

Research progress of acupuncture analgesia based on autonomic nerve regulation pathway

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Abstract

The autonomic nervous system (ANS) includes the sympathetic, parasympathetic, and enteric nervous systems, and its senior regulatory center includes the brainstem, cingulate gyrus, and hypothalamus. Acupuncture can affect visceral, vascular, and glandular functions via the autonomic nervous regulatory pathway. In this paper, the relationship between pain and autonomic nervous function, the application of acupuncture guided by the autonomic nervous system, and the basis and clinical research on acupuncture analgesia are reviewed.

Keywords: Acupuncture, Autonomic nervous system, Pain, Progress

Graphical abstract: <http://links.lww.com/AHM/A80>

Introduction

It is well known that central sensitization is an important manifestation involved in many different chronic pain conditions, and the mechanisms of pain include local and broad sensitization, central summation, and descending pain regulation^[1]. Recently, several studies have focused the mechanisms of pain on autonomic dysfunction^[2–3]. The autonomic nervous system (ANS) is a diffuse network that regulates physiological systems by integrating inputs from internal and external environments, providing *in vivo* homeostasis in cells, tissues, and organs throughout the body. The ANS controls the heart rate, blood pressure, digestion, sweating, urination, and regulation of visceral function, and is inextricably linked to the onset of a wide range of pain^[4–5].

Traditional Chinese medicine believes that acupuncture dredging meridians and regulating *yin* and *yang*, and modern medicine believes that acupuncture has a bidirectional regulation effect. Recent evidence suggests that the ANS is a key neural pathway in acupuncture

signaling^[6–7]. Hegu (LI4)^[8], Zusanli (ST36)^[9], Neiguan (PC6)^[10] can bidirectionally regulate sympathetic and vagal activity. Acupuncture reduces visceral dysfunction and inflammation, relieves pain, and restores homeostasis by modulating the ANS^[11]. The ANS is a therapeutic target for acupuncture and modulates its analgesic effects^[12].

Several studies have reported that acupuncture is based on the regulatory effect of the ANS on related diseases and on the relationship between the ANS and pain^[13–14]. Acupuncture is a common and effective pain treatment. The mechanisms underlying acupuncture analgesia have also been widely studied^[15]. Therefore, a literature review was conducted to find main published animal experiments and clinical observations on the role of ANS in pain and acupuncture. We searched PubMed, the Cochrane Library, Web of Science, and Foreign Medical Information Resource Retrieval Platform (FMRS) for more relevant literature until September 2023. This review summarizes the related studies on acupuncture regulating pain through the ANS in recent years.

Pain occurrence and autonomic nervous regulatory mechanism

The ANS includes the sympathetic, parasympathetic, and enteric nervous systems (ENS), which mainly innervate the visceral organs, blood vessels, and glands, and regulate visceral function. ANS dysfunction is often observed in patients experiencing pain (Figure 1), whereas sympathetic excitation can often induce chronic pain. In addition, dorsal root ganglion (DRG) discharge and sympathetic nerve sprouting may enhance central sensitization and pain dysfunction^[16]. Vagus nerve stimulation can improve chronic pain such as migraines^[17]. Research has shown that “Pain matrix center” such as hypothalamus, amygdala, periaqueductal gray (PAG), cingulate cortex, insular cortex are involved in the autonomic regulation of pain^[18].

Autonomic nerve activity is closely related to the occurrence of various types of pain such as migraine and trigeminal autonomic headache^[16]. During migraine attacks, sympathetic nerve reactivity is significantly increased, while the pain VAS score is increased^[19–20].

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pain caused by malignancy or other changes in the abdominal and pelvic organs^[49]. The level of cluster discharge is directly related to the spontaneous pain behavior caused by nerve injury, and blocking sympathetic nerve-mediated cluster discharge can be used to treat spontaneous pain^[2]. Vagus nerve stimulation can inhibit the production of TNF- α , IL-1 β , and IL-6 in the peripheral blood of patients with rheumatoid arthritis and reduce joint pain^[50].

