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ORIGINAL CONTRIBUTIONS

Transcutaneous Electrical Acupoint Stimulation Combined with Dexamethasone and Tropisetron Prevents Postoperative Nausea and Vomiting in Female Patients Undergoing Laparoscopic Sleeve Gastrectomy: a Prospective, Randomized Controlled Trial

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Abstract

Background Despite the administration of prophylactic antiemetics, some patients who undergo laparoscopic sleeve gastrectomy (LSG) remain at high risk for postoperative nausea and vomiting (PONV). Although many trials have been conducted, the effectiveness of transcutaneous electrical acupoint stimulation (TEAS) on the prevention of PONV remains unknown.

Methods Sixty-two female patients undergoing elective LSG were randomly assigned to the TEAS combined with dexamethasone and tropisetron (TEAS group, $n = 31$) or dexamethasone and tropisetron (control group, $n = 31$) groups. The incidence and severity of PONV, as well as the need for rescue antiemetics, were collected within 48 h after surgery.

Results The patients in both groups had similar clinical characteristics and underwent the same surgical procedure. In the TEAS group, 13 patients (41.9%) had PONV within 48 h after LSG compared to 24 patients (77.4%) in the control group ($P = 0.004$, relative risk: 0.39 [0.19, 0.80]). The severity of PONV differed significantly between groups, with five patients (16.1%) in the TEAS group and 15 patients (48%) in the control group experiencing clinically important PONV ($P = 0.007$, relative risk: 0.62 [0.42, 0.90]). Moreover, fewer patients required antiemetic rescue medication in the TEAS group compared with the control group (29.0% vs. 58.1%, $P = 0.021$).

Conclusion Multimodal antiemetic prophylaxis consisting of TEAS and antiemetics was effective in reducing PONV incidence and intensity in high-risk patients undergoing LSG.

Keywords Acupoint stimulation · Bariatric surgery · Female patients · High-risk patients · Laparoscopic sleeve gastrectomy · Postoperative nausea and vomiting

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Introduction

Postoperative nausea and vomiting (PONV) is one of the most common complications following laparoscopic sleeve gastrectomy (LSG) [1, 2] and can contribute to severe adverse events and delayed mobilization with subsequent prolonged recovery and hospital discharge [3, 4]. Although several randomized controlled trials have attempted to decrease PONV rates [5–7], effective PONV prophylaxis strategies remain elusive in LSG patients.

Multiple risk factors are associated with an increased incidence of PONV, including female gender [8]. Hence, multimodal antiemetic therapies have been proposed for the prevention of PONV [5, 6, 9]. However, even with double or triple antiemetic prophylaxis, the PONV rate remains as high as 70% in high-risk patients [10]. Additionally, decreased gastric pouch distensibility and compliance also contributed to the high incidence of PONV in LSG [11, 12]. A lower incidence of PONV was reported for decreased gastric intraluminal pressure by relaxation of the pyloric sphincter and residual stomach with drug injection into the pyloric area [12]. However, this invasive technique has the potential risk of severe complications, including gastric leak and pyloric wall hematoma.

Acupoint stimulation, as a safe and nonpharmacological method, has been used successfully to alleviate pain and regulate gastrointestinal functions in various surgeries [13–16]. Stimulation of acupoints alone or in combination with intravenous antiemetic drugs has shown positive effects in reducing the incidence of PONV [17–20]. PC6 and ST36 (also known as Nei Guan and Zusanli) are the most commonly used acupoints with antiemetic activities and are always stimulated concurrently to produce synergetic effects for better gastrointestinal motility in Chinese medicine [19, 21]. However, it is unclear if this nonpharmacological prophylaxis would provide additional benefits in the prevention of PONV after LSG. Considering the limited effect of antiemetic medicines on the prevalence of PONV in high-risk patients undergoing bariatric surgery, we conducted this study to evaluate the efficacy of multimodal prophylaxis combining acupoint stimulation and antiemetics in ameliorating PONV in female patients undergoing LSG.

Methods

This prospective, randomized, controlled trial was approved by the institutional ethics committee of the first affiliated hospital of Chongqing Medical University on December 11, 2017. The trial was registered with the Chinese Clinical Trial Registry (ChiCTR2000037785) and all participating patients provided their written informed consent.

