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Original Article

Electroacupuncture for recovery of gastrointestinal function after laparoscopic hysterectomy surgery: a prospective, randomized, controlled trial

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Abstract: Objectives: This study aimed to evaluate the effectiveness and feasibility of electroacupuncture (EA) in improving gastrointestinal peristalsis after laparoscopic surgery. Methods: This was a single-center, two-arm, prospective randomized trial in which patients were randomly allocated in a 1:1 ratio into two groups after surgery at the Affiliated Traditional Chinese Medicine Hospital, Southwest Medical University, China. Members of both groups consented to standard postoperative treatment, and the intervention group received EA treatment starting 3-5 hours after surgery, as well as in the morning and afternoon on the first postoperative day. Defecation and flatus times were the co-primary outcomes. Results: Among 88 patients who completed the outcome measurements, 43 patients were allocated to the intervention group and 45 to the control group. The mean (SD) time to first flatus was 36.4 (8.0) hours and 42.2 (8.5) hours in the intervention and control groups, respectively (HR 1.9, 95% CI, 1.2-2.9; P < 0.001). The mean (SD) time to first defecation was 46.0 (8.0) hours and 51.3 (9.4) hours in the intervention and control groups, respectively (HR 1.9, 95% CI, 1.2-3.0; P = 0.01). The Visual Analogue Scale (VAS) pain scores and Intake, Feeling nauseated, Emesis, Examination, and Duration of symptoms (I-FEED) scores were significantly lower in the intervention group compared to the control group (P < 0.001). Conclusion: EA demonstrates promising effects in accelerating the recovery of GI function and has potential for widespread adoption across diverse healthcare systems globally. However, its exact mechanism requires further in-depth research.

Keywords: Electroacupuncture, postoperative gastrointestinal dysfunction, enhanced recovery after surgery, gynecological surgery, laparoscopy, clinical trial

Introduction

One of the most frequent side effects following abdominal surgery is Postoperative gastrointestinal dysfunction (POGD), defined as a temporary impairment of gastrointestinal (GI) function [1]. It is associated with perioperative drug stimulation, surgical stress, and excessive postoperative inflammatory response and mostly manifests as nausea, vomiting, abdominal distension, delayed flatus, delayed defecation, intestinal obstruction, and gastrointestinal bleeding [2]. Although several strategies, such as early postoperative feeding, minimally invasive surgery, and symptomatic medications, have been employed to prevent POGD, their efficacy remains limited, and the incidence of POGD remains high, ranging between 10% and 30% of patients, depending on the type and site of surgery [3, 4]. The delayed recovery of GI function is associated with prolonged length of stay (LOS) and increased risks of postoperative complications [5]. According to a comprehensive global meta-analysis, POGD results in a mean increase in overall hospitalization costs by 8233 euros (66.3%), significantly escalating the financial burden on patients and healthcare systems [6, 7]. Due to the restriction of normal social activities and increased healthcare costs and resource burdens, POGD has a profound negative impact on patients and society.

In recent years, laparoscopic surgery has been widely used in gynecological fields due to its advantages of minimal trauma, rapid recovery, and aesthetic incisions [8]. Moreover, improve-

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ments in patients' physical states and the implementation of ERAS protocols have resulted in reduced complications, shorter LOS, and lower costs [9]. However, these improvements remain insufficient, as POGD continues to be a significant postoperative issue, often requiring adjunctive conventional supportive measures, such as coffee consumption, hot-pack therapy, and prokinetics [10]. Nevertheless, only a few studies have demonstrated a clear benefit of these strategies, and their efficacy, costs, complications, and applicability remain controversial [11]. Thus, there is an urgent need for safer and more effective treatments.

Increasing research is being conducted on EA as a potential therapy for gut microbiota disorders, neuroinflammation, and postoperative pain [12]. EA therapy at Zusanli (ST36) and Sanyinjiao (SP6) acupoints downregulates the Nesfatin-1 ERK/CREB pathway, reducing the reactivity of the HPA axis induced by acute surgical trauma and subsequent anxiety [13]. Moreover, EA stimulation at the Dazhui acupoint (GV14) using polyphenol-mediated conductive hydrogel microneedles effectively reduced local and systemic inflammation, creating a positive feedback loop that enhanced peripheral nerve and diabetic wound tissue repair while reducing depressive-like behaviors in rats [14]. A recent animal study demonstrated that EA can activate the vagal-adrenal anti-inflammatory axis in mice through specific body regions [15]. ST36 (Zusanli), ST37 (Shangjuxu), and ST39 (Xiajuxu) are the most frequently selected acupoints for treating gastrointestinal dysfunction, as supported by a meta-analysis, and are all located along the "Stomach Meridian" according to Chinese Medicine Theory [16]. Additionally, these three acupoints have been empirically effective in alleviating postoperative symptoms such as abdominal pain and distension in our clinical practice. Therefore, this study aimed to evaluate the feasibility and efficacy of a specific EA combination within the ERAS protocol to accelerate the recovery of gastrointestinal function following laparoscopic gynecological surgery.

Methods

Ethics statement

This single-center, two-arm, single-blind, prospective randomized study was conducted between June 2024 and September 2024 at the Gynecology Department of the Affiliated Traditional Chinese Medicine Hospital of Southwest Medical University, China. This study adhered to the principles of the Declaration of Helsinki. The trial was approved by the hospital ethics committee (approval number: KY2024-023) and registered at medicalresearch.org.cn (registration number: MR-51-24-038798). All patients provided written informed consent prior to participation.

Participation conditions

Participants meeting the following criteria were included: women aged 35-75 years (inclusive); American Society of Anesthesiologists (ASA) Physical Status Grades I-III; scheduled for laparoscopic hysterectomy with or without salpingo-oophorectomy or salpingectomy under general anesthesia; and willing to provide informed consent and participate in the study.

