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Perioperative Acupuncture and Related Techniques

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Abstract

Acupuncture and related techniques are increasingly practiced in conventional medical settings, and the number of patients willing to use these techniques is increasing. Despite more than 30 years of research, the exact mechanism of action and efficacy of acupuncture have not been established. Furthermore, most aspects of acupuncture have yet to be adequately tested. There thus remains considerable controversy about the role of acupuncture in clinical medicine.

Acupuncture apparently does not reduce volatile anesthetic requirement by a clinically important amount. However, preoperative sedation seems to be a promising application of acupuncture in perioperative settings. Acupuncture may be effective for postoperative pain relief but requires a high level of expertise by the acupuncture practitioner. Acupuncture and related techniques can be used for treatment and prophylaxis of postoperative nausea and vomiting in routine clinical practice in combination with, or as an alternative to, conventional antiemetics when administered before induction of general anesthesia.

Summary Statement: The use of acupuncture for perioperative analgesia, nausea and vomiting, sedation, anesthesia, and complications is reviewed.

Introduction

Acupuncture is an integral part of an ancient Chinese system of medicine that has been used for more than 2500 years to treat diseases and relieve pain. According to tradition, the practice of acupuncture is based on a philosophy of balance and unity between the Universe, living beings, and energy flow that penetrates everywhere and everything. Any imbalance, disruption, or energy-flow blockage within the body can cause disease or pain. The main concept and philosophy of acupuncture is to return the body to a harmonized, balanced state.

There are numerous techniques and approaches to acupuncture, reflecting a variety of medical traditions and schools from China, Korea, Japan, Vietnam, and other countries. Some of these approaches focus on points located on traditional Acupuncture Meridians that crisscross the body surface. Other methods focus on points located on the ear (Auricular Acupuncture), hands or the feet (Korean Hand Acupuncture, Su-Jok Acupuncture). In general, it is believed that the

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ears, hands, and feet are micro-models of the entire body with areas that represent the body parts, organs, meridians, and acupuncture points. These micro-models have the same principles of energy flow as the whole body. An explanation of this phenomenon is a principle of the fractalization (similarity) of living and non-living things, in which small parts have the same shape as the whole.¹ No matter what method of acupuncture is used, it is necessary to apply acupuncture to specific points to achieve analgesia or other beneficial regional or systemic effects.

Historical Perspective

The origins of Chinese medicine are shrouded in legend and obscured by the Chinese propensity for the veneration of their ancestors. The two most famous medical treatises, on which the cornerstones of all traditional Chinese medicine rest, are credited to two legendary Emperor-Gods — Shen Nung and Huan Di — who are said to have ruled between 3737 and 2597 B.C. The *Pen Ts'ao*, the pharmacopeia that forms the basis of traditional herbal medicine in China, is credited to Shen Nung. However, this book most likely appeared during the Han dynasty, between 206 B.C. and 200 A.D. A revised version is still used by traditional doctors in China. The most famous of all writings on Chinese medicine, *The Yellow Emperor's Classic of Internal Medicine*, is credited to Huan Di. It was, in fact, probably written during the fourth or third century B.C., and over the centuries it was revised several times. Its present form was written in 762 A.D. during the Tan dynasty. It is interesting to note that the acupuncture section of this book does not present the rudiments of the technique, but rather certain refinements of its application. This suggests that acupuncture was already well developed by the time this book was written.

Modern research on the basic mechanism of acupuncture started after the People's Republic of China was founded in 1949, and Mao Zedong encouraged the practice of acupuncture in the country. Ten years later, acupuncture was introduced in the former Soviet Union where research work was initiated. These results remained essentially unknown to most Western scientists and physicians. This typically reflects a failure to publish papers in English — along with a lack of interest in the Western research community.²

There was a surge of interest in acupuncture in the United States after President Nixon's visit to China in 1971. This resulted in part because James Reston, a New York Times reporter, was in China covering President Nixon's trip when he developed acute appendicitis. His postoperative pain was treated with acupuncture, and he described his experience on the front page of the New York Times, and interest in acupuncture exploded.³ Subsequently, American and European physicians visiting China witnessed surgeries being performed with acupuncture as the only anesthetic. An enormous number of articles in newspapers and magazines about the use of acupuncture in anesthesia followed. Serious fundamental research on acupuncture started only in 1976 after the endorphin hypothesis of acupuncture's mechanism of action was introduced. Further development of acupuncture research was prompted by introduction of magnetic resonance imaging (MRI) and positron emission tomographic scanning which revealed the relationship between acupuncture stimulation and activation of certain brain structures.⁴⁻⁸ Today, a critical mass of scientific work about acupuncture's mechanism of action has accumulated. Interest in the United States is so great that the National Institutes of Health has funded dozens of experimental and clinical acupuncture studies.

The World Health Organization issued a list of medical conditions that may benefit from treatment with acupuncture. Such applications include prevention and treatment of postoperative and chemotherapy induced nausea and vomiting, treatment of pain, alcohol and other drug addiction therapy, treatment of asthma and bronchitis, and rehabilitation from neurological damage such as that caused by stroke.⁹ As a result of all these activities, the Food

and Drug Administration removed acupuncture needles from the category of “experimental medical devices” and now regulates them like other medical devices.⁹

Skepticism about acupuncture nonetheless remains high among medical professionals in the United States. Contributing to this skepticism are the facts that the scientific basis of acupuncture remains unclear, the philosophical basis of acupuncture is difficult for a modern industrial society to accept, the operational language is unusual, and the traditional system of acupuncture points does not correspond to Western concepts of anatomy or neurology. Moreover, acupuncture remains a bit more of an art than a science as many factors that can profoundly influence the outcome of the treatment have to be considered. In addition to the symptoms of the disease, a practitioner might consider the patient's gender,¹⁰ psychological constitution of the patient,¹¹ season, time of the day,¹² and even the location in which treatment is administered.¹³⁻¹⁵ The result is that the efficacy of interventions may differ substantially in patients with similar complaints. Such variations make it difficult to standardize procedures and hamper acupuncture clinical research. Another problem associated with acupuncture research is defining an adequate placebo as a control intervention for acupuncture studies. Some trials compare acupuncture to drugs and others use “sham acupuncture” (acupuncture at random spots on the body surface that are thought to be inactive). There is substantial controversy, however, about the use of sham acupuncture as a control treatment.¹⁶ Results from studies using sham acupuncture are difficult to interpret since the procedure itself can provide neurohormonal and clinical effects (Fig.1).

Interest Profile

Despite much skepticism, approximately half of physicians believe acupuncture is efficacious. It has a higher rate of physician referral than other complementary therapies such as chiropractic, massage, homeopathy, or herbal therapy.¹⁷

There has been a stable and substantial increase in the use of and expenditures on alternative medicine including acupuncture. This use is distributed widely across all socio-demographic groups; however, a greater fraction of women (49%) than men (38%) have used alternative therapies. African Americans (33%) use alternative therapies less commonly than other racial groups (44%). Interestingly, people aged 35 to 49 years report greater use than younger or older people. Use is also greater among those with college educations and annual incomes exceeding \$50,000/year.¹⁸

In one study, more than half of surgery patients surveyed preoperatively had a favorable attitude towards the use of complementary and alternative medicine. Forty-two percent expressed an interest in integrating acupuncture as a treatment modality for preoperative anxiety. Those who had previously used acupuncture were more interested in using acupuncture for preoperative anxiety than those without previous experience (62% versus 39%).¹⁹

Basic Concepts

The theory of Traditional Chinese Medicine, of which acupuncture is just a part, is complex and beyond the scope of this review. Unlike Western biomedical science, Traditional Chinese Medicine does not make a distinction between physical, mental, and emotional components of life. Moreover, it considers a human being as an integral part of the universe. It is believed that everything within the universe, including humans, obey the same laws. Therefore, health and disease result from spiritual, mental, physical, and environmental balance or imbalance.

Organs and Meridians

The theory of Traditional Chinese Medicine recognizes 12 main acupuncture meridians with corresponding organs in the human body. Additionally, eight so-called “curious meridians”

can be distinguished. Most “acupuncture organs” have names similar to organs of Western Medicine, but their correlation with physiological functions and anatomical structures of recognized organs is only approximate. Organs, as seen in ancient Chinese traditions, are functional systems rather than anatomical structures with broader and sometimes peculiar physiological functions and anatomical representations. For example, two traditional “organs” namely “Triple Warmer” and “Pericardium” (“Heart Governor”) do not have distinct anatomical representation at all. All meridians and organs are connected and related to each other directly or indirectly according to various rules and principles:

1. Each organ has a corresponding meridian with acupuncture points located along it.
2. Meridians travel inside the body and on the body's surface and are connected to each other and organs by a complex network of accessory collaterals.
3. The function of the meridians is to regulate and modify the corresponding organ or group of related organs. It is believed that meridians can control pain along the areas they traverse.

Acupuncture Points

In Chinese acupuncture, points are called xue, which means “cave” or “hole.”^{20,21} In Chinese acupuncture tradition and language, the names of points are important and informative. In modern Western acupuncture, Chinese names are rarely used. Instead, the points are numbered and classified with the capital letters of the meridian to which they belong. There are 365 classic points located along the meridians and at least the same number of extra-meridian points. The exact location of the points is important since, according to classic theory, even small deviations from the intended location can nullify the response. The relationship of acupoints to anatomical landmarks is usually described in terms of the so-called Chinese inch or cun.

Several phenomena can be observed in acupuncture points that help to locate them more precisely:

1. All points are located in a small hollow or depression on the skin surface.
2. Acupuncture points are usually tender compared with the surrounding area. The patient feels slight pain radiating circumferentially for at least a centimeter, when the point is pressed.
3. A roughness or stickiness can be appreciated, when brushing slightly with the finger.²¹
4. A specific feeling called the De-Qi sensation is usually felt by the patient, when a needle stimulates the acupuncture point.

A specific sensation called De-Qi can present as soreness, numbness, warmth, heaviness, or distention around the area where a needle is inserted. Sometimes this sensation radiates along the pathway of the meridian to which the stimulated point belongs. An experienced practitioner also feels tightness and some heaviness in the fingers when the needle hits the point. This effect has been compared with the feeling one gets when “the fish catches the hook.”²² Most physicians consider the De-Qi phenomenon to be crucial in achieving the effect of acupuncture.²²⁻²⁴

The diameter of acupuncture points varies. The actual size depends on the individual point, the patient's condition, time of day, and possibly the season of the year. Depth of the points also varies. The depth depends on the complexion of the patient, skin thickness, location of the point, occupation and life style of the patient, and duration of the disease.^{21,22} However, most are 3 to 15 mm below the skin surface.

Each point has a specific function and indication for its use. For example, stimulation of certain acupuncture points distant from the source of pain can provide excellent analgesia, whereas stimulation of inappropriately selected points in close proximity to the source of pain might be ineffective or even aggravate the symptoms. Stimulation of site-specific acupoints usually induces spatially restricted analgesia — although this aspect of acupuncture has yet to be studied in detail. However, Benedetti et al.²⁵ demonstrated that placebo or treatment expectation provides an analgesic response with a highly spatial presentation, which is completely abolished by systemic naloxone administration. These data indicate that this type of analgesic response is mediated by endogenous opioid release, but that the effect is regional rather than systemic. It is possible that acupuncture manifests a similar mechanism of action. Li et al.²⁶ demonstrated that acupuncture stimulation of the ipsilateral Huantiao (GB30) point, which is traditionally thought to be effective for pain in the lower limbs including sciatica pain, significantly inhibits nociceptive responses of spinal dorsal horn neurons evoked by stimulation of the sural nerve in the rat. In contrast, stimulation of the contralateral Huantiao (GB30) and some other points produce much less, if any, inhibition.

