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Review

Electroacupuncture or transcutaneous electroacupuncture for postoperative ileus after abdominal surgery: A systematic review and meta-analysis

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ABSTRACT

Background: At present, there is no ideal treatment for postoperative ileus (POI) after abdominal surgery. This meta-analysis aims to evaluate the efficacy of electroacupuncture (EA) and transcutaneous electroacupuncture (TEA) in improving postoperative POI.

Methods: We systematically screened randomized controlled trials (RCTs) from multiple databases and included 15 high quality RCTs. Two investigators independently conducted data extraction, risk of bias assessment and statistical analysis. Meta-analysis was performed by a random- (REM) or fixed-effect (FIXED) model.

Results: A total of 15 trials involving 965 participates were included. Meta-analysis results favored EA/TEA treatment for POI by analysis of time to first flatus [mean difference (MD) −11.60 h, I^2 = 94%, REM)], time to first defecation (MD −12.94 h, I^2 = 90%, REM), time to bowel sound recovery (MD −7.25 h, I^2 = 85%, REM), time to first oral feeding (MD −15.76 h, I^2 = 47%, REM) and length of hospital stay (MD −1.19 d, I^2 = 44%, REM). Subgroup analysis of laparoscopic surgery patients also favored EA/TEA by analysis of time to first flatus (MD −2.46 h, I^2 = 0%, FIXED), time to first oral feeding (MD −10.73 h, I^2 = 0%, FIXED) and length of hospital stay (MD −1.30 d, I^2 = 32%, REM). ST36 (Zusanli), ST37 (Shangjuxu) and ST39 (Xiajuxu) are preferred EA/TEA acupoints for treating POI. There was no significant difference in postoperative analgesic consumption between EA and control groups (P = 0.39). No severe adverse events associated with EA/TEA were reported.

Conclusion: This meta-analysis suggests that EA/TEA is a safe, effective treatment for POI after abdominal surgeries including laparoscopic surgery, and that EA/TEA does not relieve postoperative pain after abdominal surgery. There is significant heterogeneity of research on this subject, thus, a professional consensus is needed to establish a standard protocol for use of this technique.

1. Introduction

Postoperative ileus (POI) is a common condition related to disturbances to gastrointestinal motility after abdominal surgeries, such as cancer resection. POI is associated with distension, nausea, vomiting and diet intolerance [1]. Factors contributing to the development of POI include surgical inflammation, activated sympathetic tone, mental status and bowel edema [2]. Although most patients recover from POI, there is a need to shorten the duration of POI to relieve these symptoms, decrease the length of hospital stays, and lower medical costs.

Prokinetic agents are controversial treatments for alleviating POI, because they can not be given after upper gastrointestinal surgery to patients who have been fasting. Enhanced recovery after surgery (ERAS) is an effective, comprehensive strategy for reducing surgery recovery time and includes various components such as early ambulation, early enteral nutrition, pain control and minimal invasive surgery [3,4].

Acupuncture, a traditional Chinese treatment for various conditions, is garnering increased attention from clinical practitioners and patients worldwide. Electroacupuncture (EA) is a modified acupuncture technique that involves stimulation of specific acupoints with small electrical currents alongside traditional acupuncture. There are various available acupoints distributed on specific line of body. And each acupoint with EA can exhibit different therapeutic effect on gastrointestinal disorders. The newly developed transcutaneous EA (TEA) method does not involve needles and has the advantages of being non-invasive, portable and the ability to be self-administered by the patient at home. To date, a small number of research studies have suggested that EA and TEA have potential to alleviate POI [5–8]. Our recent research study found that TEA could accelerate bowel movements as a

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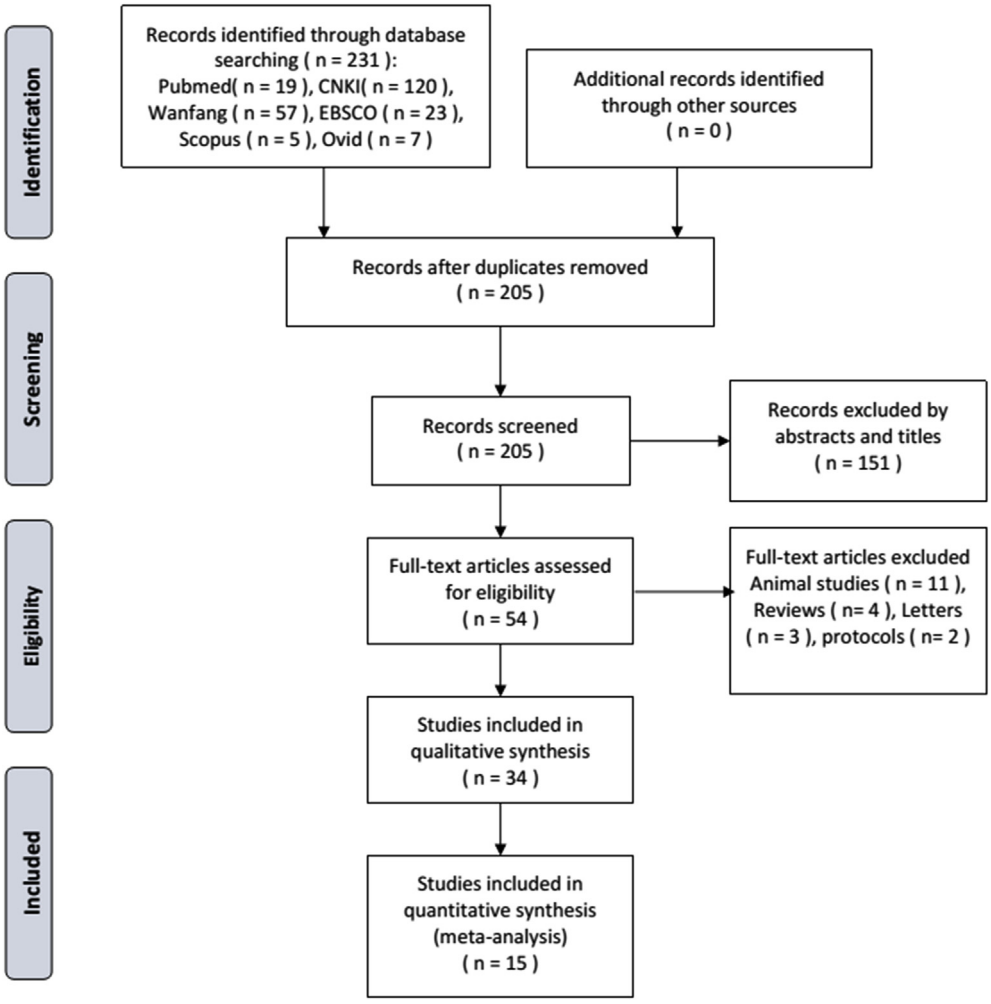