Participants

This study included 62 consecutive female patients below 65 years of age and with the American Society of Anesthesiologists (ASA) physical status class of II or IV who underwent elective LSG under general anesthesia between May 2018 and February 2020. The exclusion criteria were contraindications for transcutaneous electrical acupoint stimulation (TEAS) such as rash or local infection over the acupoint stimulation skin area or implantation of a cardiac pacemaker or defibrillator; communication difficulties; psychiatric or neurological disease; pre-use medicine or pre-existing medical condition before surgery that limited objective assessment, including the use of antiemetics, opioids, or glucocorticoids; and gastroesophageal reflux.

Sample Size

The sample size calculation was based on a preliminary study of female patients who underwent LSG. The incidence of PONV in the first 48 h after surgery was 70% for double prophylaxis with dexamethasone and tropisetron. We assumed that a 50% absolute reduction (35% expected) of PONV incidence was of clinical significance when combined with the use of TEAS. Power analysis suggested that 28 patients for each group should be recruited to provide a power of 80% ($\beta = 0.2$) and a two-sided confidence interval of 95% ($\alpha = 0.05$). Accounting for 10% potential loss to follow-up, the sample size was increased to 62 patients (31 per group).

Randomization and Blinding

After enrolment into the study, the patients were randomly assigned to the TEAS or control groups using a computerized random number generator. Group assignment was exposed from a sealed envelope only by an acupuncturist when patients arrived at the operating room. The patients were blinded to the group assignment and were told that they might or might not feel a sensation when the acupoint stimulation was working. Both acupoint stimulations in the TEAS group and placebo treatment in the control group were performed by the same acupuncturist who was not involved in the process of anesthesia and data collection. The acupoint stimulation instrument was covered with an opaque box for adequate blinding. The anesthetists were not blind to the processing because they were responsible for intraoperative management but they were not involved in the postoperative assessment. An anesthetic resident who was not involved in the anesthesia routine and who was blinded to the group assignments performed the follow-up and data collection.

Study Protocol

TEAS was adopted for acupoint stimulation in this trial of PC6 and ST36 acupoint positions that were identified by an experienced acupuncturist based on traditional anatomic localization. After cleaning the skin with alcohol, the gel electrodes were applied and then connected to the Hwato electronic acupuncture treatment instrument (model no. SDZ-V, Suzhou Medical Appliances Co., Ltd., Suzhou, China). In the TEAS group, electrical acupoint stimulation was administrated with a dense disperse frequency of 2/10 Hz about 30 min before induction and maintained during the operation. The stimulation intensity was adjusted according to individual requirements, starting at 1 mA and increasing gradually to obtain the maximum tolerance for a slight twitching of local muscles. For better prophylaxis in PONV, acupoint stimulation was performed within 12 h after the surgery twice daily (2 h and 6 h after the surgery). In contrast, the patients in the control group had gel electrodes applied and connected to an acupuncture instrument without stimulation.

Standardized Anesthesia and Perioperative Management

All patients underwent standardized anesthesia protocols. After the lungs were preoxygenated with 10 min of facemask ventilation, midazolam (2 mg), propofol (1–2 mg/kg), sufentanil (0.5 μg/kg), and rocuronium (0.9 mg/kg) were administered for anesthesia induction and tracheal intubation. Anesthesia was maintained with desflurane in air (oxygen mixture with a fraction of inspired oxygen [FiO_2] of 0.8) and intravenous infusion of dexmedetomidine (0.5 μg/kg/h), combined with remifentanil (0.1–0.2 μg/kg/h). Additional sufentanil (0.1–0.2 μg/kg) and rocuronium (0.3–0.4 mg/kg) were administered to maintain adequate levels of analgesia and muscle relaxation. The liquids, including lactated Ringer's solution and succinylated gelatin injection, were administered based on calculated preoperative deficits, surgical procedure, urine volume, and estimated intraoperative blood loss. The operations were performed by the same surgeon with 15 mm Hg intra-abdominal pressure insufflated by carbon dioxide in the reverse Trendelenburg position. At the end of the surgery, all patients received intravenous parecoxib (40 mg) and incision infiltration of 0.5% ropivacaine (10 mL), as well as a patient-controlled analgesia device of sufentanil (1.5 μg/h background infusion, 1 μg bolus, 20 min lockout time) for postoperative analgesia. No gastric tube was indwelled after operation.