Application value of autonomic nerve regulation pathway in acupuncture research

Currently, research on the regulation of autonomic nerves to guide acupuncture is mainly conducted from three aspects: sympathetic, parasympathetic, and intestinal visceral nerves. From the perspective of the selection of acupuncture points, sympathetic nerve function is mainly regulated by the points on the limbs and trunk, and the lower extremity ST36 and auricular points induce vagus nerve excitation (Figure 2). Various studies have shown that acupuncture can relieve symptomatic diseases associated with the ANS, including inflammation-related diseases^[51], functional gastrointestinal diseases^[52], chronic pain, and depression^[53]. Acupuncture can also regulate the function of the ANS, including blood pressure, muscle sympathetic nerve activity, heart rate, etc, and affect the release of adaptive neurotransmitters in related brain regions^[54] (Table 1).

Acupuncture can be explained through the reflex arc of action, which mainly includes stimulation (receptor, somatic sensory afferent), integration (central brain and spinal cord), and effect (target organ, effector, and visceral/

somatic motor efferent). Acupuncture and moxibustion through peripheral stimulation, into the center, and through central integration to reach the spleen and adrenal gland, exert an anti-inflammatory effect^[55]. For example, in 2014, Ulloa et al.^[51] found that ST36 electric acupuncture stimulated the sciatic nerve, induced the vagus nerve to activate aromatic L-amino acid decarboxylase, and promoted dopamine production in the adrenal medulla, thereby controlling systemic inflammation. Electroacupuncture exerts a systemic anti-inflammatory effect through vagus nerve excitation, which depends on T cells^[56].

In 2020, research revealed that high-intensity (3.0 mA) stimulation of Tianshu (ST25) activates the spinal-sympathetic axis, and low-intensity (0.5 mA) stimulation of ST36 drives the vagal-adrenal axis and inhibits LPS-induced inflammation. Before the occurrence of systemic inflammation induced by LPS, electroacupuncture ST25 exerted an anti-inflammatory effect. However, after LPS-induced inflammation, an obvious pro-inflammatory effect was observed. In contrast, ST36 electroacupuncture inhibited the inflammatory response before and after LPS-induced inflammation^[6]. According to a recent study published in *Nature*, low-intensity electroacupuncture at ST36 mainly plays a role in activating PROKR2-specific sensory neurons and the vagal-adrenal classical cholinergic anti-inflammatory pathway^[7].

In addition to the classical vagal-cholinergic anti-inflammatory pathway, acupuncture regulates various inflammation-related diseases through autonomic nerve regulation. Acupuncture at combined points in Fengmen (BL12) and Shenshu (BL23) reduces renal sympathetic nerve activity and prevents the development of glomerulonephritis^[57]. Feishu (BL13) acupuncture can inhibit

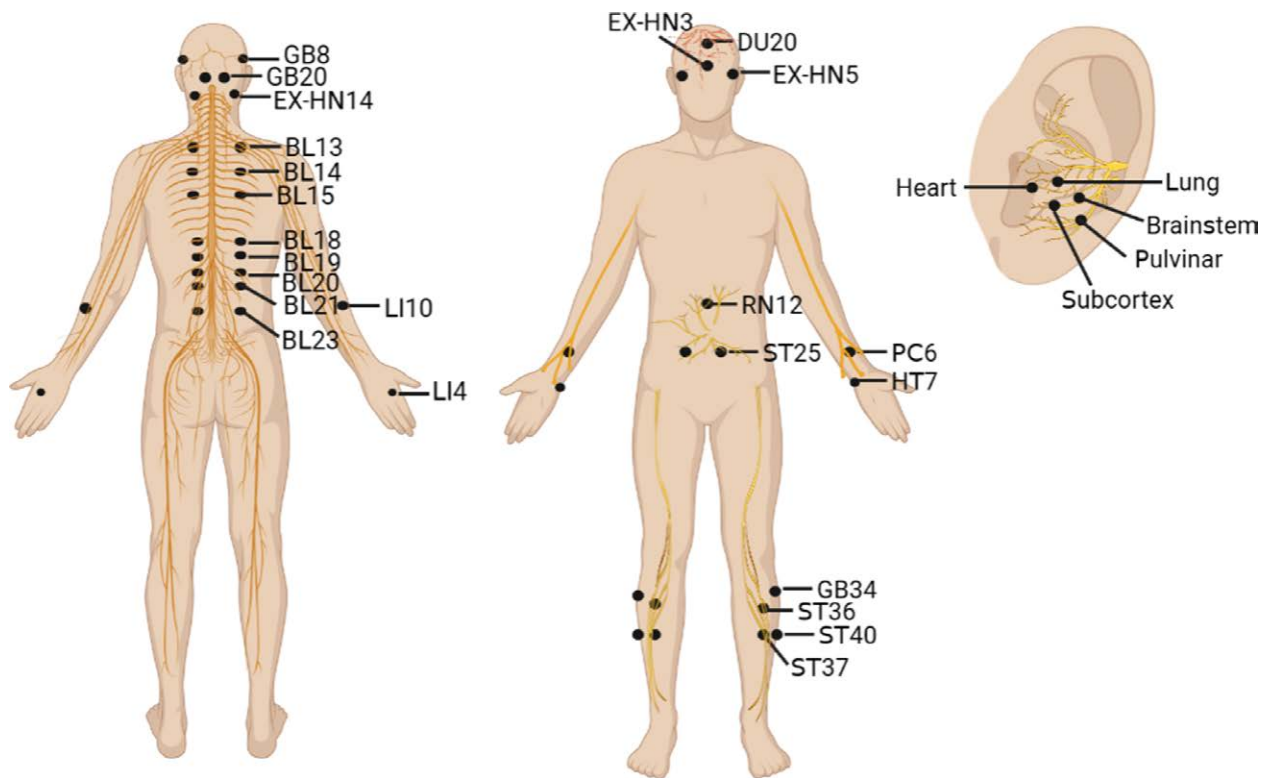


Figure 2. Anatomical position of acupoints. Electroacupuncture-related points can regulate the sympathetic and parasympathetic nerves, which including the stomach meridian of foot-yangming, bladder meridian and auricular point.

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Table 1
Effects and autonomic regulatory mechanisms of acupuncture treating diseases

Disease	Acupoints	ANS	Mechanism
System inflammation ^[6-7]	ST25, ST36	Sympathetic/parasympathetic	Low-intensity ES drives the vagus nerve-adrenal axis to produce anti-inflammatory effects dependent on NPY+ adrenal chromaffin cells; abdominal high-intensity ES of the spinal cord sympathetic axis activates NPY+ splenic noradrenergic neurons and acts on different adrenergic receptors, involved in regulating the inflammatory state. PROKR2 neurons are uniquely required for low-intensity ES to drive the vagal-adrenal anti-inflammatory axis from the hindlimb ST36 acupoint
System inflammation ^[51]	ST36	Parasympathetic	Activation of the sciatic nerve induces the activation of the vagus nerve to produce aromatic L-aminoacidcarboxylase, causing the adrenal medulla to produce dopamine, which inhibits the production of cytokines through type 1 dopamine (D1) receptors
System inflammation ^[56]	ST36	Parasympathetic	Electroacupuncture exerts a systemic anti-inflammatory effect through vagus nerve excitation, which depends on T cells
Glomerulonephritis ^[57]	BL12, BL23	Sympathetic	Reducing renal sympathetic nerve activity by inhibiting Erk1/2 MAPK pathway to reduce hypertension and glomerulonephritis
Bronchial asthma ^[58]	BL13	Parasympathetic	Therapeutic effects are achieved by inhibiting the synthesis and release of ACh signals
Colonic inflammation ^[59]	ST36	Sympathetic/parasympathetic	Electroacupuncture and chronic VNS improves inflammation in TNBS-treated rats by inhibiting pro-inflammatory cytokines <i>via</i> the autonomic mechanism
Gonarthritits ^[60]	ST36, GB34	Sympathetic	Activation of sympathetic noradrenergic signaling to control gonarthritits
Colitis ^[61]	PC6, LI4	Sympathetic/parasympathetic	Inhibition of pro-inflammatory cytokines <i>via</i> autonomic mechanisms ameliorate colitis in rats
Gastric motility ^[62]	RN12, BL21	Parasympathetic	Regulation of gastric motility <i>via</i> the PVN-DVC-vagus-gastric nerve pathway
Gastric motility ^[63]	PC6	Parasympathetic	Reducing inhibition of efferent vagal motor fibers by inhibiting GABA transmission to the DMV, thereby promoting efferent vagal activity and increasing gastric motility
Gastric motility ^[64]	ST36	Parasympathetic	The NR2A-containing NMDARs are essential for NMDAR-mediated enhancement of gastric motility caused by stimulating ST36
Hypertension ^[65]	ST36, ST40	Sympathetic	Inducing increases in NPY expression and function in the PVN contribute to hypotension and sympathetic inhibition in hypertensive rats
Hypertension ^[66-67]	PC5, PC6	Sympathetic/Parasympathetic	Improving autonomic balance, increasing sympathetic and reducing parasympathetic tone; suppresses blood pressure elevation by activating the arcuate nucleus, ventrolateral periaqueductal gray and inhibiting cardiovascular sympathetic neurons in the ventrolateral medulla
Acute respiratory distress syndrome ^[68]	ST36	Parasympathetic	Attenuation of LPS-induced ferroptosis in alveolar epithelial cells by activating $\alpha 7nAChR$ to alleviate LPS-induced ARDS
Chronic obstructive pulmonary disease ^[69]	ST36, BL13	Parasympathetic	Activating cholinergic anti-inflammatory pathways to reduce lung inflammation and improves lung function
Chronic kidney disease ^[70]	ST36, KI3	Sympathetic	Reducing blood pressure and improving chronic kidney disease by regulating renal sympathetic nerve activity and nitric oxide levels
Pancreatitis ^[71]	ST36	Parasympathetic	Through $\alpha 7nAChR$ to act cholinergic anti-inflammatory effect

Ach: Acetylcholine; ANS: Autonomic nervous system; ARDS: Acute respiratory distress syndrome; DMV: Dorsal motor nucleus of the vagus; DVC: Dorsal vagal complex; Erk1/2: The extracellular signal-regulated kinase 1/2; ES: Electroacupuncture stimulation; GABA: Gamma-aminobutyric acid; LPS: Lipopolysaccharide; MAPK: Mitogen-activated protein kinase; NR2A: glutamate receptor 2a; NMDARs: N-methyl-D-aspartate receptors; NPY: Neuropeptide Y; PVN: Paraventricular nucleus; TNBS: Trinitrobenzenesulfonic acid; VNS: Vagal nerve stimulation.

lung choline acetyltransferase (ChAT) expression and Ach release, and improve the inflammatory reaction in allergy and asthma^[58]. ST36 electroacupuncture combined with vagus nerve stimulation can effectively inhibit chronic colonic inflammation^[59]. ST36 and Yanglingquan (GB34) electroacupuncture can control local inflammation in rats with knee arthritis by activating the sympathetic noradrenergic signaling pathway^[60]. PC6 or LI4 electroacupuncture pretreatment can activate the synergistic anti-inflammatory effects of the peripheral sympathetic and parasympathetic systems^[61].

Acupuncture can also regulate various organ functions through the autonomic nerve pathway, and the autonomic nerve-related nuclear group dorsal motor nucleus of the vagus (DMV) and hypothalamic paraventricular nucleus (PVN) play leading roles in regulating gastrointestinal function. Zhongwan (RN12) and Weishu (BL21) electroacupuncture can regulate gastrointestinal function through the PVN-dorsal vagal complex-vagus-gastric neural pathway and regulate the upregulation of motilin, gastrin, and their receptors^[61]. By stimulating the PC6 point, electroacupuncture can

inhibit gamma-aminobutyric acid (GABA) nerve fiber transmission in the DMV, reduce the inhibition of vagus nerve efferents, and promote gastric activity^[63]. Low frequency somatic stimulation at ST36 upregulates gastric motility by specifically enhancing the glutamate-receptor-2a-(NR2A-) containing N-methyl-D-aspartate-receptor-(NMDAR-) mediated synaptic transmission in gastric-projecting DMV neurons^[64].

Acupuncture can regulate inflammatory diseases, gastrointestinal functional diseases through the ANS as well as cardiovascular, lung, kidney, pancreatic, and other visceral functional diseases. For example, ST36 and ST40 electroacupuncture inhibit sympathetic nerve activity in hypertensive rats, regulate Neuropeptide Y (NPY) expression in the PVN, and reduce blood pressure^[65]. Electroacupuncture Jianshi (PC5) and PC6 can inