

Perioperative acupuncture medicine: a novel concept instead of acupuncture anesthesia

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Abstract

Objective: To confirm that acupuncture applied to patients would improve the clinical curative effect and accelerate the patient's recovery by introducing the application of acupuncture in pre-operation, during operation, and post-operation.

Data sources: Literature cited in this review was retrieved from PubMed, Web of Science, and China National Knowledge Infrastructure (CNKI) and was primarily published in English or Chinese from 2010 to 2018, with keywords of "acupuncture," "electroacupuncture," "perioperative period," "sedation," "analgesia," and "recovery." Relevant citations in the retrieved articles were also screened to include more data.

Study selection: All retrieved literature was scrutinized, most typical articles related on perioperative acupuncture application in clinical study were reviewed.

Results: Acupuncture could relieve anxiety and stress during the preoperative stage. It reduces the usage of narcotics and stress response, and maintains the respiratory stability and homeostasis during surgery. It also exerts a protective effect on vital organs, and during the postoperative stages, enhances the recovery while effectively alleviating the postoperative pain. This phenomenon prevents common postoperative discomforts such as nausea and vomiting. In addition, it might improve the patients' long-term prognosis.

Conclusions: The novel concept "perioperative acupuncture medicine" is to focus on the optimal treatment in the perioperative period of surgical patients. The review reveals the important role of acupuncture in enhancing rapid recovery of patients during the perioperative period.

Keywords: Acupuncture; Acupuncture anesthesia; Perioperative acupuncture medicine

Introduction

The number of surgeries has been increasing continually in the recent years, with a postoperative mortality rate of 1/1000, which is a 100-fold difference as compared to the rate of anesthesia-related mortality (0.82/100,000). This led to the anesthesia departments to expand and recognize the perioperative care department. Several pieces of clinical evidences showed that the complications presented by the elderly with hypertension, diabetes mellitus, and cardiopulmonary diseases were the primary causes of death. Moreover, what need further investigation are that how to reduce perioperative complications, mortality and how to improve patient prognoses.

Acupuncture is commonly perceived as a hallmark of traditional Chinese medicine (TCM) that can achieve analgesic effects by regulating the nervous system and the release of peptidyl neurotransmitters. In 1958, traditional acupuncture analgesia was used to complement or substi-

tute the anesthetic and surgery. However, acupuncture has gradually phased out due to its limitations, such as the inability to provide complete anesthesia for operations, resulting in muscle tension and stretch reaction. Nevertheless, a large number of clinical trials have confirmed that acupuncture applied to surgical patients is usually beyond the scope of traditional anesthesia and has unique advantages. Pre-operative acupuncture can relieve anxiety, optimize the preoperative state, and reduce the usage of anesthetics, while surgical acupuncture can aid in postoperative and intestinal function recoveries, postoperative pain management, reduce postoperative nausea and vomiting, and shorten the length of hospital stay. Notably, acupuncture is not an alternative to narcotic drugs and modalities; however, it is an innovation in anesthetic techniques and concepts. Nevertheless, the term "acupuncture anesthesia," might mislead the general population to believe that acupuncture prevails as a form of anesthesia.

Therefore, we proposed "perioperative acupuncture medicine" as a new concept and terminology to replace

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“acupuncture anesthesia.” Perioperative acupuncture medicine refers to the use of acupuncture techniques for the optimization of preoperative and intraoperative programs as well as postoperative management. The roles of acupuncture in perioperative period were analyzed and summarized.

Acupuncture anesthesia history and development

Acupuncture anesthesia

Acupuncture stimulates the acupuncture points (also known as acupoints) for therapeutic purposes. In addition to the 2000 years of application in TCM, an increase in the usage of acupuncture in modern anesthesia has been observed.^[1] Modern acupuncture anesthesia (AA) originated in the 1930s and gained prominence throughout the 1960s and 1970s. AA is based on the surgical site, diseases, acupoints, dialectical acupoints, local acupuncture principles to acupuncture, and anesthesia effect after the implementation of an anesthetic method of surgery. On August 30, 1958, Department of Otorhinolaryngology of Shanghai First People's Hospital performed traditional acupuncture bilateral Hegu (LI4) during patient tonsillectomy. This was the first reported case, in which, acupuncture analgesia was solely used. Subsequently, the development of acupuncture anesthesia has entered a period of prosperity.