Fig. 1. PRISMA flow diagram of studies included in the review.

potential method of treating POI in post-gastrectomy patients [9]. However, there remains a lack of sufficient evidence to reach a conclusion on this subject. Hence, we systematically searched for published articles related to this treatment and carried out a systematic review. To our knowledge, this is the first meta-analysis focusing on the outcomes of EA and TEA in the treatment of POI after abdominal surgery.

2. Materials and methods

2.1. Search strategy

PubMed, Web of Science, China National Knowledge Infrastructure (CNKI), Wanfang, EBSCO, Scopus and Ovid databases were searched by two independent investigators for high-quality RCTs using the following combined terms (1# AND 2# OR 3#): 1# “electroacupuncture”, OR “transcutaneous electroacupuncture”, OR “transcutaneous electrical nerve stimulation” OR “electrical acustimulation”; 2# “postoperative”, OR “postoperative ileus”, OR “postoperative gastrointestinal motility disorder”, OR “postoperative gastrointestinal function recovery”, OR “postoperative gastrointestinal dysfunction”; 3# “surgery”, OR “abdominal surgery”.

2.2. Inclusion and exclusion criteria

The inclusion criteria were [1]: participants aged > 18 years and undergoing abdominal surgery including open and laparoscopic surgery [2]; intervention consisting of perioperative EA or TEA at single or combined acupoints, with or without acupoint drug injection [3]; the control group receiving no EA, sham EA or drug therapy [4]; outcomes evaluating time to first flatus and/or defecation and/or bowel sound recovery, and/or time to first oral feeding, and/or length of hospital stay, and/or postoperative analgesic consumption; and [5] only randomized controlled trials (RCTs).

The exclusion criteria were [1]: animal studies [2]; reviews, letters or protocols [3]; duplicate articles; and [4] no sufficient outcomes related to POI.

2.3. Data extraction and quality assessment

Data extraction was independently conducted by two investigators according to the criteria above. Disagreements were resolved through discussion and consensus was reached with a third investigator. All available information related to our research topic was extracted from the included studies. To address variations between studies, we divided outcomes into primary and secondary outcomes, and did a subgroup analysis from data of laparoscopic surgeries. The methodological qualities of the included trials were assessed by two investigators according to the Cochrane risk of bias tool. The contents included random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, selective reporting, and incomplete outcome data. The risk of bias was classified as low, high or unclear.

2.4. Statistical analysis

A meta-analysis was performed by a random- or fixed-effect model using RevMan version 5.3. Continuous variables were expressed as mean difference (MD) with 95% confidence interval (CI) and $P < 0.05$ was considered significant. Heterogeneity of the data was assessed using I^2 values. If I^2 was < 25%, we used a fixed-effect model to pool the data. If I^2 was ≥25%, we used a random-effect model for meta-analysis. Funnel plots were generated to detect publication bias, and a subgroup analysis was performed for data from laparoscopic surgeries.

The work has been reported in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines.

3. Results

A total of 231 articles were identified during the initial study selection. Twenty-six duplicates were removed, and 151 articles were excluded after reviewing abstracts and titles. An additional eleven animal studies, four reviews, three letters, and two protocols were excluded from the study pool. 20 articles were also excluded due to low study quality and insufficient data for the analysis. 15 articles were ultimately included in the final meta-analysis [5,9–22]. A flow diagram of the screening process is summarized in Fig. 1. The majority of trials were well-designed and used random treatment assignment, and the risk of bias was assessed for all included trials by the Cochrane risk of bias tool, as listed in Fig. 2.

3.1. Study characteristics

A total of 15 studies were included in this systematic review and meta-analysis. All studies were conducted in China including one in Hong Kong. There were 489 participants in the EA or TEA groups and 476 participants in the control groups (Table 1).

There were various differences among these trials. Three trials involved laparoscopic surgery, while the other 12 trials involved open surgery. Surgery type included colorectal (40%, 6/15), gastrointestinal (40%, 6/15) and hepatobiliary (26.7%, 4/15) surgery, vascular laparotomy (6.7%, 1/15) and undefined (20%, 3/15). Notably, a single abdominal surgery (one type) was performed in seven trials, and mixed abdominal surgeries (≥2 types) were performed in another eight trials. Only one trial performed TEA and 14 performed EA. The most selected acupoints were Zusanli (ST36) (93.3%, 14/15), Shangjuxu (ST37) (40%, 6/15) and Xiajuxu (ST39) (20%, 3/15), while less frequently selected acupoints included Neiguan (PC6), Sanjinjiao (SP6), Taichong (LR3), Zhigou (SJ6), Yanglingquan (GB34), Hegu (LI4) and Quchi (LI11). The majority of studies (93.3%, 14/15) used EA/TEA postoperatively until the first flatus or defecation, while the other study used EA within the 24 h prior to the surgery. Control treatments involved standard postoperative care or sham EA.

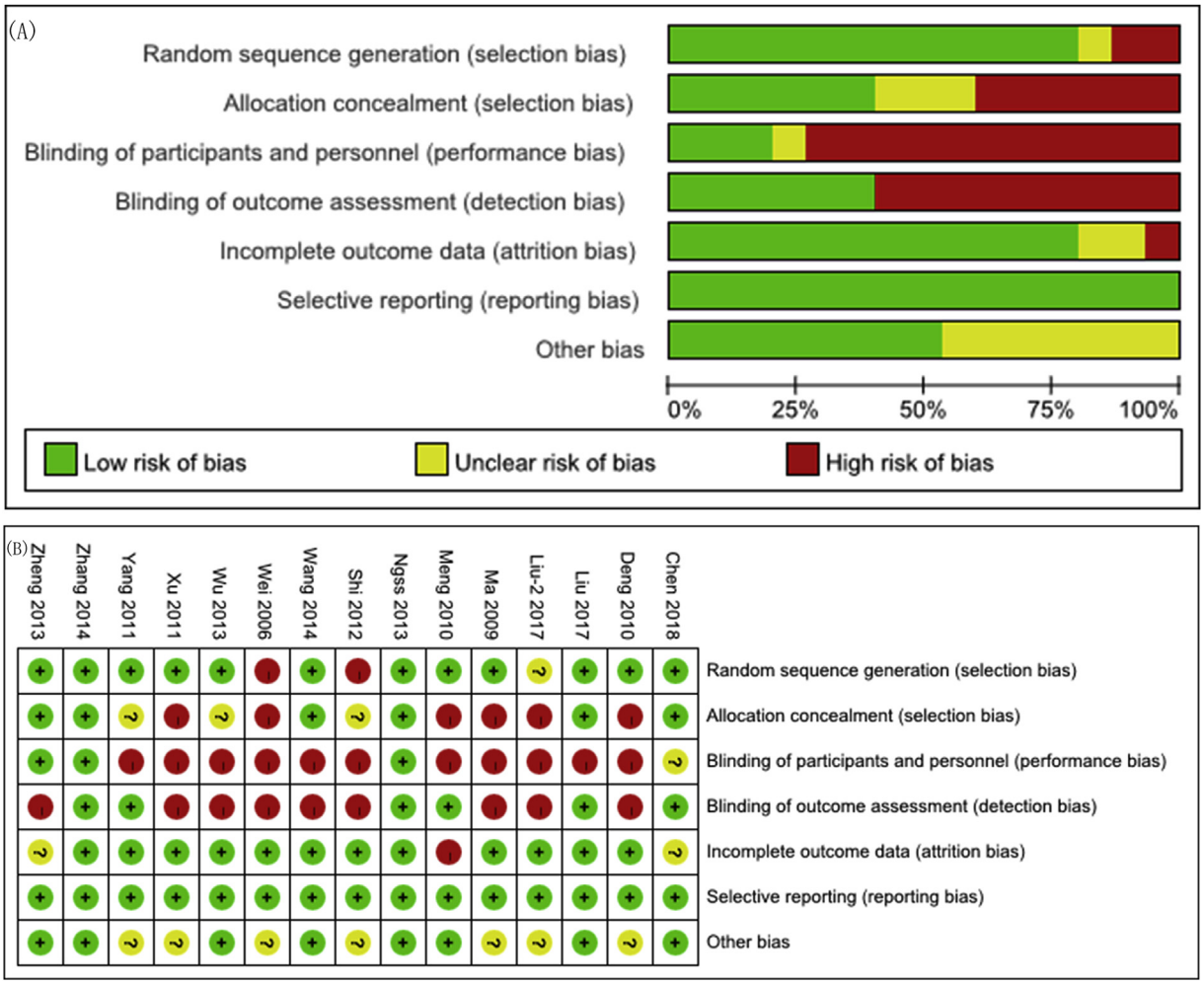

Fig. 2. (A) Risk of bias: authors' judgments about each risk of bias item presented as percentages across all included studies. (b) Risk of bias summary: authors' judgments about each risk of bias for each included study.

Table 1
Characteristics of included clinical EA or TEA trials of POI treatment.