After the operations were completed, the patients were transferred to the post-anesthesia care unit (PACU) and extubated when the extubation criteria were met. Analgesia therapy with 5 μg of sufentanil was administered upon patient request. The patients were discharged from the PACU after fulfilling the recovery criteria.

PONV Prophylaxis and Management

Prophylactic dexamethasone (10 mg intravenously) was administered during anesthesia induction and tropisetron (4 mg intravenously) at the start of skin closure. Patients with emetic episodes or who requested antiemetic therapy were administered 10 mg of metoclopramide intravenously in the PACU or ward. If symptoms persisted, 4 mg of ondansetron or 4 mg of tropisetron was added.

Data Collection

Patient characteristics (age, weight, body mass index [BMI]) and PONV risk factors were recorded before surgery. The patients were asked at 2, 6, 12, 24, 36, and 48 h after surgery using a questionnaire based on the PONV impact scale [22], which was completed by the ward nurse and checked by an anesthetic resident at 2, 24, and 48 h after surgery. Clinically important PONV was calculated as described previously [22]. Data on antiemetic and analgesic use were also collected from medical records. Pain intensity was measured and recorded using a pain visual analogue scale (VAS, from 0 = no pain to 10 = pain as bad as it possibly could be) at rest and during movement at the same time points.

The side effect of TEAS was recorded. Additionally, perioperative information and postoperative outcomes were collected in the operative room or on the ward.

Statistical Analysis

Data are expressed as means ± SD, medians (interquartile range), or numbers (percentage). To compare the general information and clinical characteristics of both groups, Shapiro–Wilk tests were used to confirm the normal distribution of the data. Then, two-sample *t* tests were used for analysis; otherwise, Wilcoxon rank-sum tests were used. Differences between PONV incidences in both groups were compared using the Pearson chi-square or Fisher's exact tests. Differences in pain VAS scores between the two groups at different time intervals were investigated using multivariate analysis of variance (MANOVA) tests. P values < 0.05 were considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics Windows, version 21.0 (IBM Corp., Armonk, NY, USA).

Results

Among 67 female patients who underwent LSG and were screened during the study period, 62 completed the study.

Five patients were excluded from the study for gastroesophageal reflux disease (three patients), infection of the acupoint stimulation area because of diabetes (one patient), and refusal to participate (one patient). The flow diagram of this study is shown in Fig. 1. Patient characteristics such as age, BMI, ASA class, Apfel score, and comorbidities did not differ between the two groups. There were also no differences in the variables of anesthesia and surgery, including anesthesia duration, operating duration, opioid consumption, and fluid volume (Table 1).

Except for one in each group, all patients were nonsmoking females and received patient-controlled intrathecal analgesia (PCIA) with opioids after LSG. Consequently, of the 31 patients in each group, 30 (96.8%) were at high risk for PONV according to the simplified risk score, having met more than three of the criteria. One patient in each group had a moderate risk for PONV. All patients received PONV prophylaxis with dexamethasone and tropisetron.

Overall, 13 of 31 patients (41.9%) in the TEAS group and 24 of 31 patients (77.4%) in the control group experienced PONV within 48 h after LSG surgery (Table 2), corresponding to a significant reduction in PONV with acupoint stimulation ($P = 0.004$, absolute risk reduction 35.5%, number-needed-to-treat 3), with a relative risk (RR) reduction of 45.9%. Five patients (16.1%) and 15 patients (48.4%) in the TEAS and control groups, respectively, reported clinically important PONV ($P = 0.007$, RR reduction 66.7%, absolute risk reduction 32.3%, number-needed-to-treat 3). The number of patients requiring antiemetic rescue medication in the TEAS group was lower than that in the control group (29.0% vs. 58.1%, $P = 0.021$). The number of antiemetic rescue medicine doses was also significantly lower in the TEAS group than that in the control group (26 vs. 57 doses, $P = 0.023$).

Four patients (13.0%) in the TEAS group and nine patients (29.0%) in the control group experienced PONV in the first 2 h after surgery ($P = 0.119$), which increased to 10 patients (32.3%) and 22 patients (71.0%), respectively, during the first 12 h after surgery (Table 3). The risks of PONV increased by 19.3% in the TEAS group and 42.0% in the control group from the first 2 to 12 h after surgery.