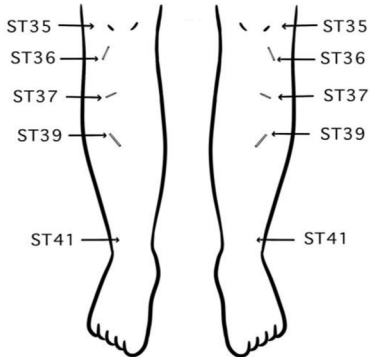
Participants were excluded if they met any of the following criteria: severe cardiac, hepatic, or renal insufficiency; skin infection or nerve damage near the experimental acupoints [Zusanli (ST36), Shangjuxu (ST37), and Xiajuxu (ST39)]; a history of gastrointestinal disorders, such as gastrointestinal tumors, chronic constipation, or peptic ulcers; participation in other clinical trials within the past month or receipt of acupuncture treatment within the last 3 months; or inability to cooperate, such as major depression or impaired communication.

Dropout criteria included: violation of the trial protocol; failure to complete the full course of treatment; occurrence of serious postoperative complications or adverse events; conversion to open laparotomy; or admission to the intensive care unit for more than 24 hours postoperatively.

Randomization

After confirming eligibility and obtaining informed consent, patients were randomly assigned (1:1) to one of two treatment groups: EA (ST36, ST37, ST39) plus standard care or standard care alone. A centralized randomization system ensured allocation concealment. The randomization sequence was computer-generated by an independent statistician using SPSS 27.0 software, and patients were automatically assigned to their respective groups only after formal enrollment. This process ensured that nei-

Table 1. Locations of ST36 (Zusanli), ST37 (Shangjuxu) and ST39 (Xiajuxu)

Acupoints	Locations	Corresponding position of human body
Zusanli (ST36)	On the lateral side of the lower leg and the tibialis anterior muscle, 3 cun below ST35, on the line between ST35 and ST41.	
Shangjuxu (ST37)	On the lateral side of the lower leg and the tibialis anterior muscle, 6 cun below ST35, on the line between ST35 and ST41.	
Xiajuxu (ST39)	On the lateral side of the lower leg and the tibialis anterior muscle, 9 cun below ST35, on the line between ST35 and ST41.	
Annotation	Dubi (ST35): Central depression of the lateral aspect of the patellar ligament. Jiexi (ST41): Central depression of the front ankle joint, between the extensor digitorum longus and extensor digitorum tendons.	

ther the enrolling researchers nor the patients could predict or influence treatment allocation.

Patients were blinded to their treatment allocation to minimize performance bias, particularly for subjective outcomes such as VAS scores. The acupuncture operators were necessarily aware of group assignments due to the nature of the intervention. However, outcome assessors remained blinded to treatment allocation throughout the trial. For example, assessors collecting time to first flatus and defecation were unaware of patients' group assignments, and all data were anonymized before analysis. Additionally, the statistician responsible for data analysis remained blinded to treatment allocation until the final analysis was completed.

Interventions

All treatments commenced 3-5 hours postoperatively. Recruited patients, along with their family members and caregivers, were informed about the importance of accurately recording the timing of first flatus and defecation to ensure comparability between the two treatment groups during the study. All EA treatments were performed by a senior Chinese medicine practitioner with over five years of clinical experience, who had undergone standardized operating procedure training prior to the trial. Patients in the EA group received bilateral treatment at the following acupoints: Zusanli (ST36, located on the lateral side of the lower leg and the tibialis anterior muscle, 3 cun below ST35, on the line between ST35 and ST41), Shangjuxu (ST37, located 6 cun below ST35), and Xiajuxu (ST39, located 9 cun below ST35), totaling six acupuncture points (**Table 1**). The acupoint locations were determined according to "Nomenclature and Location of Meridian Points" (GB/T 12346-2021) [17]. After confirming the acupoint locations, the skin was cleaned with 75% alcohol. Once the skin surface dried, disposable stainless-steel needles (length: 40 mm; diameter: 0.25 mm; Beijing Hanyi Medical Instruments Co., Ltd., China) were inserted to a depth of 20-40 mm at the six acupoints. After 30 seconds of manipulation, Deqi - a sensation of soreness, numbness, swelling, or heaviness - was achieved. Finally, bilateral connections between ST36, ST37, and ST39 were established using three electrodes from an electric device (G6805-I acupoint nerve stimulator, Qingdao Xinsheng Industrial Co., Ltd., China). The electrical intensity was adjusted to the maximum level tolerated by each patient, ranging from 0.5 mA to 2.0 mA. This range was chosen to balance patient comfort and therapeutic efficacy. The intensity was gradually increased during the initial session to determine the optimal level for each patient, which was then consistently applied in subsequent sessions. Stimulation was applied continuously for 30 minutes at a frequency of 2 Hz, a setting widely used in EA studies for its analgesic and therapeutic effects. To ensure consistency, the same EA device (G6805-I acupoint nerve stimulator) was used for all patients, and the intensity and frequency settings were documented for each session. Treatments were administered 3-5 hours postoperatively, as well as in the morning

(07:00-09:00) and afternoon (17:00-19:00) on the first postoperative day. In the control group, the same postoperative care was provided without EA or any additional interventions that could affect GI function recovery, such as Chinese medicine prescriptions, enemas, or adjunctive medications. Postoperative management followed "the Clinical Practice Guidelines for Prevention and Treatment of Postoperative Gastrointestinal Disorders with Integrated Traditional Chinese and Western Medicine", which included early food intake and early ambulation [18].

Outcomes

The primary outcomes were the time (in minutes) to first flatus and bowel movement, as recorded by patients, family members, or caregivers postoperatively. Secondary outcomes included LOS, use of additional analgesics, incidence of vomiting or bowel obstruction, complete blood count parameters (lymphocyte-to-monocyte ratio [LMR] and platelet-to-neutrophil ratio [PNR]), VAS scores, I-FEED scores, and QoR-40 (Quality of Recovery-40 questionnaire) scores. Blood work included LMR and PNR on postoperative day 2. Analgesic and antiemetic treatments were not routinely administered to patients within the first 24 hours postoperatively. Metoclopramide (10 mg intramuscularly) was administered to patients with an I-FEED score of ≥ 6 or those who requested antiemetic treatment within 24 hours postoperatively, while ketorolac tromethamine (30 mg intramuscularly) was given to patients with a VAS pain score of ≥ 6 or those who requested analgesic treatment within 24 hours postoperatively. Patients recorded their pain levels once daily from postoperative days 1 to 5 using a VAS ranging from 0 (no pain) to 10 (severe pain). Postoperative GI function was assessed from days 1 to 5 using the I-FEED scoring system, developed by a global panel of specialists in anesthesia, nursing, nutrition, and surgery with expertise in perioperative medicine and ERAS pathways during the second Perioperative Quality Initiative [19]. Based on clinical presentation, the I-FEED system assigns 0-2 points to each of five components, classifying patients as having normal gastrointestinal function (0-2 points), postoperative gastrointestinal intolerance (POGI; 3-5 points), or postoperative gastrointestinal dysfunction (POGD; ≥ 6 points). The QoR-40 is a comprehensive questionnaire assessing the overall quality of recovery after surgery and anesthesia, encompassing five dimensions (patient support, comfort, emotions, physical independence, and pain) with 40 items. Scores range from 40 to 200, with higher scores indicating better recovery [20]. QoR-40 scores were recorded on the day of admission and discharge. LOS was defined as the number of nights spent in the hospital postoperatively. All adverse events were recorded, categorized as either related or unrelated to the treatment, and monitored until resolution. All enrollment, interventions, and assessments were conducted according to the participant timeline (**Table 2**).

Statistical analysis

Sample size calculation was based on a previous pilot study conducted in 2023, forty patients in each group underwent laparoscopic hysterectomy surgery. The mean time to flatus was 36.20 ± 8.20 hours in group A (EA with standard care) and 42.72 ± 8.76 hours in group B (standard care alone). Based on this estimate, with a double-tailed $\alpha = 0.05$, $\beta = 0.10$, arm proportion = 1:1, and a dropout rate of 10%, we computed that 43 patients were necessary to identify a statistical difference in each group (according to https://www.medsta.cn/software). Continuous variables are presented as mean (standard deviation, SD) and median (min-max), while categorical variables are summarized as percentages. Furthermore, an independent t-test was used for normally distributed data, and the Mann-Whitney U test was applied for non-normally distributed data. Categorical variables were analyzed with the Fisher exact test and summarized as percentages. Additionally, two-sided *P* values and 95% confidence intervals (CIs) were provided for the calculated hazard ratios (HRs), with values less than 0.05 being deemed significant. An impartial statistician used IBM SPSS Statistics version 27.0 to accomplish the statistical analysis.

Results

Patient characteristics

From June 2024 through September 2024, after 129 patients underwent screening, 28 were deemed ineligible or declined to participate. The remaining patients were randomly allocated to the EA arm (n = 51) or the Standard care group (n = 50). After excluding patients

Table 2. Time schedule of the protocol

Time points	Perioperative period							
	Day-n after surgery							Day of discharge
	Day -1	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	
ENROLLMENT								
Selection criteria	○							
Informed consent	○							
Random assignment	○							
Basic information	○							
INTERWENTION								
Group A (EA with ERAS)		○	○					
Group B (ERAS alone)		○	○					
ASSESSMENTS								
Time to first flatus			→	→	→	→	→	
Time to first defecation			→	→	→	→	→	
Blood work	○			○				
VAS score			→	→	→	→	→	
I-FEED score			→	→	→	→	→	
QoR-40 Questionnaire	○							○
Postoperative complications		→	→	→	→	→		
Adverse events		→	→	→	→	→		
Length of hospital stay		→	→	→	→	→		
Supervision	→	→	→	→	→			

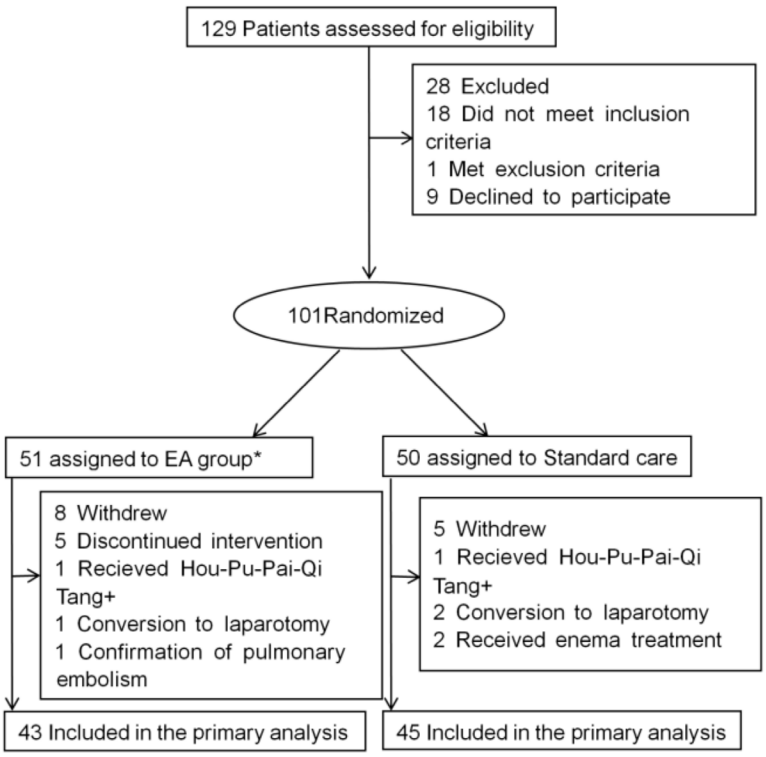


Figure 1. Flowchart of the study. EA group*: Electroacupuncture at Zusanli (ST36), Shangjuxu (ST37) and Xiajuxu (ST39) combined with standard care. Hou-Pu-Pai-Qi Tang+: This type of Chinese patent medication could mess with the results by improving gastrointestinal motility.