Acupuncture-assisted anesthesia

However, reducing the amount of intraoperative anesthetic might reduce the postoperative complications, thereby lowering the mortality rates. In response to such evidence, Han^[2] introduced the concept of acupuncture-assisted anesthesia (AAA) as acupuncture, entering the “acupuncture compound anesthesia” (ACA) stage. A large number of studies have shown that stimulating acupoints, Neiguan (PC6), Yintang (EX-HN3), and Shenmen (HT7), could significantly reduce the preoperative anxiety, postoperative nausea, and vomiting and relieve postoperative pain.^[3] Furthermore, acupuncture combined with narcotic medications could achieve complete analgesia and appropriate muscle relaxation, as well as, significantly inhibit the visceral traction reaction. On the other hand, the reduced inhalation of anesthetics, muscle relaxants, sedation, and analgesic drugs could significantly reduce the postoperative nausea and vomiting.^[4]

Acupuncture-drug balanced anesthesia

In anesthesia applications, the combination of acupuncture and medication has allowed patients to manage perioperative periods smoothly, limiting the discomforts and promoting the physiological recovery. Wang *et al*^[5] proposed that acupuncture and drug balance anesthesia promoted the postoperative recovery of patients. While Lu *et al*^[6] proposed perioperative acupuncture adjustment, which was not limited to acupuncture anesthesia, the patient's condition was optimized by less anesthetic drug use, promoting a positive role in the patient rehabilitation. Lu *et al*^[6] demonstrated the balanced analgesic effect and promoted the safety connotation, which proposed the

concept of “acupuncture-drug balanced anesthesia” referring to the use of acupuncture and drug binding application for a smooth perioperative management of patients by controlling the postoperative discomfort and promoting the recovery of physiological function. The concept of “balanced anesthesia with acupuncture” further attempted to describe the perioperative effect of acupuncture anesthesia rather accurately.^[7]

Application and benefit of acupuncture in perioperative period

Currently, the preoperative sedation with acupuncture is speculated to improve the patient's preoperative status. This might also reduce the amounts of anesthetics essential for maintaining the hemodynamic stability, providing postoperative analgesia and organ protection, to reduce the postoperative nausea and vomiting, as well as, to promote the gastrointestinal function recovery and regulate the postoperative immunity.

Preoperative application and benefits

First, acupuncture could reduce anxiety and stress in patients. Preoperative anxiety would increase the risk and difficulty of surgical stress and anesthetic management. Preoperative anxiety could also lead to sustained anxiety after surgery, increased postoperative sensitivity to pain, suppressed immune function, increased postoperative infection, and prolonged postoperative recovery time. The acupoints stimulation 30 min before induction of anesthesia allowed the patients to relax significantly, relieve the preoperative anxiety, and achieve sedation.^[8] Patients with electrical stimulation at acupuncture points Shenting (DU24) and Yintang (EX-HN3) for 6 h simultaneously might also achieve the same sedation, reduced markedly the dose of sedative drug required in critically ill patients with mechanical ventilation monitored by BIS.^[9] Selectively, the stimulation at bilateral Neiguan (PC6), Lie Que (LU7), and Yunmen (LU2) points with the similar stimulation time (30 min preoperative until surgery completion) allowed for adequate preoperative sedation.^[8] A prospective randomized double-blind clinical study found that in cataract surgery, acupuncture at Hegu (LI4), Neiguan (PC6), Waiguan (SJ5), Shenmen (HT7) point could achieve significant sedation.^[10] Similar results from a clinical trial pairing both sides of the Anming with Fengchi (GB20), Shenmen (HT7) with Hegu (LI4), and Sanyinjiao (SP6) with Zusanli (ST36) acupuncture stimulations in healthy volunteers have confirmed that the electro-acupuncture group was significantly lower in the bispectrality index and optimal sedation than the control group.^[11] A meta-analysis involving eight published studies on the effect of acupuncture on preoperative anxiety suggested that acupuncture significantly reduced the preoperative anxiety status.^[12]