Author year (Ref)	Sample size (E/C)	Age (yr)(E/C)	Abdominal surgery type	EA or TEA procedures	Timing	Control interventions
Chen 2018 [9]	63 (33/30)	63.0 ± 9.70/59.0 ± 8.30	Open & laparoscopic gastrectomy	TEA at unilateral ST36 and PC6 1 h twice daily	Post-postoperative day 1	Routine treatment
Deng 2010 [10]	70 (35/35)	49.11 ± 16.23/44.66 ± 19.53	Gastrointestinal and hepatobiliary surgery	EA at bilateral ST36, SP6 and LR3 30 min twice/daily	Post-not exactly	Routine treatment
Liu 2017 [11]	42 (21/21)	56.0 ± 11.31/56.8 ± 12.16	Vascular laparotomy	EA at bilateral ST36, PC6 and ST37 20min twice/day	Pre-within 24 h before surgery	Routine treatment
Liu-2 2017 [12]	60 (30/30)	49.0 ± 15.78/49.53 ± 11.97	Minimally invasive surgery of cholelithiasis	EA at bilateral ST36 and ST37, with heat cornel applied to abdomen 30 min twice/daily	Post-2 h after surgery	Routine treatment
Ma 2009 [13]	60 (30/30)	43.2 ± 14.3/42.5 ± 12.4	Appendectomy, colon cancer surgery, cholecystectomy	EA at bilateral ST36 30 min three times/daily	Post-12 h after surgery	Routine treatment
Meng 2010 [14]	85 (44/41)	54.3/53.1	Colon cancer surgery	EA at bilateral SJ6 and GB34 20min once/day	Post-postoperative day 1	Routine treatment
Ngss 2013 [5]	110 (55/55)	67.4 ± 9.7/68.5 ± 10.6	Laparoscopic colorectal surgery	EA at ST36, SP6, LI4 and SJ6 20min once/daily	Post-postoperative day 1	Routine treatment
Shi 2012 [15]	60 (30/30)	53.17 ± 13.49/53.77 ± 13.32	Subtotal gastrectomy, colon cancer surgery	EA at bilateral ST36, ST37 and ST39 30min twice/daily	Post-6 h after surgery	Routine treatment
Wang 2014 [16]	60 (30/30)	43.79 ± 11.73/43.93 ± 13.47	Abdominal surgery	EA at ST36, ST37, ST39, LI4 and LI11 30min twice/day	Post-postoperative day 1	Routine treatment
Wei 2006 [17]	60 (30/30)	37.27 ± 14.69/37.59 ± 13.83	Appendectomy, cholecystectomy, subtotal gastrectomy	EA at bilateral ST36, ST37 30min twice/daily	Post-6 h after surgery	Routine treatment
Wu 2013 [18]	60 (30/30)	53.13 ± 3.37/57.03 ± 3.23	Total/subtotal gastrectomy, colon cancer surgery	EA at bilateral ST36 30min twice/daily	Post-Postoperative day 1	Routine treatment
Xu 2011 [19]	45 (24/21)	57.5 ± 12.38/57.91 ± 14.11	Abdominal surgery	EA at bilateral ST36 30 min twice/daily	Post-postoperative day1	Routine treatment
Yang 2011 [20]	60 (31/29)	60.9 ± 6.63/62 ± 6.89	Colorectal surgery	EA at bilateral ST36, ST37 and ST39 30 min once/daily	Post-postoperative day1	Routine treatment
Zhang 2014 [21]	39 (19/20)	63 ± 9/60 ± 10	Colorectal surgery	EA at bilateral ST36 30min once/day	Post-30 min after surgery	Sham EA on bilateral sham ST36 30min once/daily
Zheng 2013 [22]	91 (47/44)	51.57 ± 17.35/48.13 ± 17.02	Abdominal surgery	EA at bilateral ST36 30 min once/daily	Post-within 2 h after surgery	Routine treatment

E/C: experimental vs. control group, ST36: Zusanli acupoint, ST37: Shangjuxu acupoint, ST39: Xiajuxu acupoint, PC6: Neiguan acupoint, SP6: Sanyinjiao acupoint, LR3: Taichong acupoint, SJ6: Zhigou acupoint, GB34: Yanglingquan acupoint, LI4: Hegu acupoint, LI11: Quchi acupoint.

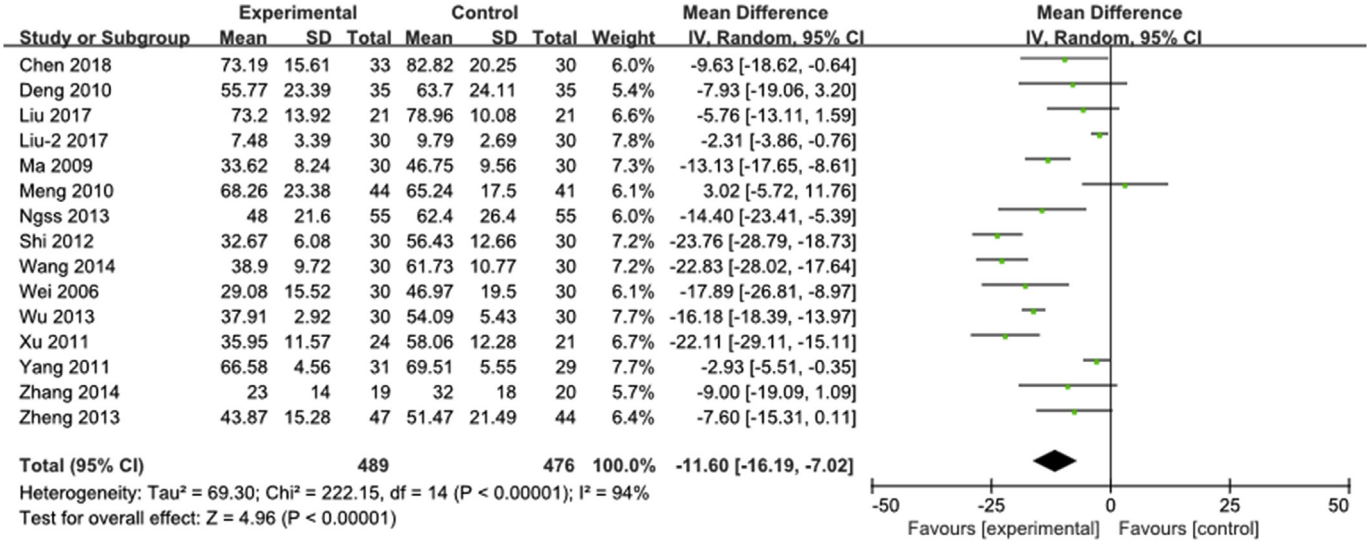

Fig. 3. Forest plot of time to first flatus in EA/TEA vs control.