who dropped out, 88 patients were recruited in total (**Figure 1**). The patients in both groups had comparable demographic and clinical features at baseline (**Table 3**). The mean (SD) age of the participants was 49.1 (6.1) years (EA group) and 51.0 (6.3) years (Standard care group). Uterine myoma was the most common surgical indication, accompanied by high-grade squamous intraepithelial lesions (HSIL) and endometriosis in both groups.

Primary and secondary outcomes

Table 4 summarizes the details of the study outcome measurements. In the postoperative phase, the time (Mean ± SD) to first flatus (36.4 ± 8.0 vs 42.2 ± 8.5 hours, HR 1.9, 95% CI, 1.2-2.9; P < 0.001) and first feces (46.0 ± 8.0 vs 51.3 ± 9.4 hours, HR 1.9,

Table 3. Demographics and baseline characteristics

Characteristic	EA group (n = 43)	Standard care group (n = 45)	*P*-value
Age, mean (SD), years	49.1 (6.1)	51.0 (6.3)	0.140
BMI[a], mean (SD), kg/m^2	25.1 (4.2)	24.1 (3.6)	0.245
Postmenopausal, n (%)	10 (23.3)	17 (37.8)	0.140
Current smoker, n (%)	2 (4.7)	0 (0)	0.236
Current drinker, n (%)	4 (9.3)	3 (6.7)	0.950
Hypertension, n (%)	7 (16.3)	5 (11.1)	0.480
Diabetes, n (%)	3 (7.0)	4 (8.9)	1.000
Previous abdominal surgery, n (%)	13 (30.2)	11 (24.4)	0.542
Type of operation[b], n (%)			0.714
Total hysterectomy	1 (2.3)	2 (4.4)	
Total hysterectomy + OS	2 (4.7)	0 (0)	
Total hysterectomy + BS	7 (16.3)	7 (15.6)	
Total hysterectomy + OSO	2 (4.7)	1 (2.2)	
Total hysterectomy + BSO	31 (72.1)	35 (77.8)	
ASA[c] (I/II/III), n (%)			0.476
I	11 (25.6)	14 (31.1)	
II	30 (69.8)	31 (68.9)	
III	2 (4.7)	0 (0)	
Duration of surgery, mean (SD), h	1.7 (0.8)	1.5 (0.6)	0.126
Anesthesia time, mean (SD), h	2.8 (0.9)	2.6 (0.7)	0.157
Intraoperative blood loss, mean (SD), mL	66.5 (52.7)	70.9 (69.1)	0.740
Self-controlled analgesia pump, n (%)	43 (100)	42 (93.3)	0.242
Major diagnosis, n (%)			0.624
Uterine myoma	16 (37.2)	22 (48.9)	
Endometriosis	11 (25.6)	9 (20.0)	
HSIL[d]	11 (25.6)	11 (24.4)	
Endometrial cancer	0 (0)	1 (2.2)	
Heavy menstrual bleeding	4 (9.3)	2 (4.4)	
POP[e]	1 (2.3)	0 (0)	

a: Body mass index. Computed by dividing height in square meters by weight in kilos. b: OS, One-side salpingectomy. BS, Bilateral salpingectomy. OSO, One-side salpingectomy-oophorectomy. BSO, Bilateral salpingectomy-oophorectomy. c: American Society of Anesthesiologists grade. d: High-grade squamous intraepithelial lesions. e: Pelvic organ prolapse.

95% CI, 1.2-3.0; P = 0.01) were significantly reduced by EA treatment (**Figure 2**). The median postoperative pain scores and I-FEED scores in the EA group were lower than those in the standard care arm at 24, 48, and 72 hours (P < 0.001). The QoR-40 scores on the day of discharge were also lower in the EA group than in the standard care group (P < 0.001). There was no significant difference between the two groups in LMR and PNR on postoperative day 2, length of hospital stay, incidence of vomiting, use of additional analgesics, and incidence of bowel obstruction. One patient in the EA group was diagnosed with paralytic bowel obstruction on postoperative day 3, as she ate hard and indigestible food without following the doctor's orders. She was discharged after symptomatic treatment. In both arms, there were no serious adverse events or fatalities. All 88 (100%) patients were discharged uneventfully.

Discussion

By evaluating the clinical effectiveness and safety of specific acupuncture combinations in patients following laparoscopic gynecological surgery, the study aims to explore the role of these combinations in aiding the recovery of GI function. We hypothesized that adjunctive therapy (EA treatment) combined with the ERAS pathway could further improve recovery for patients undergoing panhysterectomy with

Table 4. Study outcome measurements

Outcome	EA group (n = 43)	Standard care group (n = 45)	*P*-value
Primary Outcome			
Time to first flatus, mean (SD), h	36.4 (8.0)	42.2 (8.5)	< 0.001
Time to first defecation, mean (SD), h	46.0 (8.0)	51.3 (9.4)	0.010
Secondary Outcome			
LMR[a]/Day 2, mean (SD)	2.1 (0.8)	2.1 (0.8)	0.958
PNR[b]/Day 2, mean (SD)	34.0 (12.2)	31.4 (14.0)	0.349
VAS[c] scores, median (min-max)			
Postoperative 24 h	5 (3-7)	6 (4-8)	< 0.001
Postoperative 48 h	3 (1-5)	4 (1-7)	< 0.001
Postoperative 72 h	2 (1-4)	3 (1-5)	< 0.001
I-FEED[d] scores, median (min-max)			
Postoperative 24 h	3 (2-4)	3 (2-4)	< 0.001
Postoperative 48 h	2 (0-2)	2 (1-3)	< 0.001
Postoperative 72 h	1 (0-2)	2 (1-3)	< 0.001
QoR-40[e] scores, median (min-max)			
Day of discharge	196 (192-198)	192 (188-198)	< 0.001
Length of hospital stay, mean (SD), d	6.1 (1.7)	6.2 (1.3)	0.793
Vomiting, n (%)	3 (7.0)	9 (20.0)	0.142
Use of additional analgesic, n (%)	1 (2.3)	4 (8.9)	0.385
Bowel obstruction, n (%)	1 (2.3)	0 (0)	0.489

a: Lymphocyte to monocyte ratio. b: Platelet to neutrophil ratio. c: Pain scores on visual analogue scale. d: Intake, feeling nauseated, emesis, physical examination, and duration of symptoms. e: Quality of recovery-40 questionnaire.

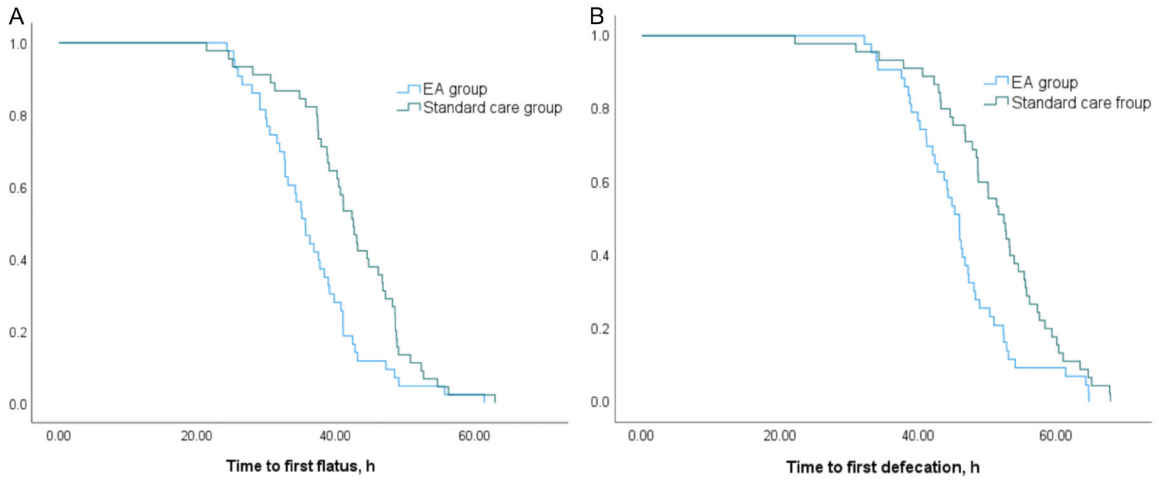


Figure 2. A. Time to first flatus is compared using the Kaplan-Meier curve. Curve Interpretation: The faster the curve falls, the earlier the event occurs. The curve declined more rapidly in the EA group, indicating that patients in the EA group had their first flatus significantly earlier than those in the control group. HR value: HR = 1.9 (95% CI, 1.2-2.9), indicating that the time to first flatus was 1.9 times faster in the EA group than in the control group, i.e., patients in the EA group had earlier flatus. *P* value: P < 0.001, indicating a statistically significant difference between groups. B. Time to first defecation is compared using the Kaplan-Meier curve. Curve Interpretation: The faster the curve falls, the earlier the event occurs. The curve declined more rapidly in the EA group, indicating that patients in the EA group had their first defecation significantly earlier than those in the control group. HR value: HR = 1.9 (95% CI, 1.2-3.0), indicating that the time to first defecation was 1.9 times faster in the EA group than in the control group, i.e., patients in the EA group had earlier defecation. *P* value: P = 0.01, indicating a statistically significant difference between groups.

or without additional resection of uterine adnexa.

Our study demonstrated that EA (ST36/ST37/ST39) combined with ERAS significantly shortened the time to first flatus and defecation compared to the standard care arm for the recovery of gastrointestinal motility. The HR for time to first flatus was 1.9 (95% CI, 1.2-2.9; P < 0.001), and the HR for time to first defecation was 1.9 (95% CI, 1.2-3.0; P = 0.01), indicating that patients receiving EA experienced a significantly faster recovery of GI function compared to the control group. Specifically, these HRs suggest that EA was associated with an approximately 90% increase in the likelihood of earlier flatus and defecation compared to standard care alone. In practical terms, this acceleration in GI recovery is clinically meaningful, as earlier restoration is closely linked to shorter hospital stays and improved postoperative outcomes [21]. However, there were no significant differences in secondary outcomes such as LOS, and the following points can explain this. First, LOS is influenced by a multitude of factors beyond GI motility, including surgical complications, pain management, patient mobility, and overall physiological recovery. Second, although EA significantly improved GI motility, the magnitude of this effect may not have been sufficient to translate into a statistically significant reduction in LOS. Third, hospitals often have standardized discharge criteria that are not solely based on GI recovery. Finally, differences in baseline characteristics, comorbidities, or surgical procedures among patients may introduce variability that masks the effect of EA on LOS.

POGD is the most serious form of impaired GI function recovery and is consistent with what is considered a postoperative ileus by most clinicians. Additionally, it is associated with prolonged LOS, increased surgical complications, and increased costs [22]. A series of intricate neurological, inflammatory, hydro-electrolytic, and pharmacological mechanisms are involved in the opening of the peritoneal cavity and manipulation of the digestive tract, culminating in the temporary paralysis of the digestive tract and the cessation of peristalsis [23]. Laparoscopic surgery involves shorter incisions, less tissue trauma, less bleeding, lower potential for desiccation, and lower potential for contamination by foreign bodies. According to a meta-analysis, laparoscopic surgery was linked, albeit only in subgroup analysis, to a lower overall incidence of late postoperative intestinal blockage following cancer surgeries [24]. Inflammatory pain, neuropathic pain, or pain based on hyperalgesia could be ameliorated by the use of intraoperative anesthesia and postoperative analgesic pumps, however, different anesthesia regimens may have adverse effects on postoperative gastrointestinal recovery [25]. Unfortunately, preventive measures are limited, and further research is needed.

A recent animal study revealed that EA of hindlimb regions (bilateral ST36 acupoint) inhibited the expression of GABAA receptors in DMV neurons, which excited the vagal nerve and, in turn, suppressed IM-induced inflammation via activation of the α7nAChR-mediated JAK2/STAT3 signaling pathway [26]. As demonstrated in another animal study, EA at ST36 is a noninvasive and effective technique that, independent of the spleen, reduces local intestinal inflammation via the vagus nerve [27]. A meta-analysis of sixteen clinical trials (1562 patients) indicates that EA enhances digestive system activity and reduces pain intensity following abdominal surgery [28]. Moreover, perioperative acupuncture treatments are practical and safe for patients undergoing abdominal surgery, as demonstrated by a recent randomized controlled trial [29]. Chronic inflammation leads to gastrointestinal dyskinesia, manifested by delayed gastric emptying and prolonged intestinal transit time. Inflammatory factors can act directly on the enteric nervous system (ENS) and smooth muscle cells, inhibiting their function [30]. EA has been shown to activate the vagus nerve, leading to the release of neurotransmitters such as acetylcholine. Acetylcholine binds to α7 nicotinic acetylcholine receptors (α7nAChR) on macrophages and other immune cells, inhibiting the release of pro-inflammatory cytokines (e.g., TNF-α and IL-6) and thereby reducing systemic inflammation [15]. Additionally, EA-induced vagal activation can influence the composition and activity of gut microbiota, promoting the growth of beneficial bacteria (e.g., Lactobacillus and Bifidobacterium) that produce anti-inflammatory metabolites such as short-chain fatty acids (SCFAs), and these SCFAs further modulate immune responses and reduce inflammation [31, 32]. EA modulates GI function by stimulating the vagal nerve system and generating an anti-

inflammatory effect. Additionally, EA has been found to protect interstitial cells of Cajal (ICC), pacemaker cells in the gastrointestinal tract that regulate gut motility, potentially through the release of neurotransmitters such as nitric oxide (NO) and serotonin (5-HT), which influence smooth muscle contraction and relaxation [33, 34]. In this study, patients assigned to receive EA treatment during the early postoperative period experienced earlier flatus and defecation compared to the control group. The median postoperative pain levels and I-FEED scores in the EA group were lower than those in the control arm at 24, 48 and 72 hours after the surgery. Nonetheless, the exact mechanisms underlying acupuncture's role in gastrointestinal function recovery warrant further investigation. Acupuncture is a safe, cost-effective, noninvasive, and widely available nonpharmacological therapy for managing various disorders. Scientific research and clinical applications of acupuncture have expanded worldwide [35]. Similarly, EA was well tolerated during our study, and no serious adverse events or complications related to the procedure were recorded.

Several limitations must be acknowledged. First, a key limitation is the absence of a sham acupuncture control group. Given the well-documented placebo effects associated with acupuncture, the lack of a sham intervention may introduce bias in patient-reported outcomes. This limitation could influence the interpretation of the observed therapeutic effects, as the placebo response cannot be fully accounted for in the current study design. Future studies could incorporate a sham EA group, which involves non-penetrative needling or stimulation at non-acupoint sites, to help control for placebo effects and improve blinding. This approach would provide a more robust assessment of the specific effects of EA and enhance the validity of the findings. Second, the trial was conducted with women after laparoscopic surgery, and the small sample size necessitates cautious extrapolation of the findings. Future research should assess EA's efficacy in more diverse populations. Third, the primary outcomes of this study are subjective and vulnerable to potential biases of self-reporting, as some patients may not have recorded exact times. Fourth, VAS and I-FEED scales are subjective, as each individual has different thresholds for pain and bloating. In future studies, subjective measures should be supplemented with objective measures (e.g., imaging studies, motion markers). Fifth, although this study was conducted using the ERAS methodology, no official compliance measurements were taken, which may have impacted the comparability of the results. Lastly, hospitalization cost analysis was not included in this study. Incorporating an economic component into the results would enhance its applicability to healthcare policymakers and clinical practice. The strengths of our trial include standardized electroacupuncture procedures, low experimental costs, a rigorous combination of acupuncture points, and a strict recruitment and time schedule protocol.

Conclusions

In summary, individuals who have undergone surgery should have access to adequate and effective supplemental methods to prevent chronic gastrointestinal dysmotility and postoperative ileus (POI). This randomized clinical trial revealed that specific acupuncture points combined with the ERAS protocol shortened the time to first flatus and defecation after laparoscopic surgery for gynecological patients. Early perioperative electroacupuncture treatment is a safe, affordable, and effective approach that may contribute to reducing healthcare disparities by providing cost-effective alternatives for postoperative care in low-resource settings. Future studies should investigate the long-term benefits of EA across diverse surgical contexts and explore its integration into standardized perioperative care protocols. More importantly, we could effectively promote the application of acupuncture in clinical training and multidisciplinary cooperation, enhancing its clinical value by incorporating acupuncture into clinical training programs, forming multidisciplinary teams, conducting joint research, standardizing operations, enhancing regulation, and promoting evidence-based medicine.