We observed no significant difference in pain VAS scores at rest ($P = 0.404$) and during movement ($P = 0.423$) within 48 h after surgery. Three patients in the TEAS group and four patients in the control group experienced moderate pain in the first 12 h after surgery, and the pain was relieved with

Table 1 Patient characteristics and perioperative information. Data are described as mean (SD), number (%), or median (25–75th percentiles). *BMI*, body mass index; *ASA*, American Society of Anesthesiologists. ▼*P* value refers to two-sample *t* test, ▽*P* value refers to the Wilcoxon rank-sum test

	TEAS group	Control group	*P* value
Age (y)	27.5 (8.0)	27.3 (8.3)	0.913▼
Weight (kg)	104.5 (19.5)	104.7 (15.9)	
BMI (kg m^{-2})	39.1 (6.5)	39.9 (5.8)	0.598▼
ASA score			
II	16 (51.6)	17 (54.8)	–
III	14 (45.2)	13 (41.9)	–
IV	1 (3.2)	1 (3.2)	–
Hypertension	10 (32.3)	8 (25.8)	–
Diabetes mellitus	8 (25.8)	7 (22.6)	–
Other comorbidities	4 (12.9)	4 (12.9)	–
Smoking	1 (3.2)	1 (3.2)	–
Previous motion sickness	7 (22.6)	5 (16.1)	–
Apfel score			
2	1 (3.2)	1 (3.2)	–
3	22 (71.0)	25 (80.6)	–
4	8 (25.8)	5 (16.1)	–
Anesthesia time (min)	169.6 (39.9)	167.1 (42.0)	0.810▼
Operative time (min)	127.5 (37.0)	128.1 (38.1)	0.944▼
Fluid volume (ml)	1477.4 (291.8)	1445.2 (348.2)	0.694▼
Intraoperative opioid consumption (*)	1.8 (0.4)	1.8 (0.4)	0.795▼
Postoperative opioid consumption (*)	0.6 (0.2)	0.6 (0.1)	0.908▼
Time to extubation (min)	10 (10, 25)	13 (10, 20)	0.564▽
Time in recovery room (min)	70 (60, 85)	60 (60, 75)	0.089▽

*Pe kg body weight in mg morphine; morphine equivalents were calculated according to their relative analgesic potency

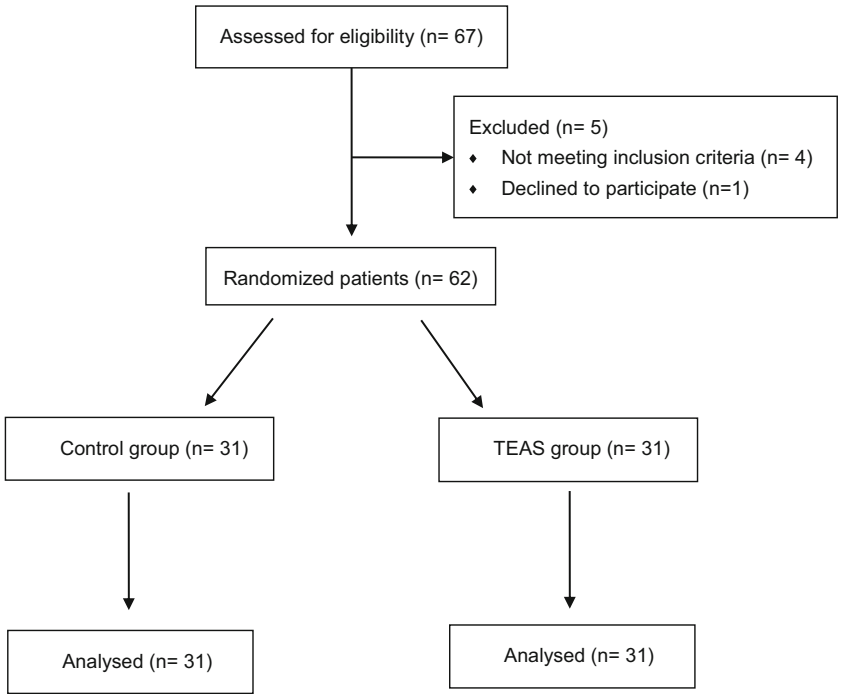

Fig. 1 CONSORT flow chart for the selection of patients included in the study. TEAS, transcutaneous electrical acupoint stimulation

