once daily. RNC: regular nursing care group; AES: acupoint electric stimulation group. ¹P < 0.05, compared with RNC group.

Figure 2 Comparison of motilin before and after surgery in two groups
Patients received regular nursing care and electric stimulation on acupoints Zusanli (ST 36) and Shangjuxu (ST 37) from the first day to the seventh day after surgery. Each session lasted for 20 min, and the treatment was given once daily. RNC: regular nursing care group; AES: acupoint electric stimulation group. ¹P < 0.05, compared with RNC group.

Figure 3 Comparison of cholecystokinin before and after surgery in two groups
Patients received regular nursing care and electric stimulation on acupoints Zusanli (ST 36) and Shangjuxu (ST 37) from the first day to the seventh day after surgery. Each session lasted for 20 min, and the treatment was given once daily. RNC: regular nursing care group; AES: acupoint electric stimulation group.
Preoperative and postoperative EGG frequency and amplitude

As shown in Figure 4, there were no significant differences in EGG frequency on the first lead on the morning of surgery and the first day after surgery between the two groups ($P > 0.05$), but there were significant differences in EGG frequency on the third and fifth day after surgery between the two groups ($P < 0.05$).

As shown in Figure 5, there were no statistical differences in EGG frequency on the second lead on the morning of surgery and the first day after surgery between the two groups ($P > 0.05$), but there were significant differences in EGG frequency on the third and fifth day after surgery between the two groups ($P < 0.05$).

As shown in Figure 6, there were no significant differences in EGG amplitude on the first lead on the morning of surgery, and the first and third day after surgery between the two groups ($P > 0.05$), but there were significant differences in EGG amplitude on the fifth day after surgery between the two groups ($P < 0.05$).

As shown in Figure 7, there were no significant differences in EGG amplitude on the second lead on the morning of surgery and the third day after surgery between the two groups ($P > 0.05$), but there were significant differences in EGG amplitude on the fifth day after surgery between the two groups ($P < 0.05$).
between the two groups ($P > 0.05$), but there were significant differences in EGG amplitude on the first and fifth day after surgery between the two groups ($P < 0.05$).

**Time to first flatus after surgery**
The time to first flatus in the AES group was significantly shorter than that in the RNC group ([65 ± 12 vs 73 ± 10] h, $P < 0.05$).

**Complications**
After surgery in the RNC group, there were 8 cases of abdominal distension (40%), 5 cases of abdominal pain (25%), and 5 cases of diarrhea (25%). In the AES group, no abdominal distension occurred; there was one case of abdominal pain (5%) and one case of diarrhea and abdominal pain (5%). The complication rate in the AES group was significantly lower than that in the RNC group ($P < 0.05$, Table 2).

**Table 2** Comparison of postoperative complications ($n$ [%])

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Distension</th>
<th>Abdominal pain</th>
<th>Diarrhea</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNC</td>
<td>20</td>
<td>8 (40)</td>
<td>5 (25)</td>
<td>5 (25)</td>
</tr>
<tr>
<td>AES</td>
<td>20</td>
<td>0 (0)†</td>
<td>1 (5)‡</td>
<td>1 (5)§</td>
</tr>
</tbody>
</table>

Notes: patients received regular nursing care and electric stimulation on acupoints Zusanli (ST 36) and Shangjuxu (ST 37) from the first day to the seventh day after surgery. Each session lasted for 20 min, and the treatment was given once daily. RNC: regular nursing care group; AES: acupuncture electric stimulation group. †$P < 0.05$ when compared to regular nursing care group.

**DISCUSSION**
The mechanisms of delayed gastrointestinal function recovery and intestinal paralysis after surgery have not been fully elucidated. Nevertheless, it is hypothesized that operative trauma and anesthesia can inhibit neural activity of the intestinal wall, resulting in delayed bowel function after surgery and intestinal paralysis. In addition, fasting and bed rest can further inhibit bowel function and delayed recovery. Clinically, the major methods for promoting intestinal movement after abdominal surgery are early movement out of bed, pharmacological promotion of peristalsis, enema, and acupuncture. For elderly patients with gastrointestinal tumors, slow recovery of gastrointestinal function may result from surgical trauma, and difficulties in ambulation can result in complications such as bloating and intestinal adhesion. Finding a method to promote postoperative bowel function recovery among elderly patients still needs to be explored.

Based on the principles of traditional Chinese medicine (TCM) regarding organs, channels, and acupuncture, acupoints were stimulated by programmed pulsed signals using modern electroacupuncture. Studies have found that a variety of elements (such as Ca, P, K, Fe, Zn, and Mn) are enriched in the connective tissue near acupuncture points. Among them, Ca$^{2+}$ and K$^+$ are important ions within the body. Collagen fibers of the connective tissue near the acupuncture points transmit infrared light, which implies that there might be a microstructure that is able to radiate after excitation, which could be a method to transmit information. Programmed pulsed electrical signals stimulating acupuncture points may promote the exchange of information and energy within the body through the above mechanism and lift the neural inhibition on endogenous locomotor activity in the intestinal wall, which promotes the recovery of gastrointestinal function. The programmed pulsed electrical stimulation on acupuncture points is safer and more convenient than traditional acupuncture, and is suitable for all patients receiving abdominal surgeries.