Secondly, acupuncture could optimize the patient's preoperative condition that improves the function and reserve of vital organs, stabilizes the blood pressure and blood sugar, and reduces the risk of intraoperative anesthesia, which is the prerequisite for successful operation, and in turn, could reduce the postoperative

complications and accelerate patient rehabilitation. A large number of studies confirmed that acupuncture also exhibited functional therapeutic effects on hypertension and hyperglycemia. Randomized controlled clinical trials confirmed that acupuncture on patients with prehypertension and moderate hypertension exerted some antihypertensive influence.^[13] Furthermore, acupuncture reduced blood pressure by inhibiting sympathetic excitability, as well as norepinephrine, renin, and aldosterone concentration controls.^[14] A meta-analysis of randomized controlled clinical trials of acupuncture on the efficacy of hypertension also showed a significant antihypertensive effect of acupuncture in patients treated with antihypertensive medications.^[15] In contrast, a study reported acupuncture treatment in essential hypertension, the changes of systolic blood pressure and diastolic blood pressure were similar between both acupuncture and sham acupuncture treatments.^[16] However, the results should be interpreted cautiously because of methodological weakness. Further clinical trials with a rigorous design and large sample sizes are needed to warrant this result. A meta-analysis by Zhao *et al*^[17] also suggested some antihypertensive effect of acupuncture on patients with hypertension. Other randomized controlled clinical studies confirmed that transcutaneous electrical nerve stimulation and abdominal acupuncture therapy “Guiding yuan, abdominal four off” could improve the conditions of patients with diabetes mellitus type 2.^[18,19] Lastly, electroacupuncture for diabetic gastroparesis could reduce the gastric retention and improve the gastroparesis symptoms.^[20]

Intraoperative application and benefits

First, acupuncture could reduce the amounts of intraoperative anesthetics. The combination of acupuncture and drugs could reduce the amounts of narcotic drugs, which in turn, could reduce the adverse reactions associated with narcotic drugs. The strength of analgesia produced by acupuncture reduced the need for an anesthetic by 10% to 30% and potentially up to 50%.^[4] A prospective, randomized, double-blind clinical study verified that transcutaneous electrical acupoint stimulation (TEAS) at Hegu (LI4), Neiguan (PC6), or Zusanli (ST36) points was divided into control, low frequency, and high-frequency groups respectively; the amount of remifentanyl used in the low-frequency group was reduced significantly, whereas no significant difference was observed between the high-frequency and control groups.^[21] In this study, Neiguan (PC6), Hegu (LI4), Lie Que (LU7), and Quchi (LI11) acupoints were selected to compare the anesthesia effects of thoracoscopic lobectomy with TEAS. The results showed that TEAS was superior to propofol-fentanyl anesthesia that enhanced the analgesic effect and reduced the amounts of narcotics.^[21] Consecutively, clinical studies have shown that electroacupuncture at the lateral Neimadian and Neiguan 30 min before and after anesthesia for esophageal cancer surgery could safely and effectively assist the intraoperative anesthesia; these could significantly reduce the amount of anesthetic drugs.^[22,23]

Secondly, the rational application of acupuncture during surgery also aids in stabilizing the intraoperative respiratory and circulatory functions and relieving the surgical