increased background infusion of the patient-controlled anesthesia device. There was also no difference in postoperative opioid consumption between the groups, based on comparisons of morphine equivalents [23]. The time to first flatus passage in the TEAS group was significantly shorter than that in the control group (23.6±7.7 vs. 32.3±13.2 h, respectively, $P = 0.003$), but no differences were observed in the times to oral diet and mobility after surgery (Table 4).

Several complications were observed in both groups. One patient in the TEAS group experienced itching in the skin area under the electrodes that disappeared within 12 h after surgery. Two patients in the control group experienced postoperative complications, including central vomiting ($n = 1$) lasting 65 days, which required several antiemetic medicines, and stitch leakage (n = 1) that required surgery to repair.

Discussion

The results of this study demonstrated that TEAS at PC6 and ST36 combined with double antiemetics was effective in lowering the incidence of PONV after LSG in high-risk patients. Furthermore, this multimodal antiemetic prophylaxis reduced the PONV intensity and the need for rescue medicines.

Previous investigations have reported that more than 60% of patients with LSG experienced PONV even with prophylactic antiemetics [11, 12]. In the present study, the incidence of PONV within 48 h in female patients with pharmacological treatment alone was 77.4%. This level is comparable to that reported previously and indicates the poor effect of pharmacological prophylaxis on the prevention of PONV in bariatric surgeries [7, 10, 24]. Compared with antiemetics alone, the

Table 2 PONV intensity in the first 48 h after surgery and the need for rescue antiemetics. Data are shown as the numbers of patients (%). *PONV*, presence of nausea or vomiting; *Nausea*, the patient experienced a feeling of nausea; *Vomiting*, any vomiting or retching; *RR*, relative risk; *CI*, confidence interval. *Pearson chi-square test

Variable	TEAS group	Control group	*P* value	RR (95% CI)
Nausea, vomiting or both (*n* (%))	13 (41.9)	24 (77.4)	0.004*	0.39 (0.19, 0.80)
Tolerable nausea (*n* (%))	10 (32.3)	9 (29.0)	0.783*	
Untolerable nausea (*n* (%))	3 (9.7)	15 (48.4)	0.001*	
Vomiting	11 (35.5)	21 (67.7)	0.011*	0.50 (0.28, 0.89)
Vomiting ≦ 2 times (*n* (%))	6 (19.4)	6 (19.4)	–	
Vomiting ≧ 3 times (*n* (%))	5 (16.1)	15 (48.4)	0.007*	
Clinical important PONV (n (%))	5 (16.1)	15 (48.4)	0.007*	0.62 (0.42, 0.90)
Rescue antiemetic administration (*n* (%))	9 (29.0)	18 (58.1)	0.021*	0.60 (0.37, 0.96)
One time (*n* (%))	2 (6.5)	6 (19.4)	–	
Two times (*n* (%))	5 (16.1)	7 (22.6)	–	
Three times or more (*n* (%))	2 (6.5)	5 (16.1)	–	

Table 3 Incidence of only nausea, vomiting, and PONV during the first 48 h after LSG. Data are shown as the numbers of patients (%). *PONV*, the presence of nausea or vomiting in the time intervals; *Only nausea*, the patient experienced a feeling of nausea but without vomiting during the relevant time interval; *Vomiting*, any vomiting or retching during the time interval; *RR*, relative risk; *CI*, confidence interval. *Pearson chi-square test, #Fisher's exact test (%)