Cho et al.,⁵ using functional MRI (fMRI), demonstrated a correlation between activation of specific areas of the brain and corresponding acupoint stimulation predicted by ancient acupuncture literature. In this study, acupuncture points belonging to the Bladder Meridian and located on the foot were stimulated. These points are traditionally related to the eyes and visual function. The investigators were able to demonstrate activation or deactivation of signal intensity in the visual cortex. A subsequent study confirmed this finding and demonstrated activation of visual and auditory cortex caused by electroacupuncture stimulation of eye-related points and ear-related points, respectively.⁸ However, electroacupuncture at sham points also elicited activation in the auditory cortical zone suggesting that acupuncture-induced activation of medial occipital cortex and superior temporal gyrus may not be an acupoint-specific phenomenon.

Point specificity was also questioned in another fMRI study by Cho et al.²⁷ where meridian and sham acupuncture were both involved in the process of transmission and perception of pain. Meridian acupuncture demonstrated more profound pain control than sham point stimulation, but the effect may not have been entirely point specific (Fig. 1). Point specificity, as claimed by traditional acupuncture literature and demonstrated by clinical practice and some experimental studies, is not fully supported by other studies and, thus, remains a controversial issue. Only careful systematic research using site-, organ-, and function-specific acupuncture points with carefully selected sham control points will resolve this issue.

Auricular Acupuncture

The ear has a close relationship with the entire body. Every part of the body has a corresponding zone of representation on the external ear. A reaction often occurs in a corresponding area on the ear when an internal organ or other part of the body is afflicted with an ailment. The nature of ear points remains unclear and there is no good theory to explain the existence of reactive points on the ears.

Each organ is thought to be represented by a point on the external ear, and this point is usually needed to achieve an analgesic effect in this organ or area. The problem, however, is that auricular points have different locations according to different systems.²⁸ For example, French and Chinese auricular acupuncture systems have different mapping. A related problem is the fact that opinions vary with regard to the properties of different ear points. Increased tenderness on pressure, spots of skin discoloration on the ear, or decreased electrical resistance is thought by some to help identify optimal sites for needling.

Mechanisms of Action

Starting in the 1960s, Western-trained Chinese physicians began to study acupuncture analgesia, particularly acupuncture-induced physiologic changes in the central nervous system. This and subsequent research in Western countries resulted in the discovery of the pathways of acupuncture analgesia, receptors, and several types of endogenous opioids involved in the process; hence, a comprehensive hypothesis of acupuncture analgesia was formed. Experimental studies on animals and clinical studies on humans have since identified numerous clinical and physiological responses to acupuncture stimulation.

Comprehensive Theory

Based on a review of hundreds of modern scientific studies on acupuncture analgesia, Pomeranz and Stux² proposed a comprehensive mechanism of action for acupuncture analgesia. The basis for the theory is that three mechanisms contribute to acupuncture analgesia.

1. Acupuncture needles stimulate type I and type II afferent nerves or A-delta fibers in muscles, all of which send impulses to the anterolateral tract of the spinal cord. At the spinal cord, pain is blocked presynaptically by the release of enkephalin and dynorphin, preventing pain messages from ascending in the spinothalamic tract.
2. Acupuncture stimulates midbrain structures by activating cells in the periaqueductal gray matter and the raphe nucleus. They in turn send descending signals through the dorsolateral tract, causing the release of the monoamines norepinephrine and serotonin in the spinal cord. These neurotransmitters inhibit pain presynaptically and postsynaptically by reducing transmission of signals through the spinothalamic tract.
3. Stimulation in the pituitary-hypothalamic complex provokes systemic release of beta-endorphin into the blood stream from the pituitary gland. Its release is accompanied by the release of adrenocorticotrophic hormone.

A-delta fibers are activated by pinprick, pressure, thermal manipulation, and by high-threshold ergo receptors in muscles. A-delta fibers provide rapid, precisely located perception of noxious stimulation without much affective response. Some of these fibers terminate on the rostral reticular formation and thalamus. From here, they pass forward to the arcuate nucleus of the hypothalamus and on to the prefrontal cortex.²⁴ Myelinated A-delta fibers are considered the most likely candidate for conveying acupuncture stimuli, but other fibers including the unmyelinated C fibers and A-beta fibers may contribute. C fibers, which are ontogenetically older, produce pain described as slow, deep, throbbing, and dull. This sort of pain is often accompanied by a strong affective component. Thus, noxious stimulation by the C fiber system leads to a perception of pain that is poorly localized, but has considerable affective impact. These fibers primarily make synaptic contacts in substantia gelatinosa in lamina II. Different kinds of fibers are involved in different components of the De-Qi sensation.²⁹ Since different modalities of acupuncture stimulation produce different types of De-Qi sensation, they may trigger diverse brain networks based on the types of afferent input.⁶

That acupuncture influences regional brain activity was elaborated by Wu et al.⁷ who reported that acupuncture at two major points, Zusanli (ST 36, Fig. 2) and Hegu (LI 4, Fig. 3), activates the hypothalamus and nucleus accumbens on fMRI imaging and deactivates the rostral part of the anterior cingulate cortex, amygdala, and hippocampal complex. In contrast, control stimulation by superficial needling that did not elicit the De-Chi sensation did not alter regional brain activity. Thus, acupuncture at major points with strong analgesic properties appears to activate structures of the descending antinociceptive pathway and to deactivate multiple limbic areas subserving pain association.

Other Potential Mechanisms

Acupuncture not only provokes release of endogenous opioids from central nervous system (CNS) stores, but may also activate other analgesic mechanisms. For example, acupuncture may relieve pain by modulating the hypothalamic-limbic system.^{4,8} Biella et al. used positron emission tomography scans in healthy volunteers who were not experiencing any pain to evaluate regional cerebral blood flow in response to classic manual acupuncture stimulation of the Zusanli (ST 36) and Qize (LU 5) acupuncture points. They were able to demonstrate activation of the left anterior cingulum, the insulae bilaterally, the cerebellum bilaterally, the left superior frontal gyrus, and the right medial and inferior frontal gyri (Fig. 4).⁴ Several imaging studies indicate that the same structures are activated by acute and chronic pain.³⁰⁻³³ Placebo acupuncture (needles inserted superficially into non-acupuncture points 1 cm lateral to each acupoint and then immediately extracted) also produced a degree of cerebral activation, but at areas differing from those activated by real acupuncture. Cho et al. had similar results (Fig. 1). All the structures that were activated by acupuncture are also involved in nociceptive processing and play a role in the concept of the “neuromatrix” as proposed by Melzack.³⁴ According to this concept, acupuncture can be thought as a conflicting message in the pain neuromatrix, unbalancing it and thus modifying the perception of pain.⁴

An interesting theory was proposed recently suggesting a potentially important integrative role of connective tissue in acupuncture's mechanism of action.³⁵ Langevin et al.³⁶ found 80% correspondence between acupuncture points and the location of intramuscular connective tissue planes in postmortem tissue sections. According to this theory, needle manipulations lead to the development of coupling between needle and tissue with subsequent transduction of the mechanical signal to a cellular response that may underlie some of the therapeutic effects of acupuncture both locally and distally. The theory probably does not explain moxibustion, acupressure, laser, and other non-invasive methods of point stimulation.

Acupuncture analgesia leads to development of tolerance, when applied continuously or repeatedly over short time intervals. It would be reasonable to speculate that once acupuncture stimulation releases endogenous opioids to exert an analgesic effect, it also provokes the release of anti-analgesic substances. It would be reasonable to speculate that once acupuncture stimulation releases endogenous opioids to exert an analgesic effect, it also provokes the release of anti-analgesic substances. Cholecystokinin is a powerful antagonist of the analgesic effect of acupuncture,³⁷⁻⁴¹ and cholecystokinin antisense RNA increases the analgesic effect induced by acupuncture.⁴¹

The majority of the studies have focused on the analgesic effects of acupuncture and the role of endogenous opioids in acupuncture analgesia. Acupuncture stimulation results in a much broader spectrum of systemic responses including altering the secretion of neurotransmitters and neurohormones and changing the central and peripheral regulation of blood flow. There are also data suggesting that acupuncture alters immune function²⁴ and accelerates nerve regeneration.^{42,43} The mechanisms of these physiological responses remain unclear.

Types of Acupuncture

Acupoint stimulation can be roughly divided into invasive and non-invasive methods. Invasive methods include skin penetration with an acupuncture needle with subsequent manual stimulation of needles, electroacupuncture, or chronic intradermal needle insertion. These methods are considered “dry needle” techniques. Drugs can be injected into acupoints, a technique considered “wet needle” acupuncture. Non-invasive methods include acupressure, transcutaneous electrical stimulation, moxibustion, and application of various stimulating patches and pellets.

Since the theory of acupuncture is based on the concept that diseases are caused by an imbalance of Qi, the goal of needle insertion is, roughly speaking, to disperse excessive Qi or to replenish it. These two goals can be achieved by several means: applying needles of different sizes or lengths, using needles made of different material, changing the direction of needle insertion, selecting different points for stimulation, etc. Strong stimulation — a bigger needle, more intense needle manipulation, or directing the tip of the needle against the hypothetical “energy flow” along the meridian — is believed to disperse the excessive energy, while mild stimulation - a smaller needle, gentle and more superficial needle insertion, or directing the needle towards the “energy flow” — is used to replenish it. Manual stimulation techniques can be altered to provide the desired effect by using strong vertical up-and-down movements, rotational movements, or mild vibrating movements for example. Practitioners believe that selecting the proper acupuncture maneuvers and appropriate point selections are key to obtaining a satisfactory therapeutic effect. Consistent with this theory, Chen et al.⁴⁴ demonstrated that different manual needling maneuvers provide different responses on tail flick latency and vocalization threshold in rats.

Electrical stimulation of acupuncture points was developed as an alternative to manual acupuncture. Electrical stimulation has several advantages in that it is: 1) less painful than manual stimulation; 2) requires less practitioner time directly spent with the patient; 3) provides better analgesia⁴⁵; and 4) facilitates standardization. Electro-stimulation is now the most common type of acupuncture analgesia.⁴⁶

The De-Qi sensation depends on the type of acupuncture stimulation. Manual stimulation mainly produces soreness, fullness, and distention, whereas electroacupuncture generally produces tingling and numbness. Kong et al. report that manual acupuncture manipulations decrease MRI signals, in contrast to electroacupuncture stimulation that generally increases MRI signal intensity.⁶ Both types of stimulation, however, produce analgesia. Various stimulation modalities thus appear to trigger different brain networks depending on how acupoints are stimulated.