and anesthesia stress. Thus, improving the safety and stability of anesthesia during perioperative period is beneficial. In experimental studies, 30 min of electric acupuncture at bilateral Houxi (SI3), Zhigou (SJ6), Neiguan (PC6), and Hegu (LI4) points before induction of anesthesia until surgery was conducted to observe the surgical resection of lungs in patients based on the stress response. The acupuncture group showed that the changes in the mean arterial pressure and heart rate were significantly less than those in the control group, and the increases in plasma adrenaline and cortisol before and after lobectomy in the acupuncture group were also less than those in the control group, indicating that acupuncture could reduce the stress response.^[24] TEAS experiments (TEAS at Yuyao [EX-HN4], Taiyang [EX-HN5], Hegu [LI4], and Fengchi [GB20] acupoints) compared the perioperative stress response of craniotomy, and confirmed that the heart rate and arterial pressure during the operation of electroacupuncture group were more stable than those of the control group. Compared to the control group, the levels of intracoronary stress indices including cortisol, epinephrine, and blood glucose were significantly lower.^[25] Another study found that when TEAS at Hegu and Neiguan during intravenous anesthesia was used in endoscopic bilateral total thyroidectomy, the mean arterial pressure was significantly more stable in the TEAS group than simple intravenous anesthesia group, shoulder irritation was suppressed, and the amount of propofol was reduced.^[26] One study found that electroacupuncture at Neiguan point continued until the end of surgery 30 min before operation could significantly reduce the serum levels of malondialdehyde (MDA) and cardiac troponin I (cTnI) and increase the serum levels of superoxide dismutase (SOD) after heart valve replacement, indicating that electroacupuncture at Neiguan could prevent the oxidative stress injury and protect the myocardial ischemia-reperfusion injury.^[27]

In addition, the rational application of acupuncture protects the heart, brain, and other vital organs. The multi-center, randomized, controlled clinical study found that electroacupuncture at the Ximen (PC4) and Neiguan (PC6) preconditioning could reduce the myocardial injury after percutaneous coronary intervention (PCI). Compared to the control group, the content of cTnI in the electroacupuncture group was significantly lower and the cardiac function index was significantly improved.^[28] The experimental electroacupuncture preconditioning at Neiguan (PC6), Lieque (LU7), and Yunmen (LU2) acupoints found the cardioprotective effect of electroacupuncture on the heart valve replacement. The results showed that the content of cTnI in the electroacupuncture group was significantly decreased after the aorta was opened. The duration of stay in the ICU in the electroacupuncture group was significantly shorter than that of the control group.^[29] Some experiments showed that TEAS at Neiguan exerted the electrical protective cardiac effects of pediatric cardiac surgery; and also, the electroacupuncture significantly reduced the pediatric serum cTnI levels and the duration of postoperative mechanical ventilation.^[30] A systematic review and meta-analysis assessed the efficacy of electroacupuncture in general anesthesia undergoing cardiac surgery, and found that the duration of mechanical

ventilation and ICU stay were reduced, the inflammatory response was blunted, and electroacupuncture might have protective effects on the heart, acupuncture might become an additional therapeutic strategy.^[31] The study confirmed that TEAS at bilateral Hegu (LI4), Quchi (LI11), Zusanli (ST36), and Sanyinjiao (SP6) assisted intravenous inhalation combined with general anesthesia for craniotomy played a neurosurgical perioperative brain protective effect by regulating the plasma endothelin and calcitonin gene-related peptide that improved the microcirculation of brain tissue and decreased the interleukin (IL)-6-mediated proinflammatory response.^[32]

Finally, acupuncture anesthesia shortened the patient's waking time. Acupuncture shortened the recovery time during the postoperative wake-up and removal of the tracheal tube, thereby reducing the risk of unintended events. One study performed the TEAS at Hegu, Neiguan and Zusanli and observed the extubation time and memory recovery time after operation; the results showed that the acupuncture group could shorten the postoperative extubation (12.5 ± 3.5 vs. 17.3 ± 6.7 min) and the memory recovery time (16.4 ± 5.9 vs. 21.8 ± 8.7 min).^[21] Other study confirmed that in outpatient breast surgery, TEAS at bilateral Hegu, Neiguan and Zusanli 30 min before induction of anesthesia, the acupuncture group significantly reduced the laryngeal mask removal and postoperative memory recovery times.^[33]

Postoperative application and benefit

Firstly, acupuncture can relieve pain, which is a critical measure of postoperative multimodal analgesia. About 80% of the patients suffer from acute pain post-surgery. Insufficient postoperative acute pain control could lead to immunosuppression (delayed wound healing, prolonged recovery, and increased risk of postoperative infection). The psychological effects include anxiety, depression, prolonged downtime, increased length of stay, and increased risk of venous thromboembolism. Postoperative acute pain 10% to 50% could be transformed into chronic pain. Short-term effective pain management post-surgery reduced the incidence of chronic pain and improved the medical outcome.^[34] Previous studies enrolled patients who underwent general anesthesia for elective gynecological laparoscopic surgery, demonstrated that TEAS was applied to four pairs of acupoints: bilateral Hegu, Neiguan, Zusanli and Sanyinjiao at 30 min; the results showed that the postoperative abdominal pain and the largest pain score in TEAS patients were significantly less than those in the control group.^[35] The study used TEAS at affected ipsilateral Hegu (LI4), Lie Que (LU7) and Quchi (GB20) point 30 min before anesthesia induction to observe the lobectomy patients after extubation pain score; the results showed that in the 2/100 Hz acupuncture group, the acupuncture pain score (1.3) was significantly smaller than that of the control group (2.4).^[19] A meta-analysis showed that the perioperative use of acupuncture could reduce the pain on day 1 after surgery; the analgesic effect of acupuncture rendered the patients in the test group to need less postoperative analgesic drugs than those in the control group.^[36] A clinical study compared the intensity of postoperative pain between patients receiving

single TEAS before surgery and patients receiving continued TEAS before, during and after surgery, and found that continuous electrical stimulation was more effective in reducing postoperative pain during laparoscopic surgery.^[37] A clinical study conducted electroacupuncture at Longshan and Chengshan acupoints 30 min preoperatively in the mixed hemorrhoids and compared the acupuncture embedding or a combination of the two and the impact on postoperative pain; the results showed that the combination of the two could relieve postoperative pain and electroacupuncture. The effect of rapid onset, the robust degree of relief, and catgut embedding showed a prolonged duration of pain.^[38] However, a randomized controlled trial showed that, compared with, pain intensity in acupuncture group was not significantly lower than conventional analgesia group, but was significantly lower than sham acupuncture group,^[39] which demonstrated that further studies are needed to support the use of acupuncture as adjuvant therapy in treating postoperative pain.

In addition, acupuncture could prevent postoperative nausea and vomiting, which is the most common anesthetic-related adverse reaction. The incidence of postoperative nausea and vomiting is approximately 25% to 35% and closely related to general and nerve block anesthesia, which often postpones the recovery of patients. Previous studies found that when TEAS at Hegu, Neiguan and Zusanli was used 30 min before the induction of anesthesia in breast surgery, the incidences of postoperative nausea (24.2% vs. 46.9%) and vomiting (15.2% vs. 34.4%) in the acupuncture group were less than that those of the control group.^[33] Some studies have observed the incidence of nausea and vomiting as well as the plasma concentration of serotonin after cesarean section by using TEAS to stimulate bilateral Neiguan and Zusanli from 30 min before surgery to the end. The results showed that TEAS could significantly alleviate postoperative nausea and vomiting as well as reduce the plasma concentration of serotonin. Furthermore, the concentration of serotonin was significantly reduced and the protective mechanism might be exerted via the plasma concentration of serotonin.^[40] Similar studies have shown that acupuncture at Neiguan could improve postoperative nausea and vomiting in gynecological laparoscopic surgery.^[41,42] Another study found that in patients undergoing laparoscopic surgery, electroacupuncture at Neiguan could significantly reduce opioids, which could cause postoperative nausea and vomiting.^[43] A randomized, controlled, clinical study found that the incidence of postoperative nausea and vomiting decreased from 20% to 5% after bilateral Zusanli electroacupuncture 24 h before gynecological laparoscopic surgery.^[44] Another meta-analysis showed that acupuncture could effectively reduce the incidence of postoperative nausea and vomiting.^[45,46]

Moreover, acupuncture could prevent postoperative cognitive dysfunction. Some studies used the model of myocardial ischemia-reperfusion injury in aged rats and compared the morphology, oxidative stress, systemic inflammatory response, and behavior of hippocampal CA1 region with respect to electroacupuncture at Baihui (DU20) and Zusanli (ST36). It was found that electro-

acupuncture could significantly improve the cognitive dysfunction induced by myocardial ischemia-reperfusion, inhibit neuronal apoptosis, and reduce the oxidative stress and inflammation reaction.^[47] Some studies also utilized the water maze test before and after intravenous propofol anesthesia and found that electroacupuncture at rat Baihui improved the cognitive impairment caused by propofol and reversed the decreased GSK-3 phosphorylation level in the hippocampal CA1 region.^[48] Also, the electroacupuncture at rat Baihui (DU20) and Dazhui (DU14) demonstrated the changes in cognitive function after left lateral lobectomy; the behavioral tests found that electroacupuncture could significantly improve the postoperative cognitive dysfunction potentially through microglia TLR2/4 signaling pathway which downregulated the level of proinflammatory cytokines in the hippocampus.^[49] Additional studies were conducted to observe the effects of electroacupuncture at Baihui and Dazhui on postoperative cognitive dysfunction (POCD) and the expression of angiotensin II (Ang II) and type 1 receptor (AT1R) in the hippocampus after partial hepatectomy in D-galactose-induced senility in rats. The results showed that electroacupuncture could improve the cognitive impairment after partial hepatectomy in rats with D-galactose-induced senility; the underlying mechanism might be related to the inhibition of the positive expression of Ang II, AT1R, and AT1R mRNA in the hippocampus.^[50] The prospective, randomized, controlled, clinical studies found that electroacupuncture at Baihui, Dazhui and Zusanli 30 min before anesthesia significantly improved the postoperative cognitive impairment in spine surgery and postoperative cognitive dysfunction in abdominal surgery; this was considered as maximally effective with 2 Hz/100 Hz and TEAS.^[51,52]

Acupuncture could promote postoperative gastrointestinal function and bladder function recovery. A study investigated electroacupuncture at Zusanli, Sanyinjiao, Hegu, and Zhigou lasting 1 to 4 days after laparoscopic colorectal cancer surgery, and showed that the first evacuation duration, the time of bowel sounds, the time of returning to normal diet, and the time of independent walking in the electroacupuncture group were significantly lower than those of the control group.^[53] A meta-analysis showed that the injection of Neostigmine, Vitamin B1, Metoclopramide, and NS at Zusanli (ST36) shortened the time to first postoperative ventilation and prevented the postoperative ileus.^[54] Electroacupuncture at Zusanli of the gastrointestinal tract and Neiguan of the pericardium were performed at 3 days postoperatively in gastric cancer patients; the results showed that the time of the first evacuation in the electroacupuncture group was significantly shorter (79.97 ± 37.31 vs. 98.09 ± 23.45 h) than that of control group.^[55] However, in another study, true acupuncture as provided did not significantly reduce postoperative ileus, compared with sham acupuncture. This study was limited by a standard deviation much larger than expected, suggesting that a study with a larger sample size might be required.^[56] A randomized, controlled, clinical trial confirmed that in the liver and vascular surgery, electroacupuncture at Zusanli and Xiayu preoperatively was significantly improved in postoperative first ventilation, defecation, and hospital stay.^[57] It was found

that electroacupuncture at Zusanli could effectively improve postoperative intestinal obstruction and shorten the recovery time by measuring the intestinal motility, c-kit and P2X7 mRNA levels of rats at different time points during the modeling, which may be related to the increase of the content of mesenchymal cells in the intestinal myenteric plexus.^[58] The effect of acupuncture at Sanyinjiao, Zusanli, Shuidao, and Shenque on day 15 after radical hysterectomy on postoperative urinary retention was assessed. The results demonstrated that the bladder function was significantly improved in the acupuncture group, and the residual urine volume (91.7 ± 17.5 mL) in the acupuncture group was also significantly reduced compared with the control group (93.5 ± 15.5 mL) among the patients with spontaneous micturition after operation, indicating that acupuncture could promote the recovery of postoperative urinary function and accelerate the removal of urinary catheter earlier.^[59]