3.2. Primary outcomes

All trials analyzed time to first flatus. Meta-analysis results indicated that time to first flatus in the EA and TEA groups was significantly shorter than that in the control group (MD −11.60h, 95%CI −16.19 to −7.02 h, I^2 = 94%, REM) (Fig. 3). Thirteen trials analyzed time to first defecation, with meta-analysis results indicating that time to first defecation in the EA and TEA groups was significantly shorter than that of the control group (MD −12.94 h, 95%CI −18.82 to −7.06 h, I^2 = 90%, REM) (Fig. 4).

3.3. Secondary outcomes

Time to bowel sound recovery in nine trials (MD −7.25 h, 95% CI −10.27 to −4.24 h, I^2 = 85%, REM) (Fig. 5), time to first oral feeding in six trials (MD −15.76 h, 95% CI −23.91 to −7.61 h, I^2 = 47%, REM) (Fig. 6) and length of hospital stay in eight trials (MD −1.19 d, 95% CI −1.78 to −0.6 d, I^2 = 44%, REM) (Fig. 7) were significantly shorter in the EA/TEA groups than in the control groups. Only two trials reported pain scores, and three reported postoperative analgesic consumption. There was no significant difference in postoperative analgesic consumption between the EA and control groups (P = 0.39) (Fig. 8).

3.4. Subgroup analysis for laparoscopic surgery

Three studies involved patients who had undergone laparoscopic surgery, including minimally invasive operations for cholelithiasis, laparoscopic colorectal surgery, and laparoscopic gastrectomy. Meta-analysis of laparoscopic patients revealed that patients in the EA/TEA groups had significantly shorter time to first flatus (MD −2.46 h, 95% CI −3.96 to −0.96 h, I^2 = 0%, FIXED) (Fig. 9), time to first oral feeding (MD −10.73 h, 95% CI −16.91 to −4.55 h, I^2 = 0%, FIXED) (Fig. 10) and length of hospital stay (MD −1.30 d, 95% CI −2.10 to −0.51 d, I^2 = 32%, REM) (Fig. 11) than the control groups.

4. Discussion

Acupuncture has been used for over 2000 years in China for treatment of various gastrointestinal disorders. EA is a modern clinical treatment that stimulates acupoints using electrical currents alongside traditional acupuncture, TEA involves the stimulation of specific acupoints without the use of needles via cutaneous electrodes. EA and TEA are of increasing popularity for rapid recovery of gastrointestinal function after abdominal surgeries. This systemic review concludes that EA and TEA are safe, effective treatment for POI after abdominal surgery. The results of this meta-analysis indicate that use of EA and TEA is associated with shorter time to first flatus, first defecation, bowel sound

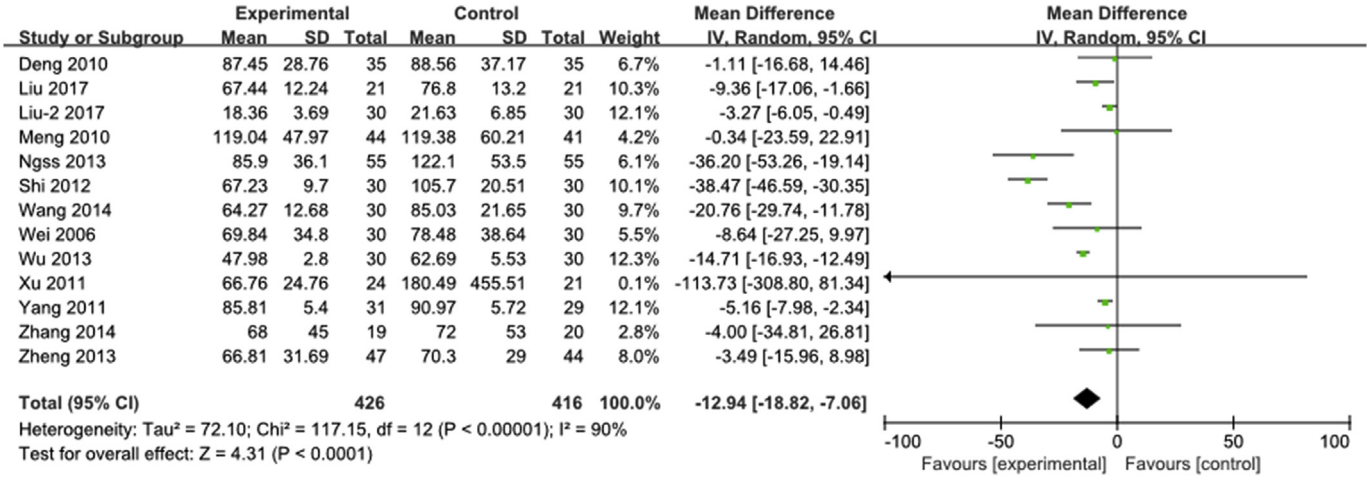

Fig. 4. Forest plot of time to first defecation in EA/TEA compared vs control.

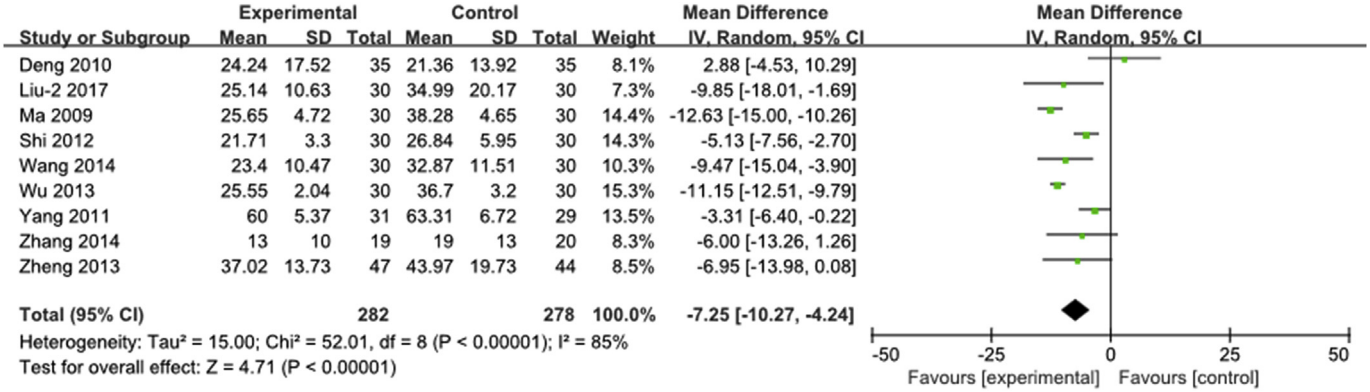

Fig. 5. Forest plot of time to bowel sound recovery in EA/TEA vs control.

recovery, first oral feeding and decreased length of hospital stay.

To our knowledge, this is the first meta-analysis focused on the effectiveness of TEA and EA in treating POI. The baseline characteristics of each study were different, so we performed a subgroup analysis on laparoscopic surgery cases. EA/TEA was found to accelerate recovery of gastrointestinal motility in patients who had received laparoscopic surgery with ERAS protocol. The finding that EA/TEA was beneficial for laparoscopic surgery patients is of vital significance to clinical work, as minimal invasive surgeries continue to increase in popularity. No adverse events were reported among the 15 trials, with the exception of one report of acupoint site bruising. In general, this data supports the safety of EA and TEA in abdominal surgery.

The underlying therapeutic mechanism of EA and TEA has not been fully elucidated. Here are five possible explanations [1]: EA at ST36 protects interstitial cells of Cajal and regulates immunity [2,23–27] EA has anti-inflammatory effects on tumor necrosis factor-α and NO activity [8,24] or anti-stress effects [3,28] EA regulates secretion of hormones related to small intestinal and colonic motility [8,29,30]; [4] EA or TEA at ST 36 activates the vagus nerve [6,7,31,32] to accelerate jejunal or colonic motility via the parasympathetic efferent pathway [33,34]; or [5] EA promotes gastric motility via the protein kinase C and mitogen-activated protein kinase signal transduction pathways [35]. Overall, the therapeutic mechanisms of EA and TEA are still controversial, but function preservation of the interstitial cells of Cajal and activation of the vagus nerve through EA/TEA are the most recognized mechanisms. Further research focused on determining the specific mechanism of action is required.

The most frequently selected acupoints were ST36 (93.3%, 14/15), ST37 (40%, 6/15) and ST39 (20%, 3/15). Based on theories of Chinese Medicine, these three acupoints are all located along the “Stomach Meridian” on the nearby lateral crural region. ST36, also called Zusanli is at the junction of the Stomach Meridian of Foot-Yangming, and plays an important role in balancing Yin and Yang *Qi* (two opposing principles in nature) in the abdomen to relieve distention and constipation. ST37, also called Shangjuxu is an acupoint that mainly regulates colon motility to assist passage of gas. Liang et al. demonstrated that EA stimulation at ST37 led to improved function of the enteric nervous system in a mouse model of constipation [36]. Similarly, Zhu et al. showed that EA at Li11 and/or ST37 improved colonic motility by increasing TPH (tryptophan hydroxylase) and serotonin levels in a cold-saline-induced rat model of constipation [30]. ST39, also called Xiajuxu, regulates motility of the small intestine, and has been traditionally applied in treating intestinal spasm. A study by Shen et al. provided evidence that EA and acupoint injection with neostigmine at ST36, ST37/ST39 and Dachangshu acupoint (BL25) shortened the recovery time of bowel sounds and gas passage [37]. Accordingly, these three acupoints are most frequently chosen in treating gastrointestinal dysfunction.

EA stimulation was applied at similar times during patient recovery amongst the included studies. Postoperative day one (7/15) was the most common time for EA stimulation, while EA was applied within 24 h before surgery in one study. Both pre- and postoperative EA were beneficial in treating POI. One animal study showed that EA had long-lasting effects on gastric activity via increased extracellular ion levels [38]. Based on our clinical experience, we recommend starting EA or TEA treatments one-day post-operation.

There were several notable limitations to this review. First, the assessed risk of bias was high due to allocation concealment, blinding of participants and personnel, and blinding of outcome assessment; this high risk of bias decreases the reliability of the data in related studies. Second, the trials were mostly performed in mainland China, so more high-quality clinical trials are required to confirm the efficacy of EA/TEA. Third, significant heterogeneity between studies was found through analysis of primary and secondary outcomes. As shown in Table 1, several types of abdominal surgeries were performed. Additionally, EA protocols, such as acupoint selection, EA timing, EA parameters, and duration of EA varied between studies. Accordingly, we recommend establishing a standardized protocol for EA therapy to minimize heterogeneity between studies. Finally, the analgesic effects of EA were not analyzed in this review due to insufficient data available

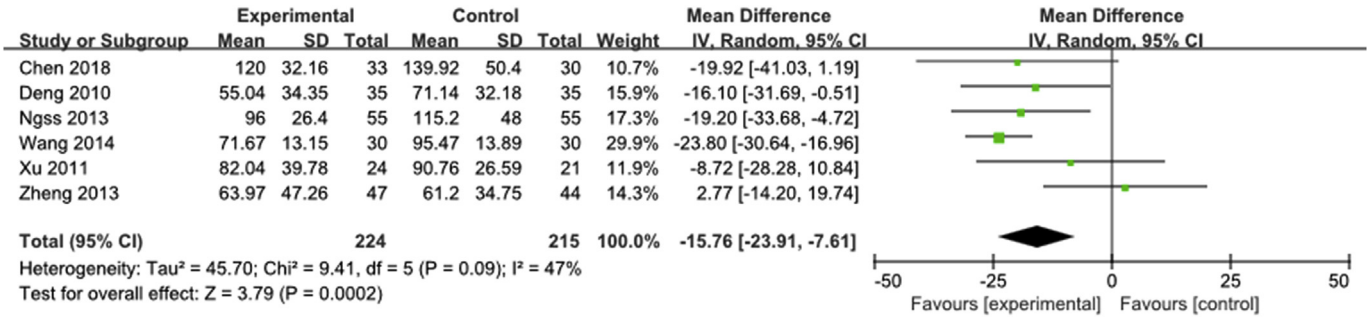

Fig. 6. Forest plot of time to first oral feeding in EA/TEA vs control.

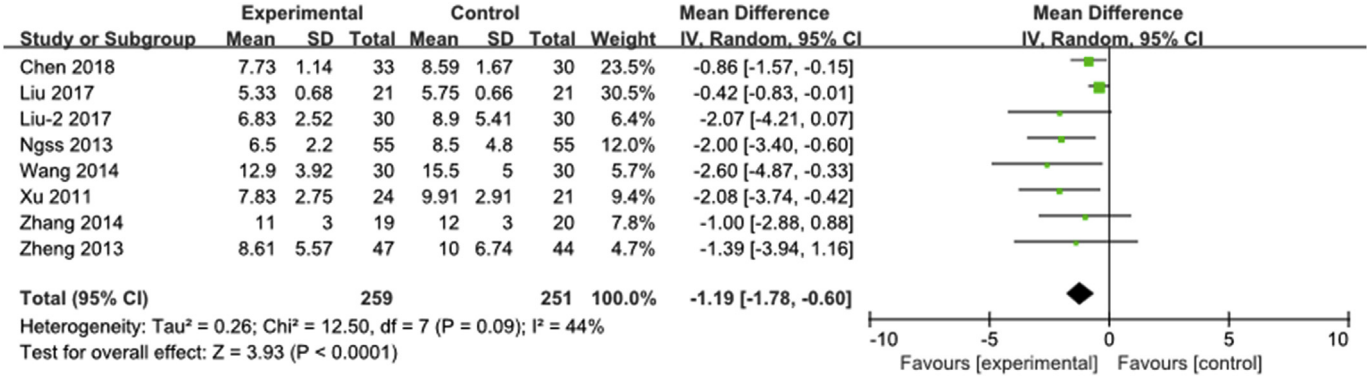

Fig. 7. Forest plot of length of hospital stay in EA/TEA vs control.

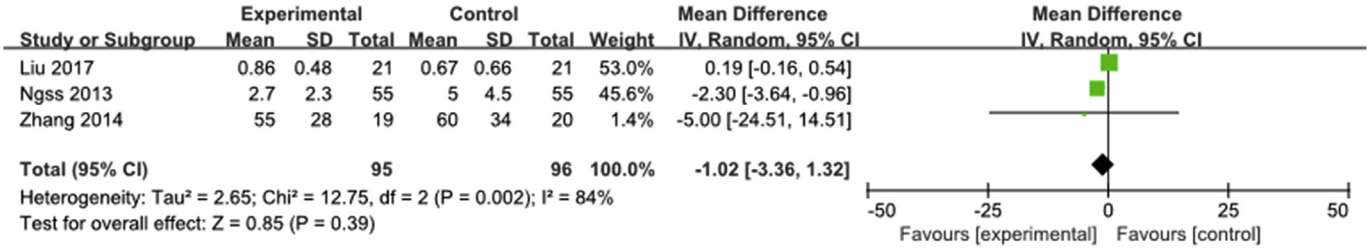

Fig. 8. Forest plot of postoperative analgesics consumption in EA/TEA vs control.

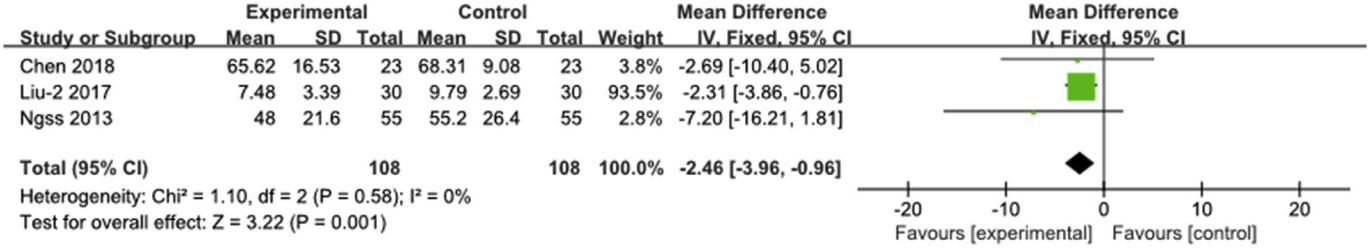

Fig. 9. Forest plot of time to first flatus of in EA/TEA vs control by subgroup analysis for laparoscopic surgery.

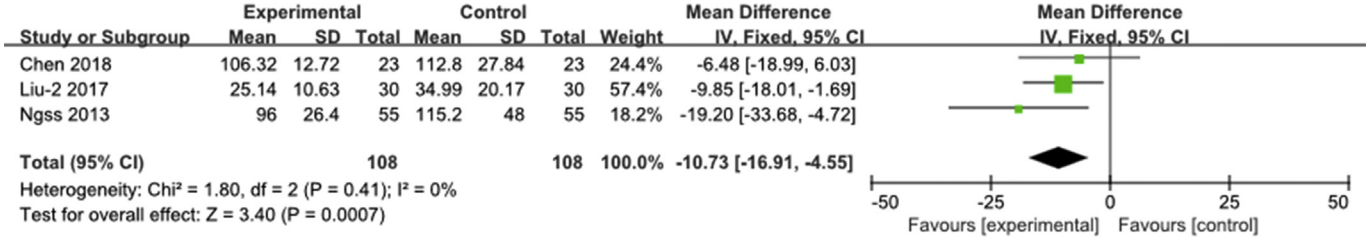

Fig. 10. Forest plot of time to first oral feeding in EA/TEA vs control by subgroup analysis for laparoscopic surgery.

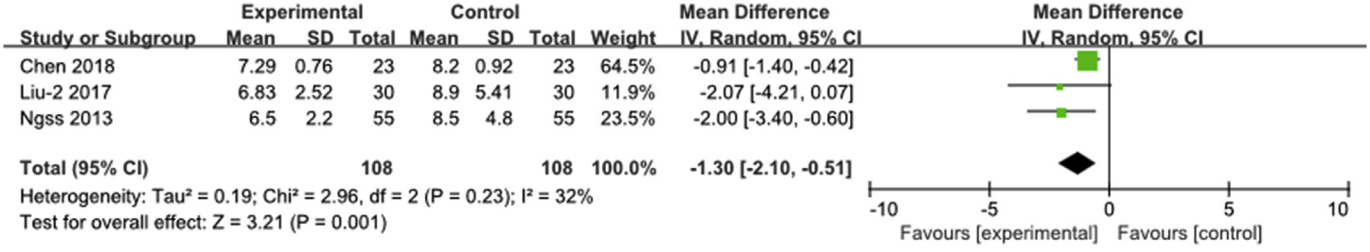

Fig. 11. Forest plot of length of hospital stay in EA/TEA vs control by subgroup analysis for laparoscopic surgery.

on this subject. The lack of difference in postoperative analgesic consumption between patients receiving EA and control patients indirectly suggests that EA did not relieve postoperative pain after abdominal surgery. In abdominal surgery patients, epidural anesthesia is selectively utilized to decrease postoperative pain scores by blocking afferent and efferent neural pathways [14]. However, one meta-analysis concluded that acupoint stimulation was effective in controlling pain in abdominal surgery patients [39]. Additionally, a prospective study found that intraoperative EA reduced postoperative pain and analgesic requirement in gynecological surgeries [40]. However, the underlying mechanism has not been determined. As mentioned before, EA has a potential role as a regulator of parasympathetic efferent pathways, therefore epidural anesthesia administration should be considered as a confounding factor in future clinical studies on the analgesic effects of EA and TEA.

TEA as a novel technique without the use of needles has clear advantages over the use of EA; TEA is non-invasive, convenient, portable, and postoperative patients are generally more receptive to the therapy. TEA has been applied to the treatment of functional dyspepsia [41], gastric dysrhythmia [42], chemotherapy-induced nausea and vomiting [43], and recently in recovery from post-gastrectomy ileus [9]. In our opinion, TEA is a promising method of treating POI.

5. Conclusion

This meta-analysis suggests that EA/TEA is an effective and safe treatment for POI following abdominal surgeries, including laparoscopic surgery. ST36, ST37, and ST39 are the preferred EA/TEA acupoints for treating POI. TEA is more promising for implementation than EA. There is a lack of clinical evidence on the ability of EA/TEA to relieve postoperative pain after abdominal surgery. Currently recognized therapeutic mechanisms of EA/TEA on POI are function preservation of the interstitial cells of Cajal and activation of the vagus nerve.

Ethical approval

None.

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Author contribution

Kai-Bo Chen and Guo-Feng Chen contributed to the study design, data analysis and risk of bias assessment and writing. Kai-Bo Chen, Yi Huang and Xiao-Li Jin contributed to the literature search and screening, and data extraction and analysis. Guo-Feng Chen contributed to manuscript revision. All authors read and approved the final version of the manuscript.

Conflicts of interest

None.

Trial registry number

Name of the registry:
Electroacupuncture or transcutaneous electroacupuncture for postoperative ileus after abdominal surgery: A systematic review and meta-analysis.
Unique Identifying number or registration ID: Reviewregistry702.
Hyperlink to the registration (must be publicly accessible):
https://www.researchregistry.com/browse-the-registry#registryofsystematicreviewsmeta-analyses/registryofsystematicreviewsmeta-analysesdetails/5d00bdc66a4969000a997825/

Guarantor

Guo-Feng Chen.

Data statement

We declare that the work described is original research that has not been published previously, and is not under consideration for publication elsewhere, in whole or in part. The data included in our meta-analysis is accurate.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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Appendix A. Supplementary data

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