Postoperative interval (h)	TEAS group	Control group	*P* value	RR (95%CI)
Only nausea during time intervals, h (*n* (%))				
0–2	3 (9.7)	7 (22.6)	0.301#	0.43 (0.12, 1.51)
2–6	0	4 (12.9)	–	
6–12	3 (9.7)	6 (19.4)	0.473#	0.50 (0.14, 1.82)
12–24	2 (6.5)	4 (12.9)	0.671#	0.50 (0.10, 2.53)
24–36	2 (6.5)	4 (12.9)	0.671#	0.50 (0.10, 2.53)
36–48	1 (3.2)	2 (6.5)	1.000#	0.50 (0.05, 5.23)
0–12	2 (6.5)	4 (12.9)	0.671#	0.50 (0.10, 2.53)
0–24	2 (6.5)	4 (12.9)	0.671#	0.50 (0.10, 2.53)
0–48	2 (6.5)	3 (9.7)	1.000#	0.67 (0.12, 3.72)
Vomiting during time intervals, h (*n* (%))				
0–2	1 (3.2)	2 (6.5)	1.000#	0.50 (0.05, 5.23)
2–6	5 (16.1)	12 (38.7)	0.046*	0.42 (0.17, 1.04)
6–12	7 (22.6)	16 (51.6)	0.018*	0.44 (0.21, 0.91)
12–24	4 (12.9)	14 (45.2)	0.005*	0.29 (0.11, 0.77)
24–36	4 (12.9)	9 (29.0)	0.119#	0.44 (0.15, 1.23)
36–48	1 (3.2)	5 (16.1)	0.195#	0.20 (0.03, 1.62)
0–12	9 (29.0)	19 (61.3)	0.011*	0.47 (0.26, 0.88)
0–24	10 (32.3)	20 (64.5)	0.011*	0.50 (0.28, 0.89)
0–48	11 (35.5)	21 (67.7)	0.011*	0.52 (0.31, 0.89)
PONV during time intervals, h (*n* (%))				
0–2	4 (12.9)	9 (29.0)	0.119*	0.44 (0.15, 1.29)
2–6	5 (16.1)	16 (51.6)	0.004*	0.31 (0.13, 0.75)
6–12	10 (32.3)	22 (71.0)	0.002*	0.46 (0.26, 0.79)
12–24	6 (19.4)	18 (58.1)	0.002*	0.33 (0.15, 0.73)
24–36	6 (19.4)	13 (41.9)	0.066*	0.46 (0.20, 1.06)
36–48	2 (6.5)	7 (22.6)	0.148#	0.29 (0.06, 1.27)
0–12	12 (38.7)	23 (74.2)	0.005*	0.52 (0.32, 0.85)
0–24	12 (38.7)	24 (77.4)	0.002*	0.50 (0.31, 0.81)
0–48	13 (41.9)	24 (77.4)	0.004*	0.52 (0.34, 0.85)

combination with TEAS reduced the total incidence of PONV within 48 h by 45.9%. The results of our study support previous findings that TEAS combined with antiemetics was more effective in PONV prophylaxis, with a 44% reduction in RR compared to antiemetics alone in gynecological surgery [18]. Also, without the combination of antiemetics prophylaxis, acupoint stimulation has been reported to reduce the RR of PONV by 48–64% in various types of surgery [25, 26]. Another finding regarding the characteristics of PONV after LSG is a peak occurrence at 6–12 h. According to previous

Table 4 Postoperative outcomes. Data are presented as mean (SD), number (%), or median (25–75th percentiles). *h*, hour; *d*, day; *n*, number. Postoperative hospital costs are indicated in yuan (¥). ▼*P* value refers to two-sample *t* test, ▽*P* value refers to the Wilcoxon rank-sum test

Variable	TEAS group	Control group	*P* value
Time to oral diet (h)	47.6 (42, 75)	46 (42, 51)	0.810▽
Time to flatus (h)	23.6 (7.7)	32.3 (13.2)	0.003▼
Time to mobility (d)	27.5 (11.9)	29.6 (13.7)	0.522▼
Postoperative hospital stays (d)	3 (3, 4)	3 (3, 4)	0.981▽
Wound-related adverse event (n)	0	1 (3.2)	–
Other complications (n)	1 (3.2)	1 (3.2)	–
Postoperative hospital costs (¥, thousand)	45.8 (8.0)	46.2 (5.9)	0.652▼

studies, the first 24 h were the high-risk period for PONV in bariatric surgeries [24]. Therefore, early prevention of PONV is advisable for high-risk patients after surgery [27]. Thus, TEAS was repeated 2 h and 6 h after surgery, which resulted in a nearly 50% reduction in PONV occurrence within the first 24 h.

In recent years, there has been an increasing focus on the prevalence of PONV after bariatric surgeries [2]. The incidence of PONV after bariatric surgeries is higher because most patients are younger women, which is an important risk factor [8, 28], in addition to non-smoker status, having experienced laparoscopy, and the use of volatile anesthetics and opioids. In addition, patients undergoing some types of surgery, especially LSG, are more likely to develop PONV as compared with other bariatric procedures. Fathy and colleagues reported that the PONV rate may be as high as 100% in patients undergoing LSG without prophylaxis [12]. In another randomized controlled trial, PONV occurred during the first 24 h in 70.0% of LSG patients, even with triple prophylactic antiemetics [10]. The susceptibility to PONV of patients undergoing LSG may be attributed to alterations in gastric structure and compliance. Relaxing the pyloric sphincter ring and canal during LSG is effective in reducing gastric pressure and PONV incidence [12]. Moreover, surgical incisions on the afferent branches of the vagus nerve may also contribute to the increased incidence of PONV [29].

This study confirmed for the first time the benefit of acupoint stimulation on the recovery of gastrointestinal function after LSG, which manifested as the alleviation of PONV severity and reduced time for the passage of flatus. The mechanisms that led to improved gastrointestinal motility after acupoint stimulation are not completely understood, but several effects of acupuncture on the gastrointestinal tract have been described previously. Stimulation at PC6 may modulate the efferent vagal innervations and inhibit the frequency of transient lower esophageal sphincter relaxation, one possible cause of delayed enteral nutrition in critically ill patients [30]. This regulation of gastrointestinal vagus nerve activity may be achieved by affecting higher cortical and subcortical circuitries. Wang and colleagues reported accelerated gastric emptying in diabetic gastroparesis following acustimulation at ST36 [16]. Stimulation at ST36 also significantly increased the numbers of c-Fos-positive cells in both the caudal nucleus tractus solitarius (NTS) and the dorsal motor nucleus of the vagus (DMV) in a rat model [31]. Therefore, the lower PONV incidence following the stimulation of both PC6 and ST36 may be attributed to accelerated gastrointestinal motility and myoelectrical activity [32]. Furthermore, acupuncture may also regulate serotonin and dopamine levels that are targeted by some common antiemetics [33].

At least two patient-related risk factors for PONV were present among the patients included in the present study; therefore, most were at high-risk for PONV, with Apfel scores above 3. In addition, some operation- and anesthesia-related risk factors may also increase the occurrence of PONV in bariatric surgeries, including intravascular volume deficits, intraoperative opioid consumption, and volatile anesthetic use [2, 10, 34]. However, all patients experienced the same anesthesia methods and were treated by the same acupuncturist in our study. No significant differences were observed in the operation time, fluid volume, and the consumption of opioids between groups, which reflects the comparability of data in both groups, likely due to the standardized anesthesia management and standard surgical procedures.

Our study has some limitations. First, female sex was the only risk factor from Apfel's study, which was an important inclusion criterion in our study; however, this study was not sufficiently powered to investigate the interactions between acupoint stimulation and other risk factors due to our limited sample size and lower proportion of other risk factors (smoking, previous PONV, or motion sickness). Furthermore, our study population did not represent all bariatric surgery, but rather only those with LSG because of a single type of surgery performed in our medical center. Thus, it is unclear whether our findings can be extended to other bariatric surgery populations. Finally, although the patients were unaware of their treatment assignment, the tingling sensations associated with acupoint stimulation were more likely to be detected after surgery, which may have contributed to the greater antiemetic efficacy of TEAS. However, this methodological problem is unavoidable in clinical studies involving the use of non-pharmacologic antiemetic therapies.

In conclusion, TEAS on PC6 and ST36 combined with dexamethasone and tropisetron reduced PONV incidence and severity compared to those for dexamethasone and tropisetron alone in high-risk patients undergoing LSG.

Authors' Contributions Study conception: Su Min
Study design: Qiuju Xiong, Ke Wei, and Su Min
Study direction: Su Min
Patient recruitment: Menghua Zeng
Study coordination: Qiuju Xiong
Study execution: Qiuju Xiong, Ke Wei, Dan Liu, and Yanmei Yang
Data collection: Jingyue Ma
Data analysis: Qiuju Xiong and Lei Zou
Paper writing: Qiuju Xiong and Ke Wei
Paper revision: Su Min

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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