Finally, anesthesia and surgical stimuli could lead to a decline in immune function, which is not conducive to the long-term prognosis of postoperative patients. Acupuncture could relieve pruritus after surgery, promote the recovery of postoperative immune function, and improve the patient's long-term prognosis. One study found that TEAS at bilateral Hegu, Neiguan, and Zusanli in breast surgery lowered the incidence of postoperative pruritus (2.61%) than that in the control group (8.25%).^[33] Furthermore, the levels of tumor necrosis factor (TNF)- α , IL-2, and IL-10 were altered after electroacupuncture at Neiguan, Lie Que, and Yunmen. The results showed that electroacupuncture downregulated the level of serum proinflammatory cytokine TNF- α and upregulated the levels of the anti-inflammatory cytokines IL-2 and IL-10. Under the same level of anesthesia, surgery could partially improve perioperative immunosuppression.^[8] The study confirmed that electroacupuncture at Baihui, Neiguan, Zusanli 30 min after general anesthesia, the incidence of cognitive impairment was significantly reduced and the releases of proinflammatory cytokines TNF- α , IL-1 β , and IL-6 were inhibited in colorectal cancer postoperative electroacupuncture group.^[60]

Potential mechanism

Although in humans, acupuncture therapy is increasingly used to treat diverse symptoms and disorders, its underlying mechanism is still unclear. This review mainly introduced the potential mechanism of perioperative acupuncture through the following three fields: the autonomic nervous system, the inflammatory responses, and the endocannabinoid system. First of all, several researches showed that autonomic nervous system has been used to study the manual acupuncture (MA) and electroacupuncture. The sympathetic-adrenomedullary and hypothalamic-pituitary-adrenocortical systems are activated that lead to increase the levels of adrenalin (epinephrine), noradrenalin (norepinephrine), and cortisol in response to stress. These mediators increase pulse rate, blood pressure, gastrointestinal (GI) motility and blood glucose levels to regulate the ability to cope with stress on all organs of the body. Studies have shown that acupuncture played an important protective role by

decreasing sympathetic nervous activity and increasing parasympathetic nervous activity.^[61-65] It was reported that the manipulation of electroacupuncture in animal models improved gastric emptying, increased vagal activity and suppressed sympathetic activity assessed by spectral analysis of heart-rate variability.^[66,67] An increasing number of reports have indicated that acupuncture might be effective in treating many types of diseases by regulating inflammatory responses.^[68] Electroacupuncture in animal models of ulcerative colitis and zymosan-induced acute arthritis was effective through regulating the levels of TNF- α , IL-1 β , IL-6, and myeloperoxidase,^[69,70] increasing superoxide dismutase, and reducing inflammatory protein.^[71,72] One study reported that electroacupuncture at the Zusanli acupoint downregulated the production of major inflammatory cytokines in an animal model of polymicrobial peritonitis, and showed that increased dopamine production by vagal activity transmitted to the adrenal gland.^[73] Finally, recent researches showed that the endocannabinoid system has been involved in many of the various therapeutic effects induced by

acupuncture,^[74] the biological effects including analgesia, neuroprotection and cardiovascular regulation shared by both acupuncture and the endocannabinoid system.^[75-80] Studies have found that acupuncture could increase the tolerance of acute cerebral ischemia-reperfusion injury and alleviate brain damage by regulating the endocannabinoid system.^[81-83] Besides, in analgesia, many various mechanisms have been proposed to explain how acupuncture might work over the past few decades. Current studies showed that a range of biochemicals or neurotransmitters were involved in acupuncture/electroacupuncture analgesia such as opioid peptides, adenosine, dopamine, cytokines, norepinephrine and serotonin.^[84-88] Many researchers thought that the secretion of endogenous opioid peptides played a pivotal role in central antinociception. Different neurotransmitters were secreted at different frequencies. Electroacupuncture activated endorphin and enkephalin at low frequency (2Hz), while activated dynorphin to suppress nociception at high frequency (100Hz) as assessed by the tail flick test.^[89,90] The following observations showed that adenosine

Table 1: Summary of basic characteristics of the included studies.

Phases	Type of surgery	Acupoints	Technique	Frequency	Benefits
Preoperative phase	Cardiac surgery; Brain surgery; Cataract surgery	Fengchi (GB20), Tianzhu (BL10), Yuyao (Ex-HN04), Neiguan (PC6), LieQu (LU7), Yunmen (LU2), Hegu (LI4), Waiguan (SJ5), Shenmen (HT7), Sanyinjiao (SP6), Zusanli (ST36)	Acupuncture; EA; Abdominal acupuncture therapy	Once, on operation day	(1) Reduce anxiety and stress ^[8-12] ; (2) Optimize condition. ^[13-20]
Intraoperative phase	Thoracoscopic lobectomy; Sinusotomy; Esophageal cancer surgery; Craniotomy; Thyroidectomy; <i>Percutaneous coronary intervention</i>	LI4, PC6, ST36, LU7, EX-HN4, GB20, SP6, Neimadian, Quchi (LI11), Houxi (SI3), Zhigou (SJ6), Taiyang (Ex-HN05), Quanliao (SI18), Ximen (PC4)	EA, TEAS	Once, before and after surgery	(1) Reduce demand of anaesthetics ^[21-23] ; (2) Stabilize circulatory function ^[24-27] ; (3) Organ protection ^[28-32] ; (4) Shorten waking time. ^[21,33]
Postoperative phase	Laparoscopic surgery; Breast surgery; Cesarean section; Gynecological laparoscopic surgery; Hepatectomy; Spine surgery; Colorectal surgery	Jiaji (Ex-B05), LI4, LU7, Distal LI 11, SJ6, SP60, PC6, ST36, Chengshan (BL57), Baihui (DU20), Dazhui (DU14), Xiayu (ST39), Shuidao (ST28), Shenque (RN8)	Acupuncture; TEAS; Catgut embedding; EA	Once, on operation day, before and after surgery, post-operation days 1-4, post-operation day 15	(1) Relieve pain ^[34-39] ; (2) Prevent postoperative nausea and vomiting ^[40-46] ; (3) Prevent cognitive dysfunction ^[47-52] ; (4) Promote organ function ^[53-59] ; (5) Recovery immune function. ^[8,33,60]

EA: Electroacupuncture; TEAS: Transcutaneous electrical stimulation.

mediated the local anti-nociceptive effects of acupuncture, both necessary and sufficient for the clinical benefits of acupuncture through the A1 receptor activation.^[86] Numerous studies indicated that spinal serotonin and norepinephrine were involved in electroacupuncture analgesia.^[85,91] Through continued research into the mechanisms of acupuncture's clinical effects, we would be able to optimize and apply acupuncture to the clinical conditions, which might benefit most from this ancient therapeutic system.

Proposal and prospect

Acupuncture has been shown to gradually promote the rehabilitation of patients perioperatively, while the acupuncture methods are also developed rapidly. In addition to the commonly used needle, triangular needle, new methods including a warm needle, pointer, electroacupuncture, ear acupuncture, acupressure, transcutaneous acupuncture, acupoint catgut implantation and laser needle, microwave needle, and ultrasonic needle innovation are also applied. Herein, we proposed "perioperative acupuncture medicine" instead of acupuncture anesthesia, which could be developed for enhanced recovery after surgery (ERAS). It focuses not only on the patient's surgical procedure but also on the final prognosis, thereby focusing on the diagnosis and treatment in the perioperative period [Table 1].

"Perioperative acupuncture medicine" also revealed the issues with acupuncture before, during, and after surgery. For example, how to choose the best acupuncture therapy for different patients? how to implement perioperative acupuncture medicine individually? These require not only the cooperation between Chinese and Western medicine, but also scientific clinical trials. Whether perioperative acupuncture can affect the long-term health of patients after surgery still needs further research. Thus, the present study necessitates further scientific investigation to enhance the theoretical significance of perioperative acupuncture medicine, expand the clinical application of perioperative acupuncture medicine, and elaborate the role in patients undergoing surgery.

Conflicts of interest

None.

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