Application and efficacy of transcutaneous electrical acupoint stimulation (TEAS) in clinical practice: A systematic review

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Abstract

Transcutaneous electrical acupoint stimulation (TEAS) is an emerging therapeutic approach that combines the effects of transcutaneous electrical nerve stimulation (TENS) with acupuncture point stimulation. Due to its noninvasive nature, it possesses relative advantages over traditional acupuncture and needle-based electrostimulation. Despite the large number of randomized clinical trials (RCTs) describing the effectiveness of TEAS in different applications, its role and mechanism are still not fully understood. The aim of this study was to systematically compare and summarize the latest studies examining a variety of TEAS applications in clinical practice. Databases, including Medline (PubMed), Cochrane Library and Google Scholar were searched without any time restrictions (as of March 2021). The analysis was performed according to the Cochrane Collaboration criteria. Out of 637 studies, only 22 RCTs were selected. Nine studies evaluated the impact of TEAS on nausea and vomiting (NV), showing beneficial effects compared to standard therapy. Eight RCTs examined the effectiveness of TEAS in pain management, reporting pain alleviation described using the visual analog scale (VAS) and lowering of total opioid doses. Improvement of postoperative recovery, in vitro fertilization and pregnancy outcomes, as well as display of cardioprotective properties were found to positively correlate with TEAS. As a noninvasive modality with advantages over classical acupuncture and needle-based electrostimulation, TEAS may be a valuable tool in clinical practice, particularly for pain and NV management. However, considering the methodological quality of the RCTs, rigorous large-scale clinical trials are required to evaluate the clinical utility of this method.

Key words: systematic review, randomized controlled trials, TEAS, clinical practice, transcutaneous electrical acupoint stimulation

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Introduction

Over the last 1,000 years, acupuncture has remained a crucial component of Traditional Chinese Medicine.[1] Originally, it was performed by applying specialized acupuncture needles into specific loci on the body, known as meridians. However, during the last several decades, the technique of acupuncture has evolved, and currently, a modified form called transcutaneous electrical acupoint stimulation (TEAS) has garnered widespread interest. The TEAS is a contemporary therapeutic method combining stimulation of acupuncture points and transcutaneous electrical nerve stimulation (TENS). Consequently, the essence of TEAS is the stimulation of sensory nerve endings along acupuncture meridians through the application of low-voltage electrical current. The modality exerts its biological effects through various molecular pathways, including the release of endogenous opioids.[2,3] Hence, the results of recent studies reveal a broad spectrum of both therapeutic and prophylactic applications of TEAS in clinical practice. The TEAS remains a widely used tool with a variety of uses, including recovery of gastrointestinal function, reduction of the occurrence of postoperative cognitive dysfunction, nausea and vomiting relief, enhancement of immune function, protection of organ function, acceleration of postoperative recovery, reduction of systolic blood pressure in patients with hypertension, and enhancement of patients' degree of overall comfort.[4] This technique has also been proven helpful in alleviating inflammation and cancer-related pain.[5] Moreover, TEAS has found a clinical application in treating various kinds of reproductive disorders, such as polycystic ovary syndrome (PCOS), pain induced by oocyte retrieval, diminished ovarian reserve, embryo transfer, and oligospermia.[6] Its promising potential is predominantly reported in pain prevention, obstetrics and anesthesiology.[7–9] Moreover, further analysis of the literature shows that TEAS may be utilized as a standalone therapy or as an adjuvant to established therapies, which could positively impact the quality of patient care. Furthermore, unlike traditional acupuncture, TEAS utilizes electrodes that are fixed to the skin through a patch, making the method noninvasive and, above all, safe for the patient.[2,10] To date, its usage has been reported in both children[11] and adolescents.[12,13] Furthermore, the therapy has the advantage of being easy to use and requires minimal training for physicians, technicians and patients. As a noninvasive acupuncture strategy, TEAS can even be performed at home by patients themselves without a prescription. Both patients and caregivers could participate in the clinical application of TEAS after a short but accurate training. However, despite many clinical applications, there are some limitations of TEAS. Firstly, there is a significant amount of conflicting data in the literature regarding the effectiveness of the technique.[14,15] Moreover, limited access to electrostimulators for patients has also been reported to be a challenge.[2] In addition, the lack of TEAS-trained health personnel is a significant issue that needs to be addressed.[16] Growing research on the application of TEAS in evidence-based practice emphasizes the need to systematize the current evidence. Therefore, we conducted a systematic review of randomized clinical trials (RCTs) evaluating the possible applications of TEAS in clinical practice and reviewed the benefits in the reported indications.

Objectives

The aim of this systematic review was to compare and summarize the findings of TEAS trials across various medical indications and provide an evaluation of its effectiveness in comparison to placebo or standard therapy.

Materials and methods

Databases

Medline (PubMed), Cochrane Library and Google Scholar databases were searched without any publication date restrictions (publication date: from inception to March 2021). Articles published after March 2021 were not included in this review due to either their publication date being beyond the custom time range or not meeting custom criteria. Although the search strategy had to be altered to meet limitations of each database, the following phrases were searched invariably: "transcutaneous electrical acupoint stimulation" OR "TEAS". The aforementioned terms were searched in titles and abstracts in order to initially qualify the research for a systematic review. Subsequently, the papers were thoroughly analyzed and assessed according to the Cochrane Collaboration criteria[17] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Criteria of inclusion and exclusion

For the purpose of evaluating the efficacy and efficiency of TEAS, we included only RCTs in which the TEAS treatment group received either standalone TEAS treatment or where it was an adjuvant to standard therapy and was compared to a) a control group (not receiving TEAS and/or receiving standard therapy) or b) a placebo group (receiving sham TEAS and/or standard therapy). Moreover, the participants had to be randomly assigned to the appropriate group, irrespective of age, sex, ethnicity, place of residence, underlying disease, or comorbidities. It is worth noting that not all of the analyzed RCTs contained information about each of these patient characteristics. Furthermore, this systematic review only considered research assessing transdermal nerve stimulation in points typical for acupuncture, regardless of length, voltage or acupoint chosen for TEAS therapy.

The following studies were excluded from the analysis: 1) not stating inclusion or exclusion criteria; 2) evaluating the effectiveness of traditional acupuncture, electroacupuncture (with the use of needles) or transdermal nerve stimulation in loci other than acupoints; 3) assessing the efficacy and effectiveness of TEAS without comparison to a control group; 4) applying any – even minimal – voltage in either the control or placebo group; 5) evaluating TEAS in places other than acupuncture points; 6) conducted on a pediatric population; and 7) conducted on animals.