Electroacupuncture (electrical stimulation of acupuncture points) with high-frequency (100-200 Hz) stimulation provides rapid-onset analgesia that is not cumulative and cannot be blocked by naloxone. This type of analgesia is probably mediated by norepinephrine, serotonin, and dynorphins.⁴⁷ In contrast, low-frequency (2-4 Hz) and medium-frequency (15-30 Hz) stimulation produces an analgesic effect that is reversed by naloxone (and therefore, presumably, mediated by enkephalin and endorphins), has a tendency to accumulate, and lasts at least an hour after treatment ceases.^{45,47} Antinociception induced by low frequency stimulation is mediated by both mu- and delta-opioid receptors; high frequency electroacupuncture stimulation induces antinociception mediated by kappa receptors; and medium frequency (e.g., 30 Hz) stimulation induces antinociception mediated by all three opioid receptor types.⁴⁸

Most modern acupuncture needles are made of stainless steel, although needles made of gold or silver are also available. Gold needles are thought to possess stimulating properties whereas silver needles are believed to be sedative. Most acupuncture needles are between 1.3 and 12.7 cm in length and range from 26 to 36 gauge in diameter. The tips of the needles are rounded and thus separate fibers rather than cutting tissues. For this reason, even capillary bleeding from an acupuncture site is rare unless a needle accidentally penetrates a vessel. Special needles are available for intradermal use, auricular acupuncture, and hand and foot acupuncture.

Application in Perioperative Care

Perioperative acupuncture and related techniques have been advocated for preoperative sedation, to reduce intraoperative opioid use, and to decrease postoperative pain. There is

compelling evidence that acupuncture reduces postoperative nausea and vomiting. It may also stabilize cardiac function and ameliorate some consequences of anesthesia and surgery.

The use of perioperative acupuncture is based on the theory that diseased organs have a reduced response threshold to stimuli, while a considerable stimulus is needed to alter the function of a healthy organ. Therefore, only a small stimulus of an acupuncture needle may cure severe disease whereas a comparable stimulus normally produces little effect.⁴⁹ To some extent then, perioperative acupuncture contradicts a fundamental principle of acupuncture philosophy in that its goal is to achieve an abnormal insensitivity to pain and reduced awareness and concern.

Perioperative acupuncture can be divided into three components: 1) pre-operative preparation; 2) intra-operative acupuncture-assisted anesthesia; and 3) postoperative care, which includes postoperative pain control, nausea and vomiting reduction, and normalization of bowel function.

Preoperative Preparation

The goals of preoperative preparation with acupuncture are to optimize the physiological and psychological conditions of the patient, reduce preoperative anxiety, and trigger release of endogenous opioids to enhance analgesia. One way that acupuncture helps in preoperative preparation is by producing relaxation and sedation. For example, Ekbohm et al.⁵⁰ demonstrated that although acupuncture failed to produce intraoperative and postoperative analgesia for dental surgery, it caused significant relaxation and drowsiness. Ulett reported that electroacupuncture to classical acupoints is associated with a deep calming effect.^{45,51} Postoperative pain intensity and consumption of postoperative analgesics both correlate with the amount of anxiety patients suffer.^{52,53}

Auricular acupuncture appears to be effective for treatment of preoperative anxiety. In two double-blinded, sham-placebo studies, Wang et al. found that preoperative acupuncture at the “relaxation” point on the ear (Fig. 5) reduced anxiety at up to 48 hours postoperatively compared sham-acupuncture.^{54,55} In a prospective, randomized, placebo-controlled, double-blinded study, electroacupuncture was shown to reduce anxiety, discomfort, and demand for sedative drugs during colonoscopy. Points LI 4 (Hegu Fig. 3), ST 36 (Zusanli; Fig. 2), SP 6 (Sanyinjiao), SP 9 (Yinlingquan) and auricular point Shenmen at the apex of triangular fossa of the ear were stimulated. Patients were divided into three groups: active acupuncture, sham acupuncture, and no acupuncture (control). All patients were given midazolam 0.02 mg/kg 15 minutes before the procedure. Additional midazolam was required in three patients in the acupuncture group (30%), eight patients in sham group (80%), and nine patients in the control group (90%). Patients in the acupuncture group scored procedure acceptability better. Thus, appropriately administered acupuncture may be a valuable alternative to preoperative anxiolytic treatment with benzodiazepines.

Intraoperative Acupuncture-assisted Anesthesia

Reduction in volatile anesthetic or opioid requirement is a clinically important outcome since it can reduce anesthetic toxicity and duration of recovery. There is evidence to suggest that inadequately treated pain, even during general anesthesia, activates pain pathways.⁵⁶ Subsequent release of local mediators then primes the pain-sensing systems and aggravates postoperative pain.⁵⁷ To the extent that intraoperative acupuncture prevents activation of pain pathways and provides analgesia, it may similarly reduce postoperative pain and the requirement for postoperative opioids (see Table 1).

It is important to emphasize that acupuncture does not provide true anesthesia or unconsciousness, since it preserves all normal sensory, motor, and proprioception sensations.

Nor does it provide adequate muscle relaxation or suppress autonomic reflexes caused by intraabdominal visceral pain.⁵⁸ Instead, acupuncture produces analgesia⁵⁹⁻⁶¹ and sedation.^{55,62}

Acupuncture is safe and in combination with conventional anesthetic techniques is capable of reducing the required dose of opioids and offers more comfortable postoperative conditions than anesthesia alone.^{59,63} Questionable results, however, were obtained by Sim et al.⁵⁸ in a blinded, randomized, placebo-controlled study, on the effect of electroacupuncture on intraoperative alfentanil and morphine consumption during gynecological surgery. Patients received true acupuncture or placebo acupuncture (continued throughout surgery), or they received no preoperative treatment and acupuncture postoperatively (continued for 45 minutes). Intraoperative alfentanil consumption was similar in the acupuncture and control groups, but was significantly greater ($P = 0.024$) in the group that received acupuncture postoperatively. This finding may indicate a treatment-expectation placebo effect accompanied by endogenous opioid release in both control and preoperative acupuncture groups, rather than an acupuncture effect, although endogenous opioid concentrations were not measured. Acupuncture-induced postoperative analgesia in the preoperative acupuncture group was obvious during the first 6-12 hours postoperatively. However, cumulative 24-hour, patient-controlled analgesia consumption of morphine was not significantly less in the acupuncture-treated groups than in the placebo groups. The inability of acupuncture to reduce the 24-hour morphine consumption can be explained by the fact that the analgesic effect of a single session of electroacupuncture lasts only two-to-three hours.⁶⁴

Acupuncture might decrease volatile anesthetic requirements. In an experimental setting, electroacupuncture produces a small, but statistically significant reduction of halothane requirement in anesthetized dogs.⁶⁵ An advantage of evaluating acupuncture during general anesthesia is that it permits full blinding without resorting to sham stimulation. In three volunteer studies, anesthetic requirement with and without acupuncture was determined by the "Dixon up-and-down method" and defined by the average desflurane concentration required to prevent purposeful movement of the extremities in response to noxious electrical stimulation.⁶⁶⁻⁶⁸ The first study was a crossover, double-blinded, placebo-controlled study in which Greif et al.⁶⁶ showed that transcutaneous electrical stimulation of the Lateralization-Control Point near the ear tragus reduces anesthetic requirement to acute noxious stimulation by $11 \pm 7\%$, $P < 0.001$. Acupuncture stimulation was initiated after induction of general anesthesia. In the second study, Taguchi et al.⁶⁸ found that acupuncture initiated after induction of general anesthesia reduced desflurane requirement by $8.5 \pm 7\%$. Auricular acupuncture was performed after induction of general anesthesia with needles placed at the Shen Men, Thalamus, Tranquilizer, and Master Cerebral Points on the right ear (Fig. 5). In the third volunteer trial, Morioka et al.⁶⁷ tested the hypothesis that electroacupuncture at the Zusanli, Yanglingquan, and Kunlun acupuncture points on the leg decrease anesthetic requirement during electrical noxious stimulation on the thighs. Desflurane requirement on the acupuncture ($4.6 \pm 0.6\%$) and control ($4.6 \pm 0.8\%$) days did not differ (Fig. 6). Acupuncture significantly reduced anesthetic requirement in two of these three volunteer trials, but neither reduction was clinically important. This conclusion is consistent with a recent clinical study in which patients given acupuncture-assisted anesthesia required even more volatile anesthetic than patients in the control group.⁶⁹ Available data thus indicate that acupuncture has little if any effect on anesthetic requirement. As might be expected, manual stimulation of classical acupuncture points during surgery did not influence pain scores or change intraoperative or postoperative analgesic requirements.⁷⁰

Postoperative Pain Control

Acupuncture and related techniques can potentially serve as important adjuvants for pain control and for relieving opioid-related side effects during the postoperative period. However, controversial results, dissimilar study designs, and diverse modes of acupuncture-point stimulation make it difficult to evaluate the clinical importance of perioperative acupuncture analgesia. There are few randomized, controlled clinical trials on acupuncture-related postoperative pain relief published in English (Table 2). Interpretation of these available studies is complicated by the fact that acupuncture success depends on numerous factors including adequate patient selection and the acupuncturist's knowledge and skill level.

Christensen et al.⁷¹ demonstrated that patients receiving electroacupuncture before and during hysterectomy had no reduction in their postoperative analgesic requirement or pain. However, in this study, patients were also given relatively high doses of meperidine for induction and intraoperative pain control. Opioid-induced analgesia may have masked the putative benefit of electroacupuncture.

In another study, acupuncture increased intraoperative discomfort, postoperative pain, and consumption of analgesic following dental surgery.⁵⁰ In this study, local anesthesia was supplemented by preoperatively or postoperatively administered acupuncture with manual stimulation. Both acupuncture groups had increased consumption of pain medication and greater pain rating postoperatively than did the control group.⁵⁰ Additionally, patients from the preoperative acupuncture group needed more local anesthetic than patients from the other groups and expressed more distress during the surgical procedure. However, patients in both acupuncture groups demonstrated significant mental relaxation. There are several potential explanations for these conflicting results. First, the relaxing effect of acupuncture might blunt the activation of a natural endogenous pain inhibiting system. Second, the vasodilatation induced by acupuncture might have caused faster washout of the local anesthetic. Third, the investigators might have used suboptimal acupoint selection and stimulation technique.

In contrast, in a randomized, double-blind, placebo-controlled trial, Lao et al.⁷² demonstrated the efficacy of acupuncture for reducing pain and postoperative analgesic consumption after a similar oral surgery procedure. The stimulated acupoints and technique selected for this study were similar to those selected for the previous one. An experienced acupuncturist performed the procedure, in contrast to the previous study where the level of expertise of the person performing acupuncture was not discussed, and it is not uncommon that acupuncture for research purposes is performed by insufficiently experienced personnel. Acupuncture or a well designed, noninsertion placebo treatment was administered twice: immediately after the surgical procedure and after the patient reported moderate pain. The results showed that pain-free postoperative time was significantly longer in the acupuncture group (173 minutes) than in the placebo group (94 minutes; $P = 0.01$). Average pain medication consumption was significantly less in the acupuncture group.

As previously mentioned, point selection and mode of stimulation perform important roles in the outcome of acupuncture for postoperative pain relief. It seems that different components of postoperative pain respond to different combinations of acupuncture points. Shu-points of the internal organs are located bilaterally 3 cm lateral to the posterior midline. Shu-points are associated with the viscera²⁰ and traditionally have been used for treatment of internal organ diseases. Stimulation of these points may alleviate pain caused by visceral dysfunction (Fig. 7).²⁰ For example, consumption of supplemental morphine is reduced by 50% and the incidence of postoperative nausea by 20-30% in acupuncture patients undergoing upper- or lower-abdominal surgery ($P < 0.01$, Fig. 8).⁵⁹ In this controlled, double blinded study, intradermal needles were inserted paravertebrally in shu-points. All needles were inserted while patients were in the pre-induction area. In addition to less morphine consumption and

postoperative nausea, patients with intradermal acupuncture had better pain relief than controls ($P<0.05$). Plasma cortisol and epinephrine concentrations were 30-50% less in the acupuncture group during recovery and on the first postoperative day ($P<0.01$).

Transcutaneous electrical nerve stimulation (TENS) near the incision site significantly reduces postoperative pain.⁷³ However, this treatment appears to be most effective for the superficial cutaneous component of postoperative pain, leaving the deep visceral pain component largely intact. It seems likely that high frequency transcutaneous electrical nerve stimulation near the incision site mainly stimulates specific afferent nerve fibers^{74,75} instead of triggering endogenous opioid-release mechanisms. Combining TENS and stimulation of viscera-associated shu-points in the treatment plan is thus promising for reducing postoperative superficial and deep visceral pain, respectively.

Both high and low frequency electroacupuncture at Zusanli (ST 36) point performed 20 minutes immediately before induction of anesthesia reduces morphine consumption after abdominal hysterectomy.⁶⁰ This point is traditionally considered effective for the treatment of abdominal disorders. The high-frequency acupuncture group had a 61% reduction in 24-hour patient-controlled analgesia morphine consumption. Pain scores postoperatively did not significantly differ between groups, but cumulative morphine consumption for the first 24 hours, number of patient-controlled analgesia demands, and intervals for the first request for analgesic were significantly less in both the high- and low-frequency electroacupuncture groups. The above parameters were also reduced in the sham-acupuncture group compared to the control group, although they were greater than in the acupuncture groups. This is unsurprising since sham acupuncture appears to have an analgesic effect in 40% to 50% of patients compared with 60% to 70% for real acupuncture and 30% to 35% for placebo (control).⁷⁶

In contrast, another study failed to confirm acupuncture-induced postoperative analgesia.⁵⁸ Similar acupuncture techniques were used and similar patient populations participated, but a statistically significant effect of preoperative acupuncture was observed only 6 to 12 hours postoperatively. This agrees with a previous study,⁶⁴ however, which demonstrated that the analgesic effect of a single session of acupuncture lasts only limited amount of time (3 hours in that particular study) after stopping of the treatment.

Chen et al.⁷⁷ compared the effect of TENS applied to various sites on postoperative opioid analgesic requirement after lower abdominal surgery. (In contrast to electroacupuncture, the TENS technique does not require skin penetration with the needle.) TENS was equally effective when applied on point Zusanli (ST 36, Fig. 2) and on the dermatomes at the level of incision. It provided about a 35% reduction in the hydromorphone consumption compared with control and sham-stimulation groups. Patients given acupuncture also suffered less postoperative nausea and vomiting. They were also less sedated, presumably because they required less opioid. A previous study similarly demonstrated a correlation between the intensity of TENS stimulation and its effectiveness for postoperative pain relief.⁶²

Postoperative Nausea and Vomiting

Postoperative nausea and vomiting (PONV) frequently complicate both general and neuraxial anesthesia and frequently delay recovery from surgery.^{78,79} Although better anesthetic techniques and a new generation of anesthetic drugs and antiemetics have significantly reduced the incidence of PONV, up to 70% of high-risk patients are still affected.⁸⁰ The etiology of PONV is likely to be multifactorial with important predictors being female gender, history of PONV or motion sickness, non-smoking status, and use of postoperative opioids.⁸¹ Risk for PONV can be predicted.⁸¹ Unfortunately the efficacy of currently available antiemetics remains limited, with each reducing relative risk for PONV by roughly a third and all having

side effects. Relatively low efficacy combined with occasional complications has generated interest in alternative methods of treatment for PONV.

The use of acupuncture for treatment of postoperative nausea and vomiting is one of the most commonly used and best investigated applications of acupuncture in anesthesia practice (Table 3). Stimulation of point Neiguan (P 6, Fig. 9) is effective at reducing PONV,^{82,83} and it may be more powerful to prevent early PONV than late PONV.⁸⁴⁻⁸⁶ Electroacupuncture at this point is also effective for postoperative nausea^{87,88} and somewhat effective for vomiting after tonsillectomy in children.⁸⁹ Stimulation of P 6 has been shown to be as effective as pharmacological treatment for PONV with ondansetron in both adults and children.^{84,89-91}

Many methods of acupuncture stimulation have been tried for PONV including manual needle stimulation,^{83,92} acupuncture with electrical stimulation,⁸⁹ combination of acupuncture and acupressure,⁹³ normal saline injection,⁸⁴ plain acupressure,⁹⁴ acupressure with electrical stimulation (i.e., Relief Band),⁹⁰ transcutaneous electrical stimulation,⁸⁸ laser stimulation,⁹⁵ and capsaicin application.⁸⁵ The optimal method of stimulation has not been identified. Non-invasive methods are easier to perform, painless, and better tolerated by the patients. However, they also appear to be less effective since they have yielded more negative study results^{94,96} and more trials with partial effects (e.g., effective for nausea but not vomiting),^{87,88} which suggests that non-invasive stimulation is insufficiently intense.⁹⁷

In 1987, Weightman et al.⁹⁸ were unable to replicate the ability of P 6 stimulation to reduce PONV.⁸² However, in this study acupuncture was not started until after the patients had been anesthetized. This observation prompted an on-going debate about the importance of starting acupuncture before induction of general anesthesia.^{83,99,100} Vickers reviewed 33 controlled trials in which the Neiguan (P 6) acupuncture point was stimulated for treatment of nausea, vomiting, or both associated with chemotherapy, pregnancy, or surgery.¹⁰¹ Acupuncture of P 6 was equal or inferior to control in all studies when acupuncture was started after induction of anesthesia. Conversely, when acupuncture was administered to conscious patients, it was statistically superior to control. A second analysis was restricted to 12 high-quality, randomized, placebo-controlled trials in which the P 6 point was stimulated in conscious patients. Eleven of these trials, involving nearly 2000 patients showed a significant positive effect of Neiguan (P 6) stimulation for prevention of nausea and vomiting. The reviewed papers showed consistent results across investigators, groups of patients, and forms of acupuncture point stimulation.¹⁰¹ The author concluded that, except when administered under anesthesia, P 6 acupuncture point stimulation is an effective antiemetic technique. An alternative explanation is that a placebo effect is responsible for the antiemetic action of acupuncture in those patients receiving it while they were awake. Many of the studies cited above did have adequate placebo control groups, which argues against a placebo effect.

Most of the studies in which acupuncture was initiated after induction of general anesthesia and failed to elicit an antiemetic effect were performed on children,^{93,96,100,102,103} who generally do not cooperate with needle insertion while awake. These studies led to the conclusion that acupuncture was ineffective for PONV in children.⁹¹ Later studies, with better design and probably better technique, refuted this conclusion and found that acupuncture for PONV is as effective in children as in adults.^{84,89,92} An interesting finding was that even when started after induction of general anesthesia,⁹² bilateral Neiguan (P 6) stimulation^{93,96} reduced PONV in children. These investigators also stimulated point Shangvan (CV 13) and used a special device (cunometer) for better point location.

Almost all clinical trials on the effect of acupuncture on PONV have used a standardized treatment involving stimulation of the Neiguan (P 6) point. Such simplification may not always be appropriate and may be the reason for failure in many studies. The classic acupuncture

approach is to treat a disease or syndrome in various ways, depending on the complex characteristics of patients and their symptoms. Neiguan (P 6) is hardly the only point thought to prevent PONV.^{59,92,104} In fact, more than thirty classical meridian acupuncture points are described as being effective for nausea and vomiting,^{12,21,105} although specific effects of the other points or point combinations have not been studied in detail. Chu et al.¹⁰⁶ however were able to decrease PONV from 64% in placebo to 24% in treated patients after strabismus-correction surgery in a randomized, controlled trial using acupressure on points Tianzhu (BL 10), Dazhu (BL 11) and Yanglingquan (GB 34). All these points are located on meridians connected to the eyes,¹⁰⁶ and the authors hypothesized that they were able to achieve good results because their point selection allowed them to diminish parasympathetic stimulation from surgical traction of eye muscles. In contrast, P 6 acupuncture fails to prevent PONV after strabismus surgery.^{96,103}

PONV can also be treated successfully with the Korean hand acupuncture system.^{85,107,108} In contrast to classical Chinese acupuncture, the Korean hand acupuncture system is comparatively recent and has been studied even less. Kim et al.⁸⁵ found about a 50% reduction in PONV after abdominal hysterectomy in a randomized, double-blinded, placebo-controlled study where capsicum plaster was applied on the point located on the lateral distal phalanx of the index finger on both hands. Results were similar when Korean hand acupuncture was used for PONV after gynecological laparoscopy.¹⁰⁷

Acupuncture may reduce nausea and vomiting via endogenous beta-endorphin release in the cerebrospinal fluid¹⁰⁹ or a change in serotonin transmission via activation of serotonergic and noradrenergic fibers.¹¹⁰ The exact mechanisms have yet to be established.

Acupuncture and Perioperative Complications

Acupuncture can be used to a certain extent as an alternative treatment of intra- and post-operative complications when conventional treatment is unavailable, undesirable, or increases risk.

Post-extubation Laryngospasm—Acupuncture with bloodletting is a technique that involves a quick needle prick with thick sharp needles on the acupuncture points. It is usually performed on distal endpoints of the meridians on the fingers or toes. Bloodletting acupuncture at Shaoshang (L 11), Shangyang (LI 1) or both (Fig. 10) reportedly prevents laryngospasm after tracheal extubation. This technique was used successfully in children, who are most prone to develop postextubation laryngospasm. However, the study design did not include the blinding of investigators.¹¹¹ The dangers of this unblinded study design were illustrated by a subsequent investigator who demonstrated that the same acupuncture technique actually aggravated laryngospasm.¹¹² Available data thus fail to support using acupuncture for laryngospasm.

Cardiovascular Resuscitation—In a study using 35 dogs anesthetized with halothane, acupuncture reversed cardiovascular depression induced by morphine and halothane. Acupuncture at point Jen Chung (GV 26, Fig. 11) significantly increased cardiac output, stroke volume, heart rate, mean arterial pressure, and pulse pressure while simultaneously significantly decreasing total peripheral resistance and central-venous pressure. The authors concluded that stimulation of the GV 26 acupoint could be helpful in resuscitating patients whose cardiovascular system is depressed by opioids and volatile anesthetics.¹¹³

Neiguan (P6) point has long been considered a primary point for treatment of various cardiovascular diseases.²¹ It has been shown to be effective as an adjunct therapeutic modality in conservative treatment of severe angina pectoris.¹¹⁴ Electroacupuncture at Neiguan (P 6) was effective in maintaining the hemodynamics and cardiac contractility in anesthetized open-

chest dogs.¹¹⁵ End-diastolic volume was maintained and even slightly increased in comparison with the control group where end-diastolic volume gradually decreased over 1.5 hours; stroke volume and cardiac output also slightly increased compared with the control group. The end-systolic pressure and end-systolic elastance increased markedly in the Neiguan (P 6) acupuncture group. No analogous data support acupuncture-induced cardiovascular benefits in humans, an obvious prerequisite to clinical application of the technique.

Impaired intestinal Function—A major side effects of the opioid administration for postoperative pain control is the impairment of intestinal function.¹¹⁶ Intraoperative and postoperative acupuncture for pain relief decreases perioperative opioid consumption⁵⁹ and may thus be beneficial for indirectly speeding postoperative recovery of intestinal function.

Acupuncture treatment has also been shown to promote postoperative recovery of impaired intestinal function after abdominal surgery.¹¹⁷ Patients were treated with auricular-plaster therapy (stimulating plaster applied on specific auricular points) combined with acupuncture at Zusanli (ST 36) To relieve abdominal distension and dysfunction after abdominal operations. Among 13 cases in the treatment group, 12 (92.4%) showed recovery of normal peristalsis within 72 hours after operation; in contrast, only 46% of the 13 control cases recovered in that time. An obvious limitation of this study is that it is extremely small compared with most trials of postoperative ileus.

General Principles of Acupuncture Analgesia

The practice of acupuncture requires certain skills, experience, and theoretical knowledge by the practitioner. Patients must also be carefully selected for acupuncture analgesia, taking into account the type of operation, the patient's age and overall condition, and the results of test needling.

Patient Selection

Acupuncture in general, and acupuncture analgesia in particular, is more effective in young adults than in elderly patients. Small children are usually poor candidates for acupuncture-assisted anesthesia and analgesia with needles simply because they are rarely willing to cooperate with the acupuncturist.

Acupuncture is not suitable for moribund patients preoperatively as it is generally much less effective on extremely sick patients.⁹⁴ In order to obtain optimal results with acupuncture, it is necessary that the patient understands what acupuncture is, has a good attitude towards acupuncture, and has faith in the efficacy of the method. These patients are also highly susceptible to bias and placebo effect, which complicates acupuncture research.

It is often helpful to needle one or two acupuncture points before making a decision to use acupuncture. This test helps to ascertain that a patient responds to needling with a good De-Qi sensation, which is a good predictor of subsequent acupuncture efficacy. If De-Qi is not achieved, endorphins are less likely to be secreted. The ancient physicians always emphasized that in order to be effective, acupuncture must cause “Qi to be received.” Sometimes it is difficult or impossible to obtain De-Qi sensation. Such patients, typically about 10% of the population, do not elicit a physiologic response on acupuncture stimulation and are referred to “non-responders.”

There are certain rules and principles that are generally applied when selecting points for acupuncture treatment. First, appropriate meridian should be selected, and then appropriate points on these meridians stimulated. For example, for postoperative pain control a meridian that passes through the surgical area or close to the surgical area is usually selected. Also,

according to the “organ phenomena” concept of Traditional Chinese Medicine, the Lung commands the skin. Consequently, stimulation of acupuncture points on the Lung Meridian can provide analgesia for surgical skin incisions. Similarly, the Liver Meridian commands the eyes, making the Liver Meridian ideal for ophthalmologic surgery.

Needling of points that easily produce a strong De-Qi sensation are thus thought to provide better analgesia. Conversely, analgesia is often poor at needling points that produce weak De-Qi response or in which the sensation is difficult to obtain. Reactive points that are commonly selected include Zhusanli (ST 36), Sanyinjiao (SP 6), Hegu (LI 4), and Neiguan (P 6, Fig. 2).

When selecting acupuncture points one has to consider convenience as well as the patient's comfort. Points located below the knee or elbow are usually selected during surgery.^{115,116}

Points located on the ear are often selected for acupuncture during the perioperative period. Locus points or surgical position points are most often selected. (According to ear acupuncture theory, locus points are the points that are projections of the surgical site on the ear.) Once the locus point is identified, auxiliary points may be added. Auricular points that possess strong tranquilizing and analgesic effects, like Shen Men, Sympathetic, Subcortex, etc, are often selected as auxiliary points for various types of surgery.

Summary

Acupuncture is increasingly being incorporated into the health care system. Growing numbers of insurance companies now either provide coverage for acupuncture or are considering doing so. Acupuncture and related techniques are increasingly practiced in conventional medical settings, with more open attitudes towards them. Consequently, the number of patients willing to use these techniques — or even specifically request them — will likely increase. In fact, more than 50% of patients involved who participated in a recent study stated that they were willing to pay extra for use of TENS technique for postoperative pain relief for future surgery.⁷⁷

Despite more than 30 years of research, the exact mechanism of action and efficacy of acupuncture have yet to be established. Furthermore, most aspects of acupuncture have yet to be adequately tested. There thus remains considerable controversy about the role of acupuncture in clinical medicine.

Acupuncture does not seem to reduce the requirement for volatile anesthetic, at least not by a clinically important amount. Preoperative sedation seems to be a promising application of acupuncture in perioperative settings, but more studies are required before this technique can be recommended for routine use. In contrast, several high quality studies have demonstrated substantial effectiveness of acupuncture for postoperative pain relief; however, this issue still remains controversial. Acupuncture may be effective for postoperative pain relief but probably requires a higher level of expertise and training of the acupuncture practitioner than generally available. Enough evidence has also accumulated to introduce acupuncture and related techniques for treatment and prophylaxis of postoperative nausea and vomiting in routine clinical practice in combination with, or as an alternative to, conventional antiemetics. However, antiemetic acupuncture appears to only be effective when administered before induction of general anesthesia.

Some promising applications of acupuncture in the perioperative setting could be treatment of postoperative ileus, postextubational laryngospasm, and correction of hemodynamic instability. However, further research will be required to clarify the role of acupuncture in the treatment of these conditions.

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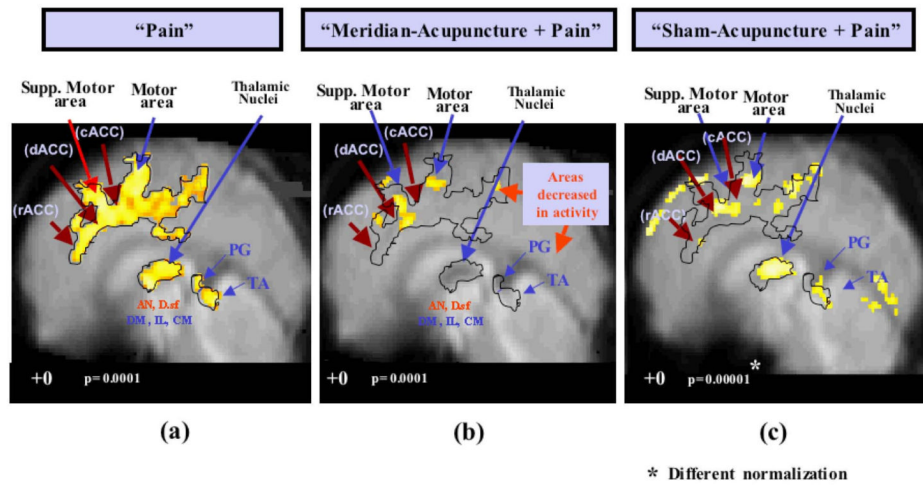
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Comparison of "Pain", "Meridian-Acupuncture + Pain", and "Sham-Acupuncture + Pain", Experiments.

**Fig. 1.**

Functional MRI (fMRI) demonstrating a correlation between activation of specific areas of the brain and corresponding acupoint stimulation predicted by ancient acupuncture literature. dACC = dorsal anterior cingulate cortex; rACC = rostral anterior cingulate cortex; cADD = caudal anterior cingulated cortex; TA = tectal area; A = anterior nucleus; DsF = dorsal superficial nucleus; DM = dosomedial nucleus; IL = intralaminar nuclei; and CM = centromedian nucleus. PG = caudal inferior parietal lobule, area 7a. Reprinted by permission of the American Academy of Medical Acupuncture.²⁷

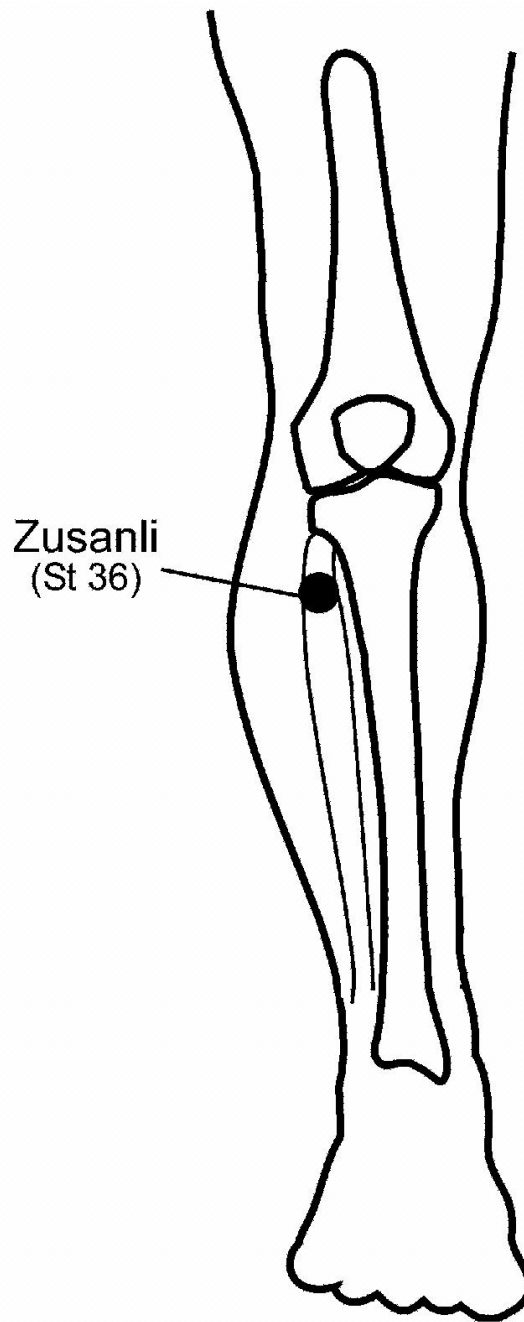


Fig. 2. Zusanli (ST 36) is one of the most frequently used points for acupuncture analgesia. It is located on the anterior aspect of the leg in the tibialis anterior muscle, 3.0 *cun* inferior to the lateral depression underneath the knee cup and one fingerbreadth lateral to the tibial crest. Its functions include replenishing energy, regulating the stomach, strengthening the spleen, clearing the channels and invigorating the collaterals, and improving general health.¹⁰⁵ Indications: abdominal distension, diarrhea, and chronic disorders causing general weakness.^{105 119}