**Effects of electric acupoint stimulation on gastrointestinal hormones**
Gastrointestinal hormones are a class of biologically active peptides secreted by scattered endocrine cells and neurons of the enteric nervous system in the digestive tract, mainly including gastrin (GAS), motilin (MTL), and cholecystokinin (CCK). These gastrointestinal hormones regulate gastrointestinal motor function in the form of excitement and/or inhibition through endocrine secretion, cavity secretion, and neurotransmitters. Any pathways influenced will cause gastrointestinal motility changes. Surgical trauma can stimulate catecholamine secretion which will affect gastrointestinal function by inhibiting the secretion of motilin and gastrin. Low levels of motilin and gastrin can directly result in postoperative gastrointestinal disorders. Sympathetic nerve excitation caused by stress can also result in inhibitory effects on the movement of the stomach and small intestine. In this study, the serum GAS level in the RNC group after operation was significantly lower than that before surgery ($P < 0.05$). On the first day after surgery, the serum MOT level was significantly lower than that before surgery ($P < 0.05$). The delayed recovery of intestinal function is related to the reduced gastrointestinal hormones. In the AES group on the third day after surgery, serum GAS and MOT levels were higher than those before surgery ($P < 0.05$). Transcutaneous electric acupoint stimulation has an impact on gastrointestinal hormone secretion among elderly gastrointestinal tumor patients. The acupuncture significantly increased plasma GAS and MOT levels and therefore activated the enteric nervous system to start gastrointestinal contractile activity.

**Effects of electric acupoint stimulation on gastrointestinal motility**
TCM theorizes that surgery and anesthesia can cause blood deficiency, which leads to organ dysfunction and gastrointestinal disorders. These problems cause weak motility of the gastrointestinal tract and movement disorder. The acupoints Zusanli (ST 36) and Shangjuxu (ST 37) are located along the Stomach Meridian, one of the regular 12 meridians that originates internally at the lateral edge of the nose, then continues to Chengqi
(ST 1) at the inferior border of the orbit, descends to the upper gum, courses around the mouth, and travels up to Touwei (ST 8) at the hairline. Acupuncture on these two points can promote gastrointestinal peristalsis, inhibit or excite the autonomic nervous system, regulate gastrointestinal motor function, prevent bile reflux, protect the gastric mucosa, and improve the body’s immune defense capability. Electrical activity routinely controls gastrointestinal smooth muscle contraction and relaxation in the body and monitoring the gastrointestinal electrical activity is a common method used to assess gastrointestinal motor function. Studies have used EGG to assess gastrointestinal function changes among patients with Crohn’s disease. The electrical activity of the stomach is myogenic, but is also regulated by neurohumoral factors. Therefore, the electrical parameters are not only indicators of gastric motility, but are also able to reflect regulatory roles of relevant factors and their relationships. The average amplitude indirectly reflects the stomach electric power, and the gastric electrical waveform frequency reflects the speed of gastrointestinal electrical rhythms. Figure 3 and 4 show significant differences in EGG amplitude indirectly reflects the stomach electric power, relevant factors and their relationships. The average amplitude of EGG changes among patients with Crohn’s disease. The electrical activity of the stomach is myogenic, but is also regulated by neurohumoral factors. Therefore, the electrical parameters are not only indicators of gastric motility, but are also able to reflect regulatory roles of relevant factors and their relationships. The average amplitude indirectly reflects the stomach electric power, and the gastric electrical waveform frequency reflects the speed of gastrointestinal electrical rhythms. Figure 3 and 4 show significant differences in EGG amplitude and frequency between the two groups. Acupoint stimulation could promote blood circulation, clear the meridian, excite the autonomic nervous system, promote gastrointestinal peristalsis, and speed up the recovery of gastrointestinal function.

Relationships between gastrointestinal hormones and gastrointestinal motility

Gastrointestinal hormones play an important regulatory role in the gastrointestinal system. Motilin and gastrin are excitatory gastrointestinal hormones that can promote gastrointestinal motility. Motilin mainly regulates periodic activities of myoelectric complex during the interdigestive period and promotes gastric emptying. Gastrin is a brain-gut peptide, which can stimulate gastric acid secretion, promote gastrointestinal motility, hinder spontaneous and motilin-induced migrating motor complex phase activities, and turn the fasting gastrointestinal movement into postprandial movement. Gastrin can also directly cause contraction of the circular muscle of the gastric body and gastric antral, which results in longitudinal muscle contraction through the cholinergic nerve pathway. Cholecystokinin can promote contraction of the gallbladder and the small intestine. Experiments have confirmed that GAS and MOT are involved in gastrointestinal motility regulation in acupoint electric stimulation. Our study showed that the amplitude and frequency of the EGG coincided with serum GAS and MOT levels in patients. Delayed recovery of gastrointestinal function after abdominal surgeries can induce internal environmental disorders and result in a variety of complications. Emphasis on the recovery of bowel function is important for improving the nutrition, promoting wound healing, and reducing complications. This study demonstrated that electric acupoint stimulation shortened the time to first flatus, lowered the complication rate, and promoted postoperative recovery of gastrointestinal function compared with the regular nursing care group. In addition, the procedure is simple, safe, efficient, and painless.

REFERENCES

5. Zhou YL, Zhang JC, Huang JP. Comparison of low frequency stimulation on acupoints and acupuncture on gastrointestinal motility after intestinal obstruction surgery. Xian Dai Zhong Xi Yi Jie He Za Zhi 2010; 19(18); 2269-2274.
10. Li YS, Jin HX, Li J, et al. Laparoscopic assisted resection of colorectal cancer on the body’s stress response. Zhong Hua Pu Tong Wai Ke Za Zhi 2008; 17(10); 1025-1027.