Data extraction and assessment of the risk of bias

One author (RK) conducted an initial analysis followed by a detailed review of studies. The 2nd author (SA) verified the research included in the systematic review. Any discrepancies were critically discussed and revised. The primary analysis of RCTs comprised of assessing their 1) validity; 2) type; 3) means of randomization; 4) description of all medical procedures among participants (e.g., type of anesthesia, form and dosage of medication); 5) means of arranging experimental control and placebo groups; and 6) tools (e.g., scales, computer programs) used to extract and present the results. The next phase of analysis involved a detailed assessment of the test group, in particular 1) sample size; 2) acupuncture points applied with precise names and locations; 3) voltage (mA), frequency (Hz) of applied current and length of therapy (s or ms); and 4) exact moment of initiation of treatment (e.g., 30 min before the general anesthesia). At the same time, in the placebo/control group assessment, the following was examined: 1) sample size; 2) location of sham electrodes; and 3) type of intervention.

Results

A total of 22 RCTs (Fig. 1, Table 1) that met the inclusion criteria were selected from 637 studies. Almost all of the studies were conducted in Asia (China in particular). The included RCTs focused mainly on assessing the efficacy and effectiveness of TEAS in preventing nausea and vomiting (NV) and pain alleviation. However, some studies examined other indications for TEAS therapy. The RCTs were significantly diversified in terms of the sample size, although most of them had a small experimental TEAS and control/placebo groups. Among the analyzed RCTs, only a few were based on a sample of female participants only.

In terms of randomization, from a total of 22 analyzed studies, only a few were appropriately conducted. For instance, most of the excluded studies included participants randomized using incorrect baseline information, multiple randomizations being performed for the same participant or a lack of double-blinding, which might have impacted the observed outcomes.

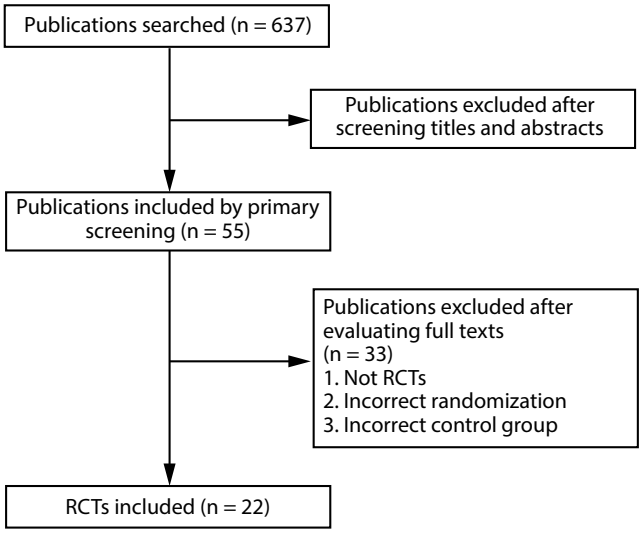

Fig. 1. Analysis of studies

RCTs – randomized controlled trials.

Effectiveness of TEAS in preventing NV

Yang et al. compared the effectiveness of TEAS with dexamethasone (Acu group), dexamethasone with tropisetron (Trp group), and dexamethasone only (Dxm group) in counteracting postoperative nausea and vomiting (PONV) 24 h after surgery. Compared to standalone glucocorticosteroid therapy, the Acu group presented a significantly lower risk of PONV ($p = 0.048$, odds ratio (OR) = 0.389, 95% confidence interval (95% CI): 0.170–0.891). Simultaneously, the authors did not show any difference in the reduction of PONV between the Acu group and Trp group ($p = 0.857$). The same study showed no difference between all of the groups in demand for anti-emetics (Acu group: 10%, 95% CI: 1–19%; Trp group: 8%, 95% CI: 0–15%; Dxm group: 14%, 95% CI: 4–24%).[18] Similarly, Liu et al. have shown the benefits of TEAS therapy in reducing PONV incidence 24 h after operation. Authors have noted 14/48 (30%) PONV in the TEAS group and 31/48 (65%) in a standard therapy group. The attained relation was statistically significant ($p < 0.05$). At the same time, the TEAS group received fewer anti-emetics than the control group ($p < 0.05$).[19] Zheng et al. also observed a reduction of PONV in the first 24 postoperative hours among patients receiving TEAS (5/30, 17%) in comparison to the control group (14/30, 47%). The correlation was statistically significant ($p < 0.05$).[20] Xu et al. reported a possible efficiency in PONV prevention on the day after surgery, comparing the TEAS group to the non-TEAS group (nausea: 33% compared to 58%, $p = 0.008$; vomiting: 22% compared to 41%, $p = 0.025$).[21] On the other hand, Ho et al. demonstrated that the occurrence of PONV was only slightly lower in the TEAS group compared to traditional therapy (9/25 (36%) compared to 11/25 (44%), respectively), and the relationship was not statistically significant.[22]

Table 1. Characteristics of clinical trials

Study	Publication year	Country	Study type	Acupuncture points	Characteristics of the study participants						Clinical indication
					intervention group				control/placebo/other group		
					n*	mA	Hz	duration	n*	description	
Xie et al.[23]	2017	China	single-blind RCT	Hegu (LI4) Neiguan (P6) Zusanli (ST36)	72 (active–acupuncture)	7–15	4	twice daily for 30 min for 6 days	70 (placebo–acupuncture)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS combined with palonosetron on chemotherapy-induced NV
Yang et al.[18]	2015	China	prospective double-blind RCT	Neiguan (P6)	50 (acupoint stimulation+ dexamethasone)	6–20	2	N/D	53 (control – tropisetron+ dexamethasone)	tropisetron+ dexamethasone	PONV in gynecological patients undergoing laparoscopic surgery
									50 (dexamethasone)	dexamethasone	
Xu et al.[21]	2012	China	prospective blind and randomized study	Neiguan (P6)	65 (TEAS)	2	2–100	30 min before the induction of anesthesia and lasted up to 24 h postoperatively	65 (sham TEAS/control)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS on PONV in patients after infratentorial craniotomy
Liu et al.[19]	2008	China	prospective double-blind randomized study	Neiguan (P6)	48 (treated)	0.5–4	2–100	at least 30 min but no longer than 60 min before the induction of anesthesia and continued until the end of surgery	48 (control)	electrodes applied in the same place as in the intervention group but with no stimulation	preventing PONV after laparoscopic cholecystectomy
Zheng et al.[20]	2008	China	RCT	Hegu (LI4) Neiguan (PC6)	30 (TEAS)	8–10	2/100	30 min before analgesia induction to 24 h after operation	30 (sham TEAS/control)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS on NV induced by patient-controlled intravenous analgesia with tramadol
Ho et al.[22]	1990	Taiwan	randomized clinical trial	Neiguan (P6)	25 (TENS)	ind.**	30	15 min	25 (control)	no treatment	postoperative vomiting
					25 (EAP)	ind.**	3	15 min	25 (drugs)	prochlorperazine 5 mg intravenously	
Zhan and Tian[30]	2020	China	single-blind RCT	Zusanli (ST36) Neiguan (PC6)	30 (TAP+TEAS)	ind.**	2–100	before leaving PACU and at 24 h after surgery	30 (control)	usual care group	TEAS to transverse abdominis plane block for postoperative analgesia in abdominal surgery
									30 (TAP)	transverse abdominis plane block	
Tu et al.[24]	2019	China	RCT	Shenyu (BL23) Yinlingquan (SP9)	60 (TEAS)	ind.** 5–10 for upper limbs 10–30 for lower limbs and trunk	2/100	before and 4 h, 8 h and 12 h postoperatively; re-implementing TEAS 3 times on the target acupoints (at 7 AM, 11 AM and 15 PM) on the next 2 days postoperatively	60 (control)	participants treated with tramadol hydrochloride 100 mg tablets for postoperative analgesia, twice daily (8 AM, 8PM), and electrodes applied in the same place as in the intervention group but with no stimulation	TEAS and postoperative analgesia after ureteroscopic lithotripsy
AminiSaman et al.[25]	2018	Iran	double-blind randomized clinical trial	Hegu (LI4) Zusanli (ST36)	25 (acu-TENS)	5–10	1–10	4 times in 24 h for 30 min	25 (placebo)	electrodes applied in the same place as in the intervention group but with no stimulation	TENS at the acupuncture points to relieve pain of patients under mechanical ventilation