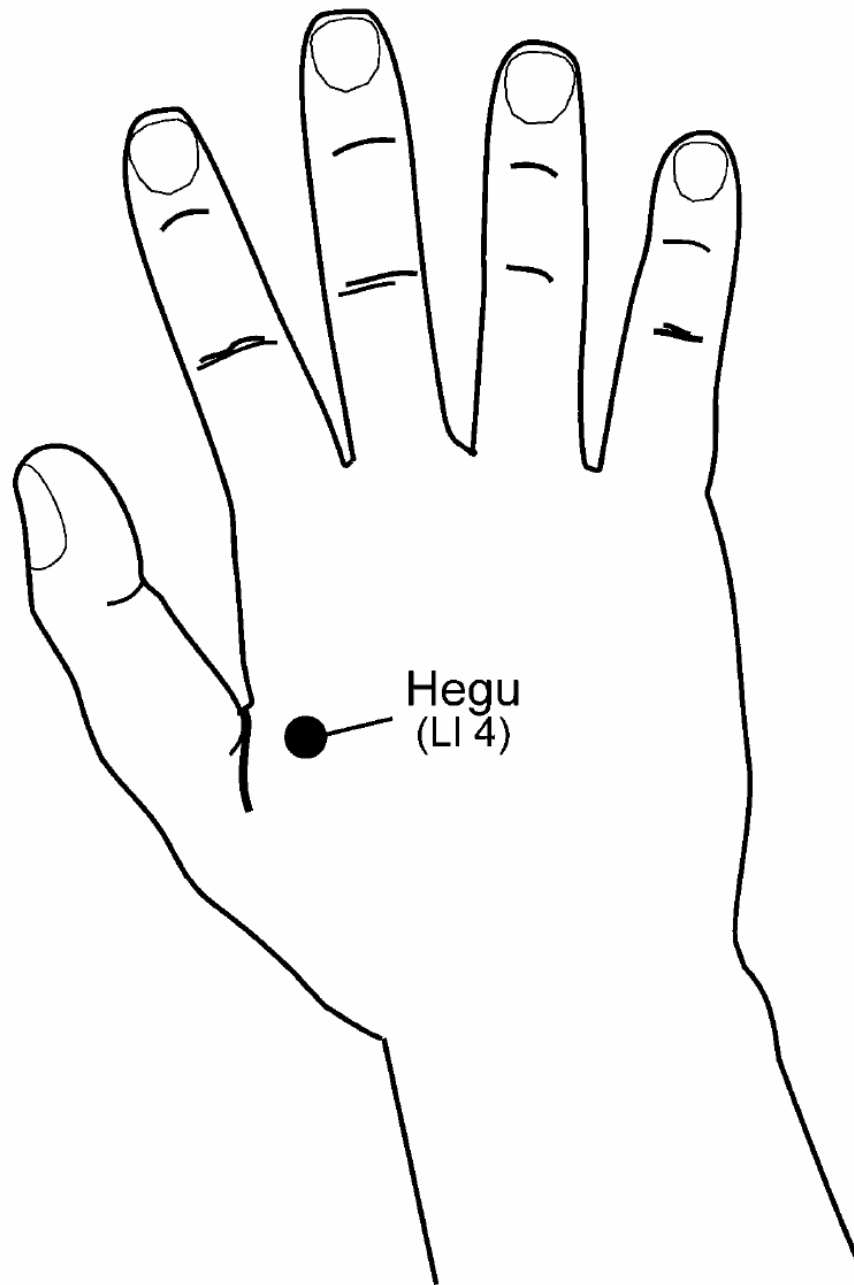


Fig. 3. Hegu (LI 4) is one of the most commonly used acupuncture analgesia points. It is located on the dorsum of the hand between the first and second metacarpal bones in the first dorsal interosseous muscle on the radial aspect of the second metacarpal. Its functions include dissipating pathogenic heat, sedating pain, and regulating Qi and blood.¹⁰⁵ Indications include fever, headache, toothache, eye disorders, sore throat, facial hemiplegia, trismus.^{105,119}

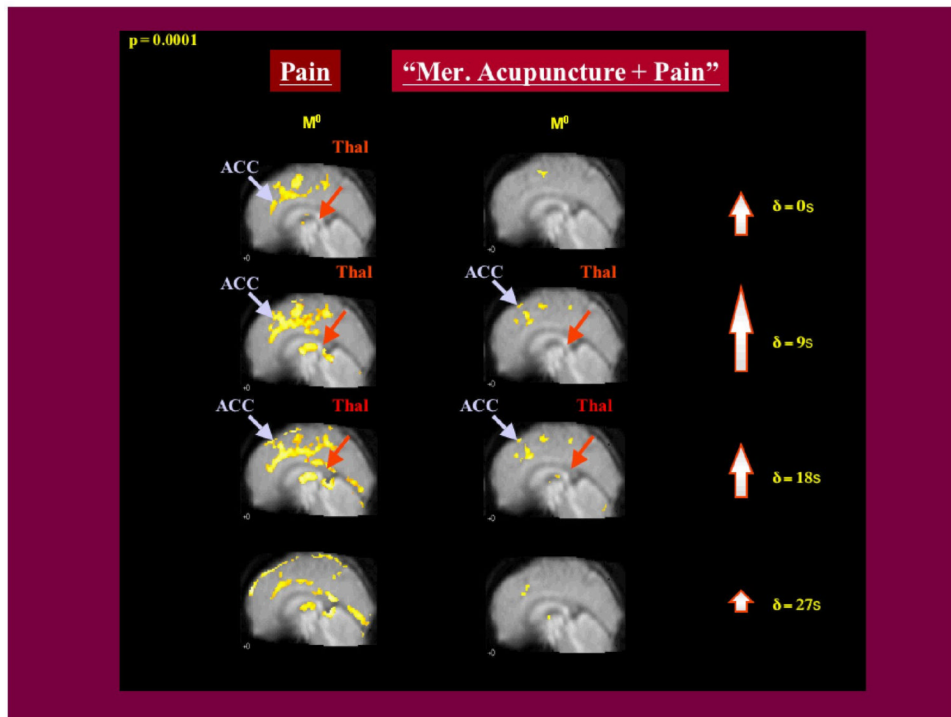


Fig. 4. Side-by-side comparison of two cortical activations (visualized with functional MRI (fMRI)) seen at the mid-line sagittal view caused by pain (left column) and pain with LI 3 meridian acupuncture (right column). ACC = anterior cingulate cortex; δ = response time; Thal = thalamus; M⁰ = Center of mid-sagittal view slice. Reprinted by permission of the American Academy of Medical Acupuncture.²⁷

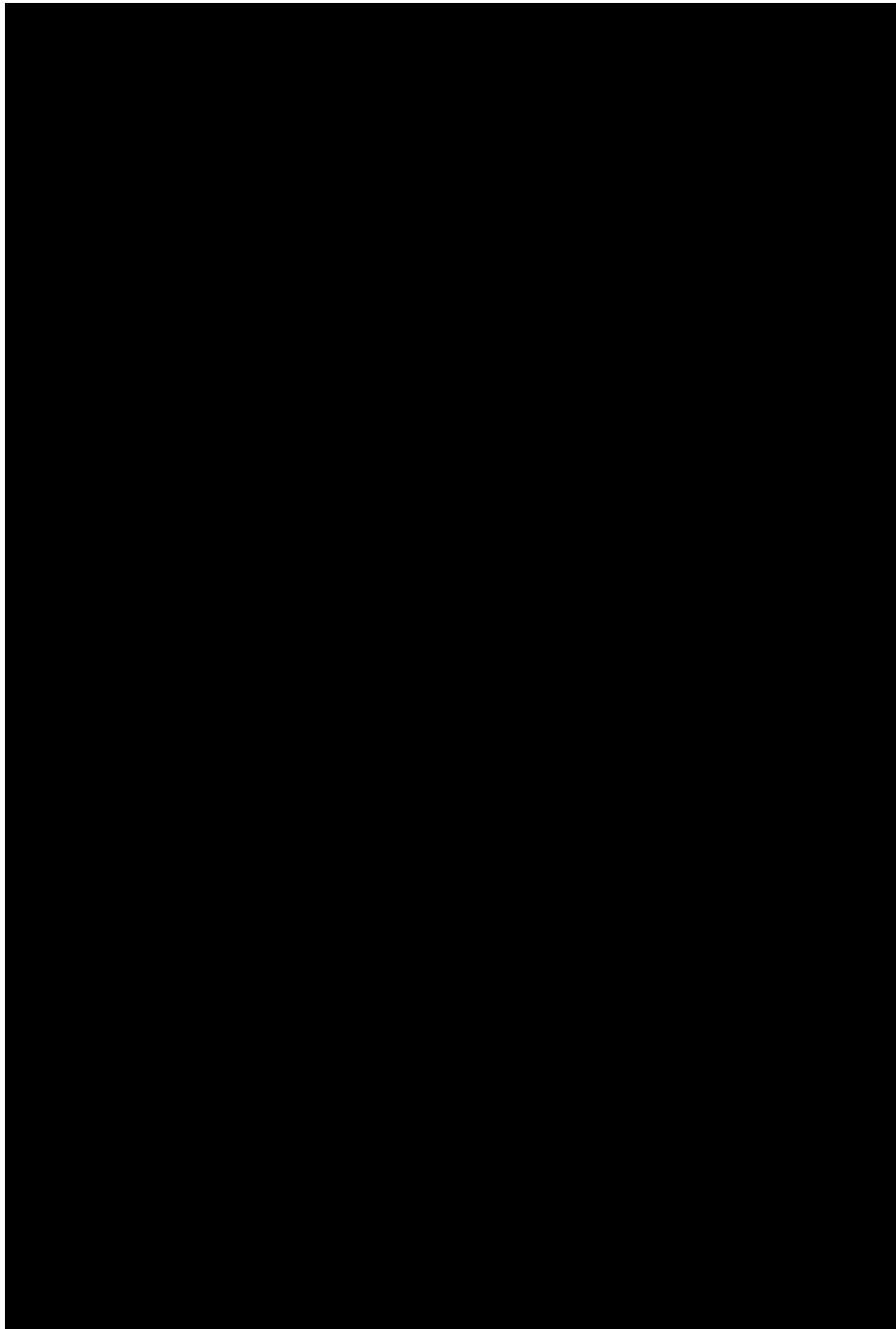


Fig. 5.
Auricular acupuncture points used for relaxation and intraoperative anesthetic reduction.



Fig. 6. Circles show the individual concentrations of desflurane required to prevent movement in response to intense electrical stimulation in volunteers with (Acupuncture) and without (Control) electro-acupuncture. Needles were placed at the Zusanli, Yanglingquan, and Kunlun acupuncture points on the legs after induction of anesthesia. Squares show the mean \pm SD concentrations with each treatment. The anesthetic requirements did not differ significantly. Used with permission.⁶⁷

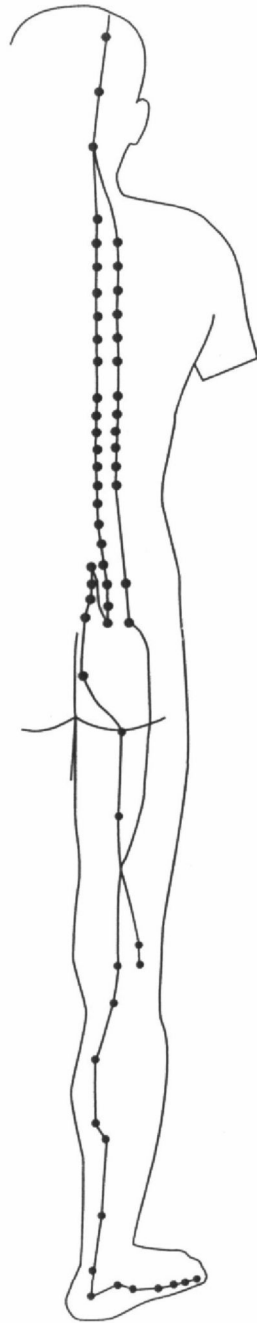


Fig. 7. Back shu points (medial line of points). Shu points of the internal organs are located bilaterally 3 cm lateral to the posterior midline. Shu points are associated with the viscera²⁰ and traditionally have been used for treatment of internal organ diseases. Stimulation of these points may alleviate pain caused by visceral dysfunction.²⁰



Fig. 8. Daily consumption of morphine in patients undergoing upper- and lower-abdominal surgery with pre-operative acupuncture at points BL 18-24 and BL 20-26. For upper-abdominal surgery, results were obtained from 50 acupuncture patients (circles) and 48 control patients (squares). For lower-abdominal surgery, data were obtained from the 39 acupuncture patients (circles) and 38 control patients (squares). Data are expressed as means \pm SDs. Asterisks (*) indicate statistically significant differences ($P < 0.0001$) between first and other postoperative days in each group; pound signs (#) indicate statistically significant differences ($P < 0.01$) from the control group. Used with permission.⁵⁹

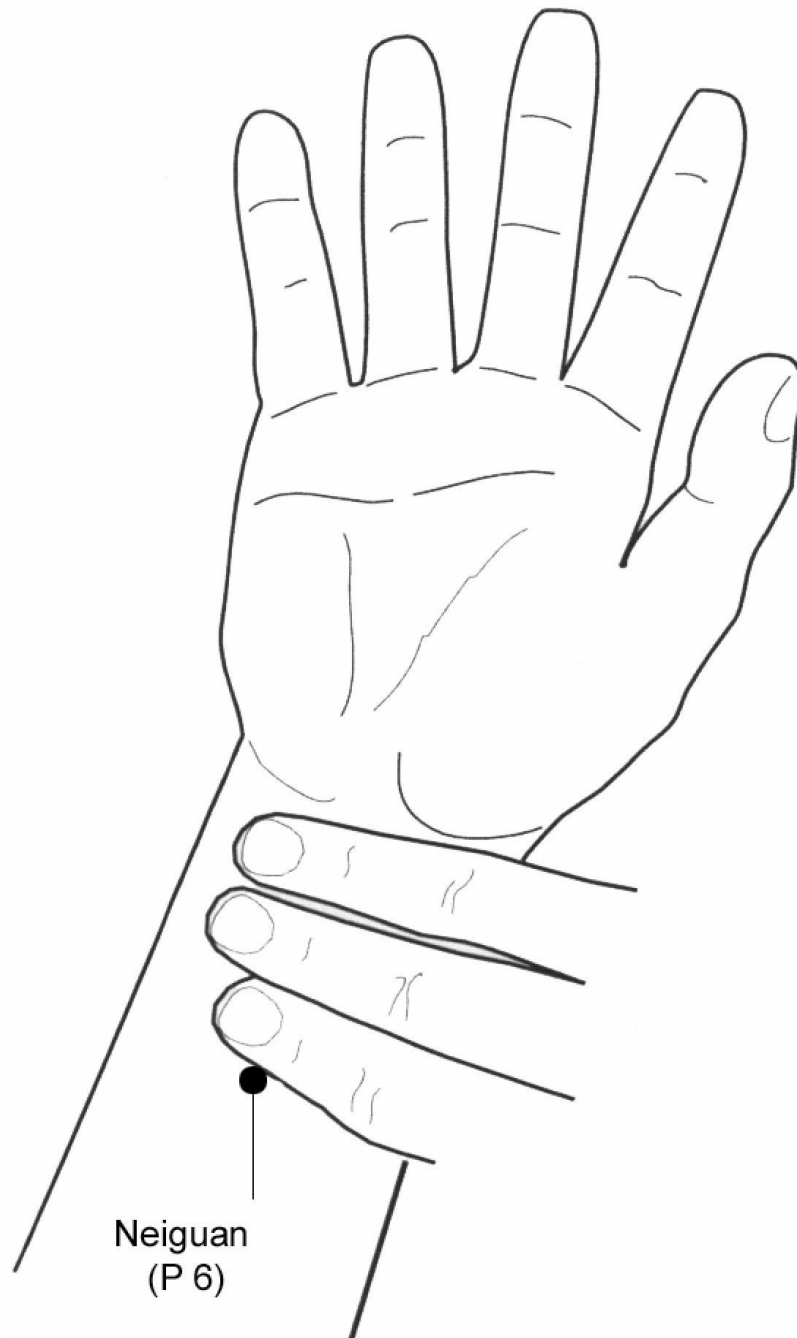


Fig. 9.

Nei Guan (P 6) point is located 2 cun or about 5 cm above the transverse crease of the wrist between the tendons of *m. palmaris longus* and *m. flexor carpi radialis*. The name of the point means “Inner Pass” or “Inner Gate” This point is the connecting luo point of the Pericardium Channel to the Triple Warmer Channel.²⁰ It is considered one of the major points of the meridian system. Its functions include dissipating pathogenic heat and clearing dysphoria, relaxing the chest and impelling the flow of Qi, reversing the adverse flow of Qi and quelling nausea, regulating the stomach and reducing pain. Besides possible nausea and vomiting, indications for this point include insomnia, amnesia, epilepsy, mania, dysphoria, chest pain,

palpitations of the heart, and dyspnea.¹⁰⁵ Nei Guan (P 6) also maintains hemodynamics and enhances cardiac contractility on anesthetized open-chest dogs.¹¹⁵

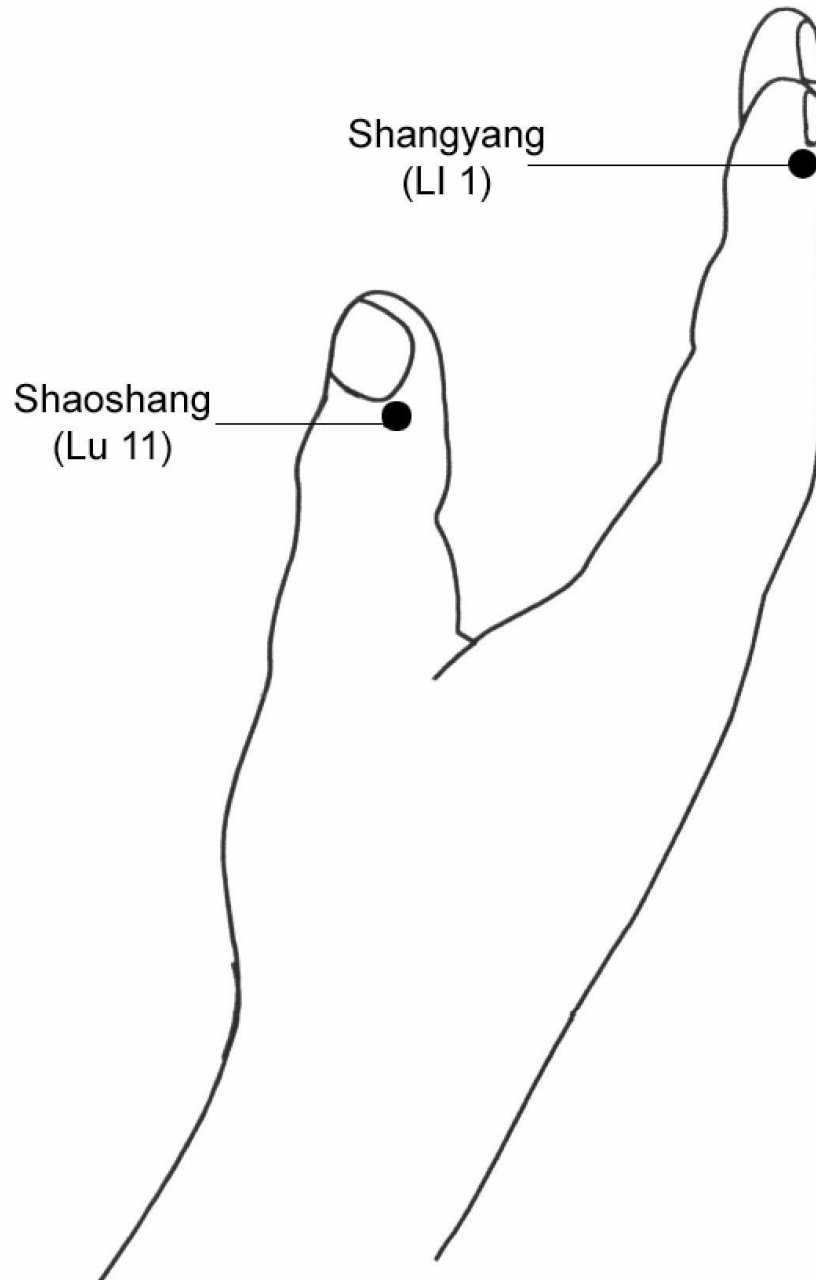


Fig. 10. Point Shaoshang (L 11) is located at the radial aspect of the thumb, 0.1 cun (2.5 mm) proximal to the vallum unguis. Its functions include “restoring Yang and reviving from prostration, clearing the pharynx.” Indications: syncope, sore throat, mania. Shangyang (LI 1) is located at the radial aspect of the index finger, 0.1 cun (2.5 mm) distal to the vallum unguis. Functions include dissipating pathogenic heat, stimulating the mind, clearing the pharynx, sedating pain, high fever, coma, and sore throat.¹⁰⁵

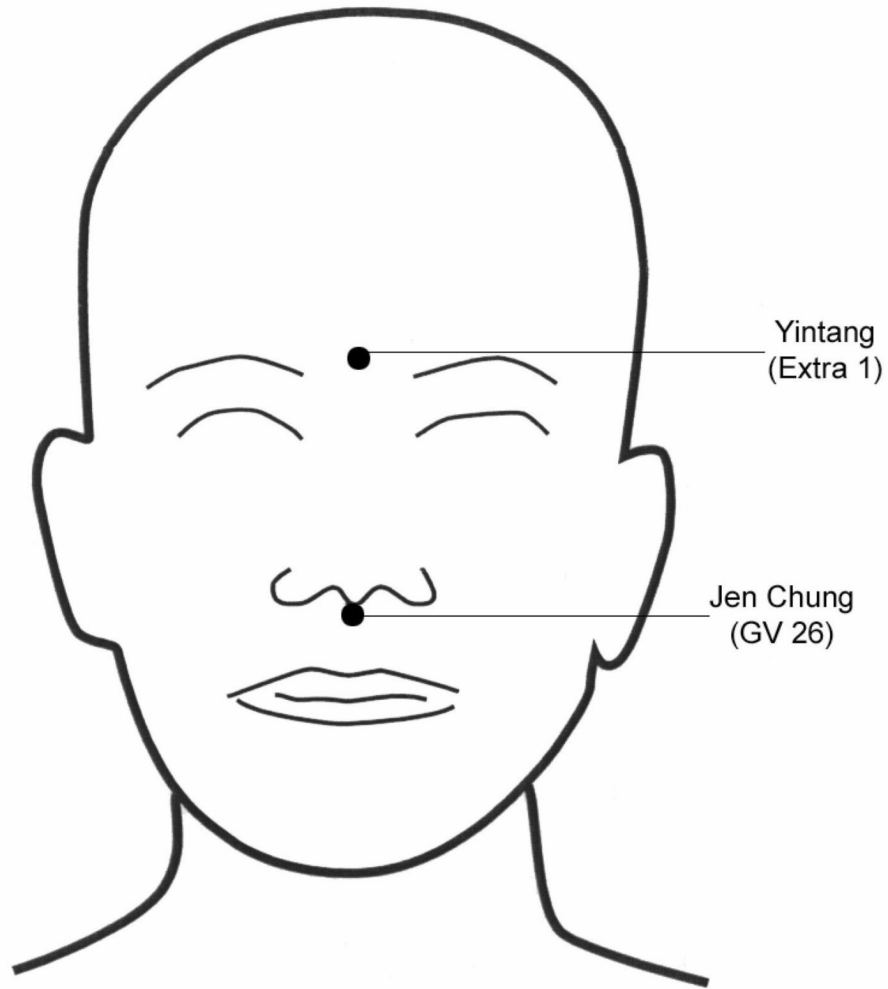


Fig. 11.

Jen Chung (GV 26) is believed to be a “point of resuscitation.” It is located on the upper one-third of the distance between the nose and upper lip. Its functions include “dissipating pathogenic heat and reviving the sensory organs from unconsciousness, sedating pain and calming the spirit.”^{105,119} Indications include convulsions, loss of consciousness, syncope, heat stroke, hypertension, facial paresis, facial spasm, and aphonia.¹⁰⁵ Yintang (Extra 1) is located between the eyebrows. Indications: headache, vomiting, vertigo, epistaxis, convulsions, and insomnia.^{105,119}

Randomized, Controlled Blinded Studies of Intraoperative Anesthetic/Analgesic Consumption during Acupuncture-Assisted Anesthesia.

Table 1

Authors	Subjects	Type of noxious stimulation	Acupuncture points	Method of stimulation	Anesthetic or analgesic consumption		P
					Acupuncture	Control	
Gupta et al. ⁷⁰	Patients N=42	Knee surgery	SP 9, SP 10, ST 34, LI 4 ipsilateral	Manual	Fentanyl 75.9 (14.2) µg	Fentanyl 69.4 (9.1) µg	0.09
Greif et al. ⁶⁶	Healthy Volunteers N=20	Electrical tetanus noxious stimulation on the thighs bilaterally	Lateralization-Stabilization point at the ear tragus bilaterally	Transcutaneous electro-stimulation	Desflurane 4.4 (0.6)%	Desflurane 4.9 (0.7)%	< 0.001
Taguchi et al. ⁶⁸	Healthy Volunteers N= 10	Electrical tetanus noxious stimulation on the thighs bilaterally	Shen Men, Thalamus, Tranquilizer, Cerebral master point on the right ear	Manual	Desflurane 4.4 (0.8)%	Desflurane 4.9 (0.7)%	0.003
Morioka et al. ⁶⁷	Healthy Volunteers N=14	Electrical tetanus noxious stimulation on the thighs bilaterally	ST 36, GB 34, BI 60 bilaterally	Electro-acupuncture	Desflurane 4.6 (0.6)%	Desflurane 4.6 (0.8)%	0.8
Sim et al. ⁵⁸	Patients N=90	Gynecologic surgery bilaterally	ST 36, P 6, subcutaneously along skin incision	Electro-acupuncture	Alfentanil 0.44 (0.15) µg-kg-1-min-1	Alfentanil 0.51 (0.21) µg-kg-1-min-1	0.47

In all studies, acupuncture was initiated after induction of general anesthesia except for Sim et al. when it was started 45 minutes before induction of general anesthesia. Control group in this study was blinded by placebo acupuncture 45 minutes before induction of general anesthesia. Data presented as means (SDs).

Table 2 Randomized Trials on Postoperative Analgesic Consumption Reduction and Other Effects Produced by Acupuncture Analgesia.

Authors	Study design	Surgery and anesthesia	Acupuncture points	Method of stimulation	Postoperative analgesic consumption	P	Postoperative pain and other outcomes
Ekblom et al. ⁵⁰	Pre and Post-surgery acupuncture "No acupuncture" control, no blinding	Oral surgery Local anesthesia N=110	LI 4, ST 6, ST 7, SJ 5, ST 19,	Manual	Significantly increased in both acupuncture groups	P<0.03	Significantly increased in preoperative acupuncture group No significant difference in the pain score between two groups
Lao et al. ⁷²	Placebo controlled, Double-blind	Oral surgery Local anesthesia N=39	LI 4, ST 6, ST 7, SJ 17	Manual	Significantly decreased in acupuncture group	P=0.05	No difference in the pain score between two groups
Christensen et al. ⁷¹	No "acupuncture" control Single-blind	Abdominal hysterectomy General anesthesia N=50	GV 4, BI 32, SP 6, ST 36	Electroacupuncture initiated after induction	No difference in analgesic consumption between acupuncture and control groups	P=0.48	No significant difference in the pain score between control, "sham", and both acupuncture groups Significantly longer time for first pain medicine request in both electroacupuncture groups
Lin et al. ⁶⁰	"No acupuncture" control Double-blind	Abdominal hysterectomy General anesthesia N=100	ST 36	Low- and high frequency electroacupuncture	Significantly lower in both electroacupuncture and "sham" groups	P<0.05	Significantly lower in acupuncture group Decreased PONV in acupuncture group
Kotani et al. ⁵⁹	"No acupuncture" control Double-blind	Upper and lower abdominal surgery General and epidural morphine postoperatively N=165	Back shu points	Intradermal needle insertion without stimulation	Significantly lower morphine consumption in acupuncture groups	P<0.01	Significantly lower in acupuncture group Decreased PONV in acupuncture group
Chen et al. ⁷⁷	"Sham" and placebo control Single blind	Abdominal hysterectomy Myomectomy General anesthesia N=100	ST 36, at dermatomal distribution of incisional site	Transcutaneous electrical nerve stimulation (TENS)	Reduced in both acupuncture and dermatomal group vs "sham" and control groups	P<0.5	Pain treatment satisfaction was better in acupuncture group and dermatomal group
Sim et al. ⁵⁸	Placebo control Single-blind	Abdominal hysterectomy General anesthesia N=90	ST 36, P 6, along skin incision	Electroacupuncture before induction or after surgery	Reduced in acupuncture group within 6-12 postoperative hours	P<0.015	No difference in VAS score or PONV

VAS = visual analog scale (0 = none, 100 = worse imaginable), PONV = postoperative nausea and vomiting

Table 3

Randomized, controlled, blinded studies on acupuncture for postoperative nausea and vomiting (PONV).

Authors	Study design	Patients	Surgery and anesthesia	Points	Method of stimulation	Outcome	Incidence of PONV PONV (%)			P
							Acupuncture or related technique	Control	Antiemetic drug or second control	
Lee et al., 82	Sham control Single-blind	Adults N=50	Gynecology General anesthesia	P 6	Manual acupuncture Before induction	N 0-6 V 0-6	3/25 (12) 3/25 (12)	12/25 (48) 5/25 (20)		N/A
Chahman et al., 98	Placebo control Double-blind	Adults N=46	Laparoscopy General anesthesia	P 6	Manual acupuncture After induction	N 0-1 N&V 0-1	5/20 (25) 4/20 (20)	5/24 (21) 1/24 (4)		P=ns
Sum et al., 87	Placebo control Double-blind	Adults N=162	General surgery General anesthesia	P 6	Acupressure Before induction	V 0-24	8/49 (16)	11/54 (20)	10/49 (20)*	P=0.002
Soulaki et al., 86	Placebo control Double-blind	Adults N=103	Gynecology General anesthesia	P 6	TENS Before induction	V 0-2	12/51 (24)	22/52 (42)		P<0.05
et al., 118	Placebo control Double-blind	Adults N=60	C-section Epidural morphine	P 6	Acupressure On awake patient	N 0-48 V 0-48	1/30 (3) 0/30 (0)	13/30 (43) 8/30 (27)		P<0.05
Ali et al., 83	Placebo control Double-blind	Adults N=81	Gynecology laparoscopic General anesthesia	P 6	Manual stimulation After induction	N 0-24 V 0-24	2/40 (5) 8/40 (20)	15/41 (37) 12/41 (29)		P=0.001
et al., 110	Placebo control Double-blind	Adults N=75	C-section Spinal anesthesia	P 6	Acupressure Before induction	N 0-2 V 0-2	6/25 (24) 3/25 (12)	19/25 (76) 6/25 (24)	4/25 (16) 1/25 (4)	P<0.001 P=0.049
et al., 90	Placebo and sham control Double-blind	Adults N=120	Plastic surgery General anesthesia	P 6	Acupressure with electrical stimulation After induction	N 0-2 V 0-2 N @ 24 V @ 72 V @ 72	13/40 (33) 1/40 (2) 14/40 (35) 4/40 (10) 3/40 (8) 0	16/40 (40) 5/40 (12) 20/40 (50) 8/40 (20) 5/40 (12) 1/40 (2)	13/40 (33)* 0* 8/40 (20)* 0* 0* 0*	N/A
Wahler et al., 107	Placebo control Double-blind	Adults N=80	Gynecology laparoscopy General anesthesia	K-K 9	Korean Hand Acupressure	N 0-24 V 0-24	16/40 (40) 9/40 (22.5)	28/40 (70) 20/40 (50)	14/50 (28) 10/50 (20) 16/50 (32) 13/50 (26)	P=0.006 P=0.007
et al., 85	Placebo control Double-blind	Adults N=160	Abdominal hysterectomy General anesthesia	K-D2	Korean Hand capsicum application	N 0-8 V 0-8 N @ 24 V @ 24	13/50 (26) 9/50 (18) 15/50 (30) 11/50 (22)	37/60 (62) 28/60 (47) 42/60 (70) 34/60 (57)		P<0.001
entis and Anette, 100	Placebo control Double-blind	Children N=45	Tonsillectomy General anesthesia	P 6	Manual acupuncture stimulation After induction	V 0-24	9/23 (39)	8/22 (36)		P=ns
entis and Anette, 103	Medication treatment control Double-blind	Children N=90	Strabismus correction General anesthesia	P 6	Manual acupuncture stimulation After induction	V 0-5 V 0-48	8/30 (27) 13/29 (45)	5/30 (17)** 12/29 (41)**	5/30 (17)§ 10/29 (34)§	P=ns
et al., 106	Placebo control Double-blind	Children N=65	Strabismus correction General anesthesia	Bl 10, Bl 11, GB 34	Acu-pressure plasters Night before surgery	V 0-24	10/34 (29.4)	19/31 (64.5)		P<0.05
gger et al., 95	Placebo control Double-blind	Children N=40	Strabismus correction General anesthesia	P 6	Low level laser Before induction	V 0-24	5/20 (25)	17/20 (85)		P=0.0001
gger et al., 108	Placebo control Double-blind	Children N=50	Strabismus correction General anesthesia	K-K9	Korean Hand acupressure	V 0-24	5/25 (20)	17/25 (68)		P=0.001
et al., 89	Sham control No acupuncture control Double-blind	Children N=120	Tonsillectomy General anesthesia	P 6	Acupuncture with electrical stimulation After induction of general anesthesia	N 0-24 V 0-24	24/40 (60) 25/40 (63)	37/40 (93) 31/40 (78)	34/40 (85) 35/40 (88)	P=0.0007 P<0.05
g et al., 84	Sham, placebo, and antiemetic medication controls Double-blind	Children N=187	General surgery General anesthesia	P 6	Saline injection into the point After induction of anesthesia at the end of surgery	N 0-2 V 0-2 N	16/50 (32) 6/50 (12)	29/45 (64) 14/45 (31)	23/49 (47) 9/49 (18)	P=0.012 P=0.048 P=ns P=ns

Interventions	Study design	Patients	Surgery and anesthesia	Points	Method of stimulation	Outcome	Incidence of POMV PONV (%)		P
							Acupuncture or related technique	Control	Antiemetic drug or second control
						@24 V @24	12/50 (24) 9/50 (18)	15/45 (33) 11/45 (24)	18/49 (37) ** 9/49 (19) **

V = nausea, V = vomiting, TEENS = transcutaneous electrical nerve stimulation; times are in hours. Values in parentheses are percentages. N/A indicates that p values were not published.

drochlorperazine

metoclopramide

ondansetron

Acupuncture and ondansetron

6

Droperidol

Acupuncture and droperidol

Sham acupuncture