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Disclosure of conflict of interest

None.

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References

[1] Mazzotta E, Villalobos-Hernandez EC, Fiorda-Diaz J, Harzman A and Christofi FL. Postoperative Ileus and postoperative gastrointestinal tract dysfunction: pathogenic mechanisms and novel treatment strategies beyond colorectal enhanced recovery after surgery protocols. Front Pharmacol 2020; 11: 583422.

[2] Wang Y, Wang L, Ni X, Jiang M and Zhao L. Effect of acupuncture therapy for postoperative gastrointestinal dysfunction in gastric and colorectal cancers: an umbrella review. Front Oncol 2024; 14: 1291524.

[3] He GZ, Bu N, Li YJ, Gao Y, Wang G, Kong ZD, Zhao M, Zhang SS and Gao W. Extra loading dose of dexmedetomidine enhances intestinal function recovery after colorectal resection: a retrospective cohort study. Front Pharmacol 2022; 13: 806950.

[4] Li WJ, Gao C, An LX, Ji YW, Xue FS and Du Y. Perioperative transcutaneous electrical acupoint stimulation for improving postoperative gastrointestinal function: a randomized controlled trial. J Integr Med 2021; 19: 211-218.

[5] Yang JW, Shao JK, Wang Y, Liu Q, Liang JW, Yan SY, Zhou SC, Yang NN, Wang LQ, Shi GX, Pei W and Liu CZ. Effect of acupuncture on postoperative ileus after laparoscopic elective colorectal surgery: a prospective, randomised, controlled trial. EClinicalMedicine 2022; 49: 101472.

[6] Sun L, Wei X, Feng T, Gu Q, Li J, Wang K and Zhou J. Electroacupuncture promotes gastrointestinal functional recovery after radical colorectal cancer surgery: a protocol of multicenter randomized controlled trial (CORRECT trial). Int J Colorectal Dis 2024; 39: 198.

[7] Wolthuis AM, Bislenghi G, Fieuws S, de Buck van Overstraeten A, Boeckxstaens G and D'Hoore A. Incidence of prolonged postoperative ileus after colorectal surgery: a systematic review and meta-analysis. Colorectal Dis 2016; 18: 01-9.

[8] Huang WH, Zhang J, Ding SS and Xue JJ. Efficacy of acupuncture for nausea and vomiting after laparoscopic surgery: a systematic review and meta-analysis. Asian J Surg 2023; 46: 4462-4464.

[9] Boitano TKL, Smith HJ, Rushton T, Johnston MC, Lawson P, Leath CA 3rd, Xhaja A, Guthrie MP and Straughn JM Jr. Impact of enhanced recovery after surgery (ERAS) protocol on gastrointestinal function in gynecologic oncology patients undergoing laparotomy. Gynecol Oncol 2018; 151: 282-286.

[10] Gungorduk K, Paskal EK, Demirayak G, Köseoğlu SB, Akbaba E and Ozdemir IA. Coffee consumption for recovery of intestinal function after laparoscopic gynecological surgery: a randomized controlled trial. Int J Surg 2020; 82: 130-135.

[11] Wang Y, Yang JW, Yan SY, Lu Y, Han JG, Pei W, Zhao JJ, Li ZK, Zhou H, Yang NN, Wang LQ, Yang YC and Liu CZ. Electroacupuncture vs sham electroacupuncture in the treatment of postoperative ileus after laparoscopic surgery for colorectal cancer: a multicenter, randomized clinical trial. JAMA Surg 2023; 158: 20-27.

[12] Yang L, Ding W, Dong Y, Chen C, Zeng Y, Jiang Z, Gan S, You Z, Zhao Y, Zhang Y, Ren X, Wang S, Dai J, Chen Z, Zhu S, Chen L, Shen S, Mao J and Xie Z. Electroacupuncture attenuates surgical pain-induced delirium-like behavior in mice via remodeling gut microbiota and dendritic spine. Front Immunol 2022; 13: 955581.

[13] Zheng J, Wang Y, Zhang C, Zhang A, Zhou Y, Xu Y, Yu J and Tian Z. Electroacupuncture negatively regulates the Nesfatin-1/ERK/CREB pathway to alleviate HPA axis hyperactivity and anxiety-like behaviors caused by surgical trauma. Chin Med 2024; 19: 108.

[14] Hou Y, Guo X, Ran J, Lu X and Xie C. Conductive polyphenol microneedles coupled with electroacupuncture to accelerate wound healing and alleviate depressive-like behaviors in diabetes. Bioact Mater 2025; 44: 516-530.

[15] Liu S, Wang Z, Su Y, Qi L, Yang W, Fu M, Jing X, Wang Y and Ma Q. A neuroanatomical basis for electroacupuncture to drive the vagal-adrenal axis. Nature 2021; 598: 641-645.

[16] Chen KB, Huang Y, Jin XL and Chen GF. Electroacupuncture or transcutaneous electroacupuncture for postoperative ileus after abdominal surgery: a systematic review and meta-analysis. Int J Surg 2019; 70: 93-101.

[17] Wu XD, Huang LX and Zhao JS. Interpretation of China national standard Nomenclature and Location of Meridian Points (GB/T 12346-2021). Zhongguo Zhen Jiu 2022; 42: 579-582.

[18] Xue J, Xu Z, Wang Q, Hou H, Wei L, Zhang J, Zhao X, Chen L, Ding F, Ma L, Zhao Y, Wang Y, Ma D, Wang T, Liu R, Gan TJ, Robinson N, Frank Y, Su F, Chi Y, Yang D, Liu S, Cui S, Wei Y, Chen Z, Qin Y, Cao L, Chen G, Shu K, Xiao Z, Zhang H,

Yu J, Hu Z, Cheng H, Ma W, Liu G, Wang X, Cao X, Gao J, Kong G, Tao Q, Wang B, Wang J, Li H, Lyu C, Zhang Z, Li T and Yang K. Clinical practice guidelines for prevention and treatment of postoperative gastrointestinal disorder with Integrated Traditional Chinese and Western Medicine (2023). J Evid Based Med 2024; 17: 207-223.

[19] Alsharqawi N, Alhashemi M, Kaneva P, Baldini G, Fiore JF Jr, Feldman LS and Lee L. Validity of the I-FEED score for postoperative gastrointestinal function in patients undergoing colorectal surgery. Surg Endosc 2020; 34: 2219-2226.

[20] Vignaud M, Morel C, Henault A, Futier E, Pereira B, Lambert C and Beloeil H. Variability and reliability of the french version of the quality of recovery-40 questionnaire (QoR-40). Anaesth Crit Care Pain Med 2021; 40: 100822.

[21] Kong Q, Chen LM, Liu CY, Li W and Yin PH. The effect of acupuncture on gastrointestinal recovery after abdominal surgery: a narrative review from clinical trials. Int J Surg 2024; 110: 5713-5721.

[22] Hedrick TL, McEvoy MD, Mythen MMG, Bergamaschi R, Gupta R, Holubar SD, Senagore AJ, Gan TJ, Shaw AD, Thacker JKM, Miller TE, Wischmeyer PE, Carli F, Evans DC, Guilbert S, Kozar R, Pryor A, Thiele RH, Everett S, Grocott M, Abola RE, Bennett-Guerrero E, Kent ML, Feldman LS and Fiore JF Jr. American society for enhanced recovery and perioperative quality initiative joint consensus statement on postoperative gastrointestinal dysfunction within an enhanced recovery pathway for elective colorectal surgery. Anesth Analg 2018; 126: 1896-1907.

[23] Buscail E and Deraison C. Postoperative ileus: a pharmacological perspective. Br J Pharmacol 2022; 179: 3283-3305.

[24] Yamada T, Okabayashi K, Hasegawa H, Tsuruta M, Yoo JH, Seishima R and Kitagawa Y. Meta-analysis of the risk of small bowel obstruction following open or laparoscopic colorectal surgery. Br J Surg 2016; 103: 493-503.

[25] Weibel S, Jelting Y, Pace NL, Helf A, Eberhart LH, Hahnenkamp K, Hollmann MW, Poepping DM, Schnabel A and Kranke P. Continuous intravenous perioperative lidocaine infusion for postoperative pain and recovery in adults. Cochrane Database Syst Rev 2018; 6: CD009642.

[26] Yang NN, Yang JW, Ye Y, Huang J, Wang L, Wang Y, Su XT, Lin Y, Yu FT, Ma SM, Qi LY, Lin LL, Wang LQ, Shi GX, Li HP and Liu CZ. Electroacupuncture ameliorates intestinal inflammation by activating α7nAChR-mediated JAK2/STAT3 signaling pathway in postoperative ileus. Theranostics 2021; 11: 4078-4089.

[27] Liu S, Fu W, Fu J, Chen G, He Y, Zheng T and Ma T. Electroacupuncture alleviates intestinal inflammation via a distinct neuro-immune signal pathway in the treatment of postoperative ileus. Biomed Pharmacother 2024; 173: 116387.

[28] Chen HT, Hung KC, Huang YT, Wu JY, Hsing CH, Lin CM, Chen IW and Sun CK. Efficacy of electroacupuncture in improving postoperative ileus in patients receiving colorectal surgery: a systematic review and meta-analysis. Int J Surg 2024; 110: 1113-1125.

[29] Lam WL, Wang J, Yeung WF, Cheung CW, Chan KKL, Ngan HYS, Wong CKH, Jiang F, Ma PWS, Leung TW, Leung WC, Liu TC, Chen H and Lao L. A combination of electroacupuncture and auricular acupuncture for postoperative pain after abdominal surgery for gynaecological diseases: a randomized controlled trial. Phytomedicine 2022; 104: 154292.

[30] Bercik P, Collins SM and Verdu EF. Microbes and the gut-brain axis. Neurogastroenterol Motil 2012; 24: 405-413.

[31] Xu H, Wen Q, Hu H, Yang S, Lu L, Hu X, Li H, Huang X and Li N. Electroacupuncture at ST36 modulates the intestinal microecology and may help repair the intestinal barrier in the rat model of severe acute pancreatitis. Microb Biotechnol 2024; 17: e14401.

[32] Bonaz B, Bazin T and Pellissier S. The vagus nerve at the interface of the microbiota-gut-brain axis. Front Neurosci 2018; 12: 49.

[33] Liu M, Zhang S, Gai Y, Xie M and Qi Q. Changes in the interstitial cells of cajal and immunity in chronic psychological stress rats and therapeutic effects of acupuncture at the zusanli point (ST36). Evid Based Complement Alternat Med 2016; 2016: 1935372.

[34] Zhang R, Lao L, Ren K and Berman BM. Mechanisms of acupuncture-electroacupuncture on persistent pain. Anesthesiology 2014; 120: 482-503.

[35] Song G, Fiocchi C and Achkar JP. Acupuncture in inflammatory bowel disease. Inflamm Bowel Dis 2019; 25: 1129-1139.