Table 1. Characteristics of clinical trials – cont.

Study	Publication year	Country	Study type	Acupuncture points	Characteristics of the study participants						Clinical indication
					intervention group				control/placebo/other group		
					n*	mA	Hz	duration	n*	description	
Yeh et al.[26]	2018	Taiwan	randomized clinical trial	Chengshan (BL57) Erbai (EX–UE2)	39 (TEAS)	0.06–2.30	2/100	20 min; a total of 4 times: 1st time at the 4th hour after surgery, 2nd time at the 6th hour after surgery, 3rd time at 7 AM on the day after surgery, and 4th time at 11 AM on the day after surgery	41 (control)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS on post-hemorrhoidectomy-associated pain, anxiety and heart rate variability
Liu et al.[28]	2015	China	randomized blind controlled trial	Hegu (LI4) Waiguan (TE5) Jinmen (BL63) Taichong (LR3) Zusanli (ST36) Qiuxu (GB 40) Fengchi (GB20) Tianzhu (BL10) Cuanzhu (BL2) Yuyao (EX–HN4)	46 (TEAS)	4.89 ±2.15 6.79 ±3.51 7.04 ±3.35 5.61 ±2.13 ind.**	2/100	30 min before anesthesia induction, maintained throughout the operation and terminated at the end of surgery	46 (sham TEAS)	electrodes applied in the same place as in the intervention group but with no stimulation	intraoperative and postoperative anesthetic and analgesic effect of multipoint TEAS combined with sufentanil anesthesia in patients undergoing supratentorial craniotomy
Chen et al.[29]	2015	China	prospective triple-blind randomized placebo-controlled trial	Jiaji (EX–B2)	114 (TEAS)	optimal intensity was set to initiate visible slight twitching of the surrounding muscle	2/100	30 min	115 (sham TEAS)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS reduces abdominal pain after colonoscopy
Lan et al.[31]	2012	China UK	RCT	Neiguan (P6) Hegu (LI4) Zusanli (ST36) Fengshi (GB31)	30 (acu-TENS)	9–20	2/100	30 min before incision, and at several time points 2 days after surgery: at 2 h, 4 h, 20 h, and 44 h	30 (sham TEAS/control)	electrodes applied in the same place as in the intervention group but with no stimulation	TENS on acupoints reduces fentanyl requirement for postoperative pain relief after total hip arthroplasty in elderly patients
Wang et al.[27]	1997	USA	prospective single-blind randomized sham-controlled study	Hegu (LI4)	25 (low-TEAS)	4–5	2 and 100	36 min	26 (PCA only)	intravenous PCA alone with hydromorphone	effect of the intensity of TEAS on the postoperative analgesic requirement
					25 (high-TEAS)	9–12	2 and 100	29 min	25 (sham TEAS)	PCA with hydromorphone+sham TEAS (no electrical stimulation, but with functional indicator lights on)	
Yu et al.[36]	2020	China	prospective double-blind randomized placebo-controlled trial	Baihui (GV20) Yingtang (EX–HN3) Zusanli (ST36) Neiguan (PC6)	30 (TEAS)	12–15 ind.**	2/100	30 min before anesthesia	30 (control)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS on the quality of early recovery in patients undergoing gynecological laparoscopic surgery

Table 1. Characteristics of clinical trials – cont.

Study	Publication year	Country	Study type	Acupuncture points	Characteristics of the study participants						Clinical indication
					intervention group				control/placebo/other group		
					n*	mA	Hz	duration	n*	description	
Chi et al.[35]	2019	China	prospective randomized sham-controlled trial	Zusanli (ST36) Sanyinjiao (SP6) Neiguan (PC6) Quchi (LI11)	26 (TEAS)	ind.**	2/10	30 min before the epidural anesthesia and on postoperative day 1 and 2	26 (sham TEAS)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS for improving postoperative recovery, reducing stress and inflammatory responses in elderly patients undergoing knee surgery
Li et al.[32]	2019	China	single-center prospective exploratory randomized therapeutic clinical trial	Neiguan (PC6) Ximen (PC4)	61 (TEAS)	ind.**	4/20	30 min before anesthesia induction until the end of surgery	61 (control)	electrodes applied in the same place as in the intervention group but with no stimulation	cardioprotective effect of TEAS on perioperative elderly patients with coronary heart disease
Bai et al.[9]	2018	China	prospective randomized controlled clinical trial	Hegu (LI4) Neiguan (PC6) Lieque (LU7) Chize (LU5) Futu (LI18) Renying (ST9)	37 (TEAS)	6–15	2/10	30 min before anesthesia to 5 min before the end of surgery	38 (control)	electrodes applied in the same place as in the intervention group but with no stimulation	TEAS on the stress response during extubation after general anesthesia in elderly patients undergoing elective supratentorial craniotomy
Qu et al.[37]	2017	China	prospective randomized controlled study	Xuehai (SP10) Diji (SP8) Taichong (LR3) Zusanli (ST36) Zigong (EX–CA1) Guanyuan (RN4) Neiguan (PC6) Zhongwan (RN12)	108 (TEAS–2)	N/A	2	30 min respectively at 24 h before TVOR and 2 h before ET	109 (control)	routine procedure of IVF treatment and no TEAS was applied	TEAS improves the outcomes of IVF
					111 (TEAS–100)		100				
					114 (TEAS–2/100)		2/100				
Zheng et al.[38]	2015	China	randomized controlled study	Guanyuan (RN4) Zhongji (RN3) Sanyinjiao (SP6) Zigong (EX–CA1) Tianshu (ST25) Shenyu (BL23) Yaoyangguan (DU3) Mingmen (DU4)	56 (TEAS)	2–25	2	lasted for 30 min and was given once a day; after 3 courses, the treatment continued during the ovulation cycle until the day of egg retrieval	56 (FHP) 54 (AEC) 60 (control)	regardless of the displayed electric current, its output current is stable at 5 mA oral tablets of estradiol valerate and dydrogesterone	TEAS on ovarian reserve of patients with diminished ovarian reserve in in vitro fertilization and embryo transfer cycles
Jones and Ngai[33]	2014	Australia China	randomized placebo-controlled cross-over design	Neiguan (PC6)	10 (acu-TENS)	ind.**	2	45 min before exercise	10 (placebo)	similar to the acu-TENS protocol but without electrical output from the TENS unit	acu-TENS lowers blood lactate levels and enhances heart rate recovery after exercise
Ngai and Jones[34]	2013	China	double-blind randomized controlled cross-over study	Feishu (BL13)	9 (acu-TENS)	the highest tolerable intensity but short of pain	2	45 min	9 (placebo-TENS)	electrodes applied in the same place as in the intervention group but with no stimulation	skin impedance and heart rate variability with application of acu-TENS to BL13

RCT – randomized controlled trial; TEAS – transcutaneous electrical acupoint stimulation; TENS – transcutaneous electrical nerve stimulation; TAP – transverse abdominal plane block; IVF – in vitro fertilization; EAP – electroacupuncture; N/A – not applicable; N/D – no data; PONV – postoperative nausea and vomiting; PACU – post-anaesthesia care unit; TVOR – transvaginal oocyte retrieval; ET – embryo transfer; AEC – artificial endometrial cycle treatment; FHP – comforting false Han's placebo; PCA – patient-controlled analgesia; n* – the number of participants included in the appropriate group; ind.** – individually – the highest tolerable level that caused no discomfort for the participants.

Table 2. Characteristics of randomized clinical trials (RCTs) assessing the effectiveness of transcutaneous electrical acupoint stimulation (TEAS) in nausea and vomiting (NV) prophylaxis

Study	Publication year	Indication	Results
Yang et al.[18]	2015	PONV in gynecological patients undergoing laparoscopic surgery	NV ora within 24 h after operation: a) 28% (95% CI: 15–41%) of patients in the Acu group (dexamethasone+TEAS) b) 26% (95% CI: 14–39%) of patients in the Trp group (dexamtethasone+tropisetron) c) 50% (95% CI: 36–64%) of patients in the Dxm group (dexamethasone alone)
Liu et al.[19]	2008	NV after laparoscopic cholecystectomy	in the study group compared with the research group: a) incidence of NV was significantly lower ($p < 0.05$) b) doses of anti-emetics were significantly lower ($p < 0.05$) c) occurrence rate of severe nausea was significantly lower ($p < 0.01$)
Zheng et al.[20]	2008	NV induced by intravenous analgesia with tramadol	The incidence and scores of NV in group A (with TEAS) was significantly lower than in group B (without TEAS) ($p < 0.05$ or $p < 0.01$).
Xu et al.[21]	2012	postoperative NV after infratentorial craniotomy	in the study group compared with the research group: a) incidence of NV was significantly lower ($p < 0.05$) b) doses of anti-emetics were significantly lower ($p < 0.05$) c) occurrence rate of severe nausea was significantly lower ($p < 0.01$)
Ho et al.[22]	1990	emesis after laparoscopy	The incidence of postoperative emesis in the TENS group was slightly lower compared with the control group (9/25 compared to 11/25).
Xie et al.[23]	2017	chemotherapy-induced NV	The differences in occurrence rates and severities of NV after TACE were not significant ($p > 0.05$).

TENS – transcutaneous electrical nerve stimulation; PONV – postoperative nausea and vomiting; 95% CI – 95% confidence interval; TACE – transarterial chemoembolization.

Xie et al. evaluated whether a combination of TEAS and palonosetron might alleviate nausea and/or vomiting in patients undergoing intravenous chemotherapy for late-stage liver cancer. Results showed a reduction of NV incidence and nausea intensity, although the correlation was not statistically significant ($p > 0.05$).[23] In conclusion, the majority of the studies showed a positive role for TEAS in the reduction of NV after surgery. However, not all RCTs clearly present significant differences between TEAS and non-TEAS groups in this regard. Table 2 presents a summary of RCTs assessing the effectiveness of TEAS in NV prophylaxis.

Effectiveness of TEAS in pain alleviation

Tu et al. demonstrated that in comparison to the control group, patients receiving TEAS were characterized by lesser pain, as evaluated using the visual analog scale (VAS) in the 4th ($p = 0.01$), 12th ($p = 0.03$) and 24th ($p < 0.01$) hour after surgery. The same study showed that patients in the TEAS group received fewer analgesics during the first 48 h post-operation compared to the control group (127.14 ±28.46 compared to 415.27 ±86.37, $p < 0.01$).[24] AminiSaman et al. investigated the relationship between TEAS and pain reduction after mechanical lung ventilation. Compared to the control group, the TEAS group was less prone to pain ($p < 0.05$) and, simultaneously, received fewer analog-sedatives in the postoperative period.[25] Similar results were obtained by Yeh et al.[26] and Wang et al.[27] On the other hand, Liu et al. evaluated whether the use of TEAS could affect the course of anesthesia and analgesia in patients undergoing supratentorial craniotomy. The results showed that in comparison to the control group, the TEAS group received fewer anesthetics during surgery (sufentanil: 95.6 ±21.76 μg compared to 117.7 ±37.95 μg, $p < 0.05$; propofol: 216.3 ±67.72 mg compared to 234.1 ±71.30 mg). Moreover, the researchers reported a lower pain rate (described using VAS) in the TEAS group on the 1st day after surgery ($p < 0.001$). Nevertheless, the same study showed that VAS rates were higher in the 2nd and 3rd days following surgery in the TEAS group than in the control group.[28] Chen et al. assessed pain levels after the application of TEAS in patients undergoing colonoscopy. Compared to the control group, the TEAS group showed a statistically significant reduction of pain ($p = 0.007$) after the procedure – in the TEAS group, only 13/114 (11.4%) showed symptoms of pain compared to 29/115 (25.2%) in the control group.[29] Furthermore, TEAS, in combination with other therapeutic methods, might have an impact on patient outcomes. Zhan and Tian evaluated whether combining TEAS with transversus abdominis plane block (TAP) impacts postoperative pain alleviation. The study showed that the TAP and TEAS combination significantly reduced pain 24 h and 48 h after an abdominal operation ($p = 0.01$, $p < 0.0001$; $p = 0.004$) compared to the control group. Moreover, the same study demonstrated that in the TAP and TEAS groups, pain levels of VAS were lower than in the standalone TAP group ($p = 0.03$).[30] Lan et al. showed that patients in the TEAS group required lower doses of fentanyl 24 h and 48 h after surgery compared to the control group (respectively: 360 ±117 μg compared to 572 ±132 μg, $p < 0.001$;

Table 3. Characteristics of randomized clinical trials (RCTs) in pain indication

Study	Publication year	Indication	Results
Tu et al.[24]	2019	postoperative analgesia after ureteroscopic lithotripsy	In the study group, the VAS scores were significantly lower when compared with the control group at 4th h (3.68 ±0.68 compared to 4.79 ±0.82, p = 0.01), 12th h (2.64 ±0.72 compared to 3.92 ±0.88, p = 0.03), and 24th h (2.21 ±0.88 compared to 3.38 ±0.74, p < 0.01). In the study group, the total analgesic consumption was significantly lower when compared with the control group (127.14 ±28.46 compared to 415.27 ±86.37, p < 0.01) within 48 h postoperatively. In the study group, the incidence rates of vertigo (6.7% compared to 18.3%, p < 0.01), nausea and vomiting (11.7% compared to 21.7%, p < 0.01), and constipation (10.0% compared to 20.0%, p = 0.03) were lower when compared with the control group.
AminiSaman et al.[25]	2018	pain under mechanical ventilation	Level of pain was lower in the study group compared with the sham group (p < 0.05); the amount of analgesic and sedation drugs used was less significant in the treated group compared with the sham group (p = 0.01, p = 0.04).
Yeh et al.[26]	2018	post-hemorrhoidectomy pain	Level of pain measure using VAS score in the study group was lower compared with the control group and trend differences (time-by-group interactions) were significant at time 2 (p = 0.004), time 3 (p < 0.001) and time 4 (p < 0.001).
Wang et al.[27]	1997	postoperative analgesic required	In the study group, the amount of analgesic medication used was lower compared with the control group (by 65% for high-TEAS, by 34% for low-TEAS, by 23% for control group).
Liu et al.[28]	2015	anesthetic and analgesic effect during and after supratentorial craniotomy	In the study group, the amount of sufentanil and propofol used were lower compared with the control group (sufentanil: 95.6 ±21.76 μg compared to 117.7 ±37.95 μg, p < 0.05; propofol: 216.3 ±67.72 mg compared to 234.1 ±71.30 mg); level of pain measured using VAS score was lower in the study group on day 1 after surgery compared with the control group (p < 0.001), but on days 2 and 3 the level of pain was lower in the control group.
Chen et al.[29]	2015	pain after colonoscopy	In the study group, the level of pain was lower compared with the control group (p = 0.007).
Zhan and Tian[30]	2020	TEAS and TAP for postoperative analgesia in abdominal surgery	The combination of TEAS and TAP significantly reduced postoperative pain at 24 h and 48 h after surgery (p = 0.01, p < 0.0001; p = 0.004) compared with the control group.
Lan et al.[31]	2012	postoperative pain after total hip arthroplasty	In the study group, the amount of fentanyl used was lower compared with the control group at 24 h and 48 h after surgery (360 ±117 μg compared to 572 ±132 μg, p < 0.001; 712 ±184 μg compared to 1022 ±197 μg, p < 0.00); in both groups, no differences in the level of pain were observed.

TEAS – transcutaneous electrical acupoint stimulation; TENS – transcutaneous electrical nerve stimulation; TAP – transverse abdominal plane block; VAS – visual analog scale.

712 ±184 μg compared to 1022 ±197 μg, p < 0.001). No significant difference in pain level has been observed in both groups.[31] Taken together, all of the aforementioned studies demonstrated the positive role of TEAS in alleviating pain after surgery and reducing drug doses. Table 3 presents a summary of RCTs assessing the effectiveness of TEAS in pain alleviation.

Effectiveness of TEAS in other indications

Cardioprotection

Li et al. studied the possible protective impact of TEAS on cardiac muscle in patients with diagnosed coronary artery disease qualified for spinal surgery. The cardioprotective effect was evaluated by measuring the level of markers in blood serum, including troponin (high-sensitive troponin T (hs-cTnT)), C-reactive protein (CRP) and creatine kinase (CK), on the 1st, 3rd and 5th day after the surgery. In both the TEAS treatment and control groups, the levels of all of the markers were elevated (p < 0.05). However, compared to the control group, the concentration of hs-cTnT in the TEAS group on days 1 and 3 was significantly lower (p < 0.05). There was no difference in CRP and CK levels between the groups. Moreover, heart rate (HR) on days 1, 3 and 5 after surgery compared to the day before the surgery was higher in both groups, wherein the increase was lower in the TEAS treatment group.[32] Jones and Ngai assessed whether TEAS might accelerate normalization of HR in patients who were subject to physical effort. Compared to the control group, the TEAS group demonstrated a shorter time to HR normalization after physical exercise (9.98 ±4.54 min, p = 0.047, 95% CI: 0.23–19.72).[33] A study by Ngai and Jones confirms the cardioprotective properties of TEAS, as they showed a reduction of low frequency to high frequency (LF/HF) ratio by 0.37 ±0.01 (p = 0.012) compared to the control group.[34] In conclusion, all these studies show the positive impact of TEAS in cardioprotection. Table 4 presents a summary of RCTs assessing the effectiveness of TEAS in other indications.

Table 4. Characteristics of randomized clinical trials (RCTs) in other medical indications

Study	Publication year	Indication	Results
Bai et al.[9]	2018	improving postoperative recovery	In the control group, the QoR-40 scores were lower compared with the research group (164.3 ±13.7 compared to 176.9 ±11.1, p < 0.01). In the study group, cases of cough and PONV were lower compared with the control group (respectively: 10 (27.0) compared to 19 (50.0), p = 0.04; 13 (35.1) compared to 24 (63.2), p = 0.02).
Li et al.[32]	2019	cardioprotection in coronary heart disease after spinal surgery	In the study group compared with the control group, the concentration of hs-cTnT was lower on 1st and 3rd day after surgery (p < 0.05). In both groups, HR was higher after surgery than before, but in the study group the increase was lower.
Jones and Ngai[33]	2014	heart rate normalization after exercise	In the study group compared with the control group, time to normalization of HR after exercise was shorter (9.98 ±4.54 min, p = 0.047, 95% CI: 0.23–19.72)
Ngai and Jones[34]	2013	heart rate variability after acu-TENS	In the study group, LF/HF ratio was lower by 0.37 ±0.01 (p = 0.012) compared with the control group.
Chi et al.[35]	2019	improving postoperative recovery	In the control group, the QoR-40 scores were lower compared with the study group (160.1 ±5.5 compared to 170.9 ±5.0 respectively, p < 0.05).
Yu et al.[36]	2020	improving postoperative recovery	In the control group, the QoR-40 and MMSE scores were lower compared with the study group (respectively: QoR-40: 1st day – 166.07 ±8.44 compared to 175.33 ±9.66, 2nd day – 187.73 ±5.47 compared to 191.40 ±5.74; MMSE: 1st day – 24.60 ±2.35 compared to 26.10 ±2.78, 2nd day – 26.53 ±2.94 compared to 27.83 ±2.73); in treated group, the incidence of PONV was lower compared with the control group (23.3% compared to 56.7%).
Qu et al.[37]	2017	improving IVF outcomes	In the 2/100 Hz TEAS group, the clinical pregnancy, implantation and live birth rates were higher compared with other groups (p < 0.05).
Zheng et al.[38]	2015	improving pregnancy outcomes	In the TEAS group compared with the control group, clinical pregnancy rate was higher (42.31% (n = 22/52) compared to 21.57% (n = 11/51), p < 0.05).

TEAS – transcutaneous electrical acupoint stimulation; hs-cTnT – high-sensitive troponin T; TENS – transcutaneous electrical nerve stimulation; PONV – postoperative nausea and vomiting; MMSE – Mini-Mental State Examination; IVF – in vitro fertilization; QoR-40 – Quality of Recovery-40 questionnaire; HR – heart rate; 95% CI – 95% confidence interval; LF/HF – low frequency to high frequency.

Postoperative general condition

Chi et al. assessed whether TEAS treatment could affect the general condition of a patient after knee surgery. For this, they used the Quality of Recovery-40 questionnaire (QoR-40). Compared to the TEAS treatment group, the control group scored lower in QoR-40 on the 1st day after surgery, and the relationship was statistically significant (170.9 ±5.0 compared to 160.1 ±5.5, p < 0.05, respectively). The same study showed that CRP in the TEAS group was notably lower (p < 0.05).[35] Bai et al. achieved comparable results, showing a statistically significant relationship in QoR-40 score in the TEAS group compared to the control group (176.9 ±11.1 compared to 164.3 ±13.7, p < 0.01). Moreover, they showed that patients receiving TEAS less often suffered from cough (10 (27.0) compared to 19 (50.0), p = 0.04) and NV (13 (35.1) compared to 24 (63.2), p = 0.02).[9]

Yu et al. analyzed the influence of TEAS on the perioperative period in patients after laparoscopy due to gynecological diseases. The study included not only QoR-40 but also Mini-Mental State Examination (MMSE). Compared to the control group, scores in the TEAS group were significantly higher in both scales on day 1 and 2 after surgery (QR-40: 1st day – 166.07 ±8.44 compared to 175.33 ±9.66, 2nd day – 187.73 ±5.47 compared to 191.40 ±5.74; MMSE: 1st day – 24.60 ±2.35 compared to 26.10 ±2.78, 2nd day – 26.53 ±2.94 compared to 27.83 ±2.73). In addition, the incidence of PONV was considerably lower in the TEAS group (56.7% compared to 23.3%).[36]

Obstetrics

Qu et al. examined the implication of TEAS on in vitro fertilization (IVF). The authors identified 4 groups: controls and 3 TEAS groups with various frequencies: 2 Hz, 100 Hz and 2/100 Hz. Compared to all other groups, the number of pregnancies, successful implantations and live births in the 2/100 Hz group was significantly higher (p < 0.05).[37]

Zheng et al. showed that TEAS therapy in women with lowered ovarian reserve notably increased the number of pregnancies after IVF in comparison to the control group (respectively: 42.31% (n = 22/52) compared to 21.57% (n = 11/51), p < 0.05).[38]

Discussion

Our review is the first to identify and analyze TEAS trials in several medical indications, providing an evaluation

of TEAS effectiveness in comparison to placebo or standard therapy. Out of 22 chosen RCTs, 9 studies evaluated the effectiveness of TEAS in the treatment of NV, demonstrating superior clinical outcomes in TEAS-treated patients in comparison to standard therapy. Eight of those studies were focused strictly on PONV. Those RCTs bear promising results, as PONV, a direct consequence of total opioid dosage, occurs in up to 27% of surgical patients, contributing to prolonged hospital stays and resulting in higher hospitalization expenses.[39] Another 8 RCTs evaluating pain management found TEAS to be more effective in pain reduction. The studies showed lower VAS and/or total analgesics doses in the TEAS study group when compared with other study arms. Most of those studies evaluated the effectiveness of TEAS in surgical pain management exclusively. However, there was 1 notable study on the efficacy of TEAS in decreasing pain related to mechanical ventilation.[25] Such application of TEAS might be particularly valuable in the face of the coronavirus disease 2019 (COVID-19) global pandemic that is associated with a significant percentage of patients requiring prolonged mechanical ventilation depending on disease severity. Despite ample evidence on the effectiveness of TEAS on both PONV and pain control, there are some studies that show contrasting results. One RCT showed significantly worse outcomes of TEAS compared to control in pain alleviation at days 2 and 3.[28] However, this study primarily evaluated the impact of TEAS on anesthetics use, and the modality ended upon culmination of the surgery. Besides the influence of TEAS on pain management, it might have a broadly defined beneficial impact on patients recovering from surgical interventions. Three RCTs demonstrated that patients receiving TEAS scored higher in either QoR-40 or MMSE. Such findings seem to be crucial, as quality of recovery is directly associated with satisfaction and quality of life up to 3 years after surgery.[40] Another 3 RCTs display the cardioprotective properties of TEAS by either lowering the HR, reducing the HR normalization time or lowering the LF/HF ratio. Furthermore, the results of 2 RCTs showed improved pregnancy and IVF outcomes after TEAS therapy – a crucial feature given the rising infertility rates worldwide.[41]

Only one previous systematic review assessed the effectiveness of acupuncture and, as a separate subgroup, acupuncture-related methods in treating postoperative pain. Wu et al. included only 5 studies that compared TEAS with standard treatment. Similar to our results, they found that patients receiving TEAS suffered less pain on the 1st day after surgery, as evaluated by VAS ($p = 0.0020$). Also, consistent with our findings, they found that the TEAS group required a lower total opioid dose on the 1st postoperative day than the control group ($p < 0.001$).[42]

Although the results of these studies are encouraging, they have limitations, primarily with respect to methodology. The biggest concern is insufficient blinding of care providers. In all of the studies that included a placebo group, the care provider knew whether they applied a true or sham treatment modality. A considerable amount of properly executed RCTs are required to establish TEAS as a noninvasive alternative to standard therapy in the aforementioned indications and other ones. To do so, researchers need to adhere to appropriate methods of intervention. Sizeable cohorts including the study group, along with control and placebo arms, as well as proper randomization are necessary. Means of double-blinding should be developed, as informing the research staff might cause bias. For publication purposes, much like the Standards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA),[43] the Consolidated Standards of Reporting Trials (CONSORT) has been developed to avoid unnecessary mistakes and hindering otherwise useful studies from being recreated.[44]

Limitations

We recognize that our review has a number of limitations. Firstly, we only included trials published in English, possibly significantly reducing the database. Even though a substantial effort was put into extracting every available RCT on the subject, we cannot guarantee that the search was all-inclusive. The most significant factor limiting the quality and conclusiveness of this review is selective publishing. Since only 1 included RCT showed a negative outcome of TEAS, RCTs with negative results likely remain unpublished, misrepresenting the outcome of TEAS overall.

Conclusions

The results of this systematic review demonstrate TEAS as an emerging, noninvasive modality with distinct advantages over classical acupuncture and needle-based electrostimulation, regardless of its application (as a standalone TEAS therapy or as an adjuvant to standard therapy). Our study suggests this approach may be useful in clinical practice, particularly for pain and NV management. However, considering the methodological quality of most RCTs, rigorous large-scale clinical trials of TEAS are needed to evaluate the clinical utility of this technique.

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References

1. Yu Y, Sha SB, Zhang B, et al. Effects and mechanism of action of transcutaneous electrical acupuncture point stimulation in patients with abnormal semen parameters. *Acupunct Med*. 2019;37(1):25–32. doi:10.1136/acupmed-2017-011365

2. Szmit M, Agrawal S, Goździk W, et al. Transcutaneous electrical acupoint stimulation reduces postoperative analgesic requirement in patients undergoing inguinal hernia repair: A randomized, placebo-controlled study. *J Clin Med*. 2021;10(1):146. doi:10.3390/jcm10010146
3. Bodnar RJ. Endogenous opiates and behavior: 2012. *Peptides*. 2013;50:55–95. doi:10.1016/j.peptides.2013.10.001
4. Wang Y, Fang J, Zhou Y, Lyu Z. Transcutaneous electrical acupoint stimulation: Research progress in clinical application (review). *Acupunct Electrother Res*. 2022;47(4):379–390. doi:10.3727/036012921X16341481788249
5. Zhao W, Wang C, Li Z, et al. Efficacy and safety of transcutaneous electrical acupoint stimulation to treat muscle spasticity following brain injury: A double-blinded, multicenter, randomized controlled trial. *PLoS One*. 2015;10(2):e0116976. doi:10.1371/journal.pone.0116976
6. Qu F, Li R, Sun W, et al. Use of electroacupuncture and transcutaneous electrical acupoint stimulation in reproductive medicine: A group consensus. *J Zhejiang Univ Sci B*. 2017;18(3):186–193. doi:10.1631/jzus.B1600437
7. Sun K, Xing T, Zhang F, et al. Perioperative transcutaneous electrical acupoint stimulation for postoperative pain relief following laparoscopic surgery: A randomized controlled trial. *Clin J Pain*. 2017;33(4):340–347. doi:10.1097/AJP.0000000000000400
8. Shuai Z, Li X, Tang X, Lian F, Sun Z. Transcutaneous electrical acupuncture point stimulation improves pregnancy outcomes in patients with recurrent implantation failure undergoing in vitro fertilisation and embryo transfer: A prospective, randomised trial. *Acupunct Med*. 2019;37(1):33–39. doi:10.1136/acupmed-2017-011483
9. Bai WY, Yang YC, Teng XF, Wan YX, Wei W, Zhu JC. Effects of transcutaneous electrical acupoint stimulation on the stress response during extubation after general anesthesia in elderly patients undergoing elective supratentorial craniotomy: A prospective randomized controlled trial. *J Neurosurg Anesthesiol*. 2018;30(4):337–346. doi:10.1097/ANA.0000000000000460
10. Chen J, Tu Q, Miao S, Zhou Z, Hu S. Transcutaneous electrical acupoint stimulation for preventing postoperative nausea and vomiting after general anesthesia: A meta-analysis of randomized controlled trials. *Int J Surg*. 2020;73:57–64. doi:10.1016/j.ijsu.2019.10.036
11. Zhuo L, Zhao X, Zhai Y, et al. Transcutaneous electrical acupoint stimulation for children with attention-deficit/hyperactivity disorder: A randomized clinical trial. *Transl Psychiatry*. 2022;12(1):165. doi:10.1038/s41398-022-01914-0
12. Chen J, Zhang Y, Li X, et al. Efficacy of transcutaneous electrical acupoint stimulation combined with general anesthesia for sedation and postoperative analgesia in minimally invasive lung cancer surgery: A randomized, double-blind, placebo-controlled trial. *Thorac Cancer*. 2020;11(4):928–934. doi:10.1111/1759-7714.13343
13. Gao W, Li W, Yan Y, et al. Transcutaneous electrical acupoint stimulation applied in lower limbs decreases the incidence of paralytic ileus after colorectal surgery: A multicenter randomized controlled trial. *Surgery*. 2021;170(6):1618–1626. doi:10.1016/j.surg.2021.08.007
14. Meng D, Mao Y, Song QM, et al. Efficacy and safety of transcutaneous electrical acupoint stimulation (TEAS) for postoperative pain in laparoscopy: A systematic review and meta-analysis of randomized controlled trials. *Evid Based Complement Alternat Med*. 2022;2022:9922879. doi:10.1155/2022/9922879
15. Yang H, Hu WH, Xu GX, et al. Transcutaneous electrical acupoint stimulation for pregnancy outcomes in women undergoing in vitro fertilization-embryo transfer: A systematic review and meta-analysis. *Front Public Health*. 2022;10:892973. doi:10.3389/fpubh.2022.892973
16. Ijaz N, Boon H. Evaluating the international standards gap for the use of acupuncture needles by physiotherapists and chiropractors: A policy analysis. *PLoS One*. 2019;14(12):e0226601. doi:10.1371/journal.pone.0226601
17. Higgins JPT, Thomas J, Chandler J, et al., eds. *Cochrane Handbook for Systematic Reviews of Interventions*. 2nd ed. Hoboken, USA: John Wiley & Sons; 2019. doi:10.1002/9781119536604
18. Yang XY, Xiao J, Chen YH, et al. Dexamethasone alone vs in combination with transcutaneous electrical acupoint stimulation or tropisetron for prevention of postoperative nausea and vomiting in gynaecological patients undergoing laparoscopic surgery. *Br J Anaesth*. 2015;115(6):883–889. doi:10.1093/bja/aev352
19. Liu YY, Duan SE, Cai MX, Zou P, Lai Y, Li YL. Evaluation of transcutaneous electroacupoint stimulation with the train-of-four mode for preventing nausea and vomiting after laparoscopic cholecystectomy. *Chin J Integr Med*. 2008;14(2):94–97. doi:10.1007/s11655-008-0094-4
20. Zheng LH, Sun H, Wang GN, Liang J, Wu HX. Effect of transcutaneous electrical acupoint stimulation on nausea and vomiting induced by patient controlled intravenous analgesia with tramadol. *Chin J Integr Med*. 2008;14(1):61–64. doi:10.1007/s11655-007-9006-2
21. Xu M, Zhou SJ, Jiang CC, et al. The effects of P6 electrical acustimulation on postoperative nausea and vomiting in patients after infratentorial craniotomy. *J Neurosurg Anesthesiol*. 2012;24(4):312–316. doi:10.1097/ANA.0b013e31825eb5ef
22. Ho RT, Jawan B, Fung ST, Cheung HK, Lee JH. Electro-acupuncture and postoperative emesis. *Anaesthesia*. 1990;45(4):327–329. doi:10.1111/j.1365-2044.1990.tb14744.x
23. Xie J, Chen LH, Ning ZY, et al. Effect of transcutaneous electrical acupoint stimulation combined with palonosetron on chemotherapy-induced nausea and vomiting: A single-blind, randomized, controlled trial. *Chin J Cancer*. 2017;36(1):6. doi:10.1186/s40880-016-0176-1
24. Tu Q, Gan J, Shi J, Yu H, He S, Zhang J. Effect of transcutaneous electrical acupoint stimulation on postoperative analgesia after ureteroscopic lithotripsy: A randomized controlled trial. *Urolithiasis*. 2019;47(3):279–287. doi:10.1007/s00240-018-1056-8
25. AminiSaman J, Mohammadi S, Karimpour H, Hemmatpour B, Sharifi H, Kawyannejad R. Transcutaneous electrical nerve stimulation at the acupuncture points to relieve pain of patients under mechanical ventilation: A randomized controlled study. *J Acupunct Meridian Stud*. 2018;11(5):290–295. doi:10.1016/j.jams.2018.06.008
26. Yeh ML, Chung YC, Hsu LC, Hung SH. Effect of transcutaneous acupoint electrical stimulation on post-hemorrhoidectomy-associated pain, anxiety, and heart rate variability: A randomized-controlled study. *Clin Nurs Res*. 2018;27(4):450–466. doi:10.1177/1054773816685745
27. Wang B, Tang J, White PF, et al. Effect of the intensity of transcutaneous acupoint electrical stimulation on the postoperative analgesic requirement. *Anesth Analg*. 1997;85(2):406–413. doi:10.1097/00000539-199708000-00029
28. Liu X, Li S, Wang B, An L, Ren X, Wu H. Intraoperative and postoperative anaesthetic and analgesic effect of multipoint transcutaneous electrical acupuncture stimulation combined with sufentanil anaesthesia in patients undergoing supratentorial craniotomy. *Acupunct Med*. 2015;33(4):270–276. doi:10.1136/acupmed-2014-010749
29. Chen Y, Wu W, Yao Y, Yang Y, Zhao Q, Qiu L. Transcutaneous electric acupoint stimulation at Jiaji points reduce abdominal pain after colonoscopy: A randomized controlled trial. *Int J Clin Exp Med*. 2015;8(4):5972–5977. PMID:26131193.
30. Zhan W, Tian W. Addition of transcutaneous electric acupoint stimulation to transverse abdominis plane block for postoperative analgesia in abdominal surgery: A randomized controlled trial. *Eur J Integr Med*. 2020;35:101087. doi:10.1016/j.eujim.2020.101087
31. Lan F, Ma YH, Xue JX, Wang TL, Ma DQ. Transcutaneous electrical nerve stimulation on acupoints reduces fentanyl requirement for postoperative pain relief after total hip arthroplasty in elderly patients. *Minerva Anestesiol*. 2012;78(8):887–895. PMID:22531569.
32. Li H, Wu C, Yan C, et al. Cardioprotective effect of transcutaneous electrical acupuncture point stimulation on perioperative elderly patients with coronary heart disease: A prospective, randomized, controlled clinical trial. *Clin Interv Aging*. 2019;14:1607–1614. doi:10.2147/CIA.S210751
33. Jones AYM, Ngai SPC. Acu-TENS lowers blood lactate levels and enhances heart rate recovery after exercise. *J Tradit Chin Med*. 2014;1(1):73–80. doi:10.1016/j.jtcms.2014.11.006
34. Ngai SPC, Jones AYM. Changes in skin impedance and heart rate variability with application of Acu-TENS to BL 13 (Feishu). *J Altern Complement Med*. 2013;19(6):558–563. doi:10.1089/acm.2012.0097
35. Chi YL, Zhang WL, Yang F, Su F, Zhou YK. Transcutaneous electrical acupoint stimulation for improving postoperative recovery, reducing stress and inflammatory responses in elderly patient undergoing knee surgery. *Am J Chin Med*. 2019;47(7):1445–1458. doi:10.1142/S0192415X19500745
36. Yu X, Zhang F, Chen B. The effect of TEAS on the quality of early recovery in patients undergoing gynecological laparoscopic surgery: A prospective, randomized, placebo-controlled trial. *Trials*. 2020;21(1):43. doi:10.1186/s13063-019-3892-4

37. Qu F, Wang FF, Wu Y, et al. Transcutaneous electrical acupoint stimulation improves the outcomes of in vitro fertilization: A prospective, randomized and controlled study. *Explore (NY)*. 2017;13(5):306–312. doi:10.1016/j.explore.2017.06.004
38. Zheng Y, Feng X, Mi H, et al. Effects of transcutaneous electrical acupoint stimulation on ovarian reserve of patients with diminished ovarian reserve in in vitro fertilization and embryo transfer cycles: Effects of TEAS on ovarian reserve. *J Obstet Gynaecol Res*. 2015;41(12): 1905–1911. doi:10.1111/jog.12810
39. Amirshahi M, Behnamfar N, Badakhsh M, et al. Prevalence of postoperative nausea and vomiting: A systematic review and meta-analysis. *Saudi J Anaesth*. 2020;14(1):48–56. doi:10.4103/sja.SJA_401_19
40. Gornall BF, Myles PS, Smith CL, et al. Measurement of quality of recovery using the QoR-40: A quantitative systematic review. *Br J Anaesth*. 2013;111(2):161–169. doi:10.1093/bja/aet014
41. Marques-Pinto A, Carvalho D. Human infertility: Are endocrine disruptors to blame? *Endocr Connect*. 2013;2(3):R15–R29. doi:10.1530/EC-13-0036
42. Wu MS, Chen KH, Chen IF, et al. The efficacy of acupuncture in postoperative pain management: A systematic review and meta-analysis. *PLoS One*. 2016;11(3):e0150367. doi:10.1371/journal.pone.0150367
43. MacPherson H, White A, Cummings M, Jobst K, Rose K, Niemtzow R. Standards for reporting interventions in controlled trials of acupuncture: The STRICTA recommendations. *Clinical Acupuncture and Oriental Medicine*. 2002;3(1):6–9. doi:10.1054/caom.2001.0114
44. Moher D, Schulz KF, Altman DG. The CONSORT statement: Revised recommendations for improving the quality of reports of parallel-group randomised trials. *Lancet*. 2001;357(9263):1191–1194. doi:10.1016/S0140-6736(00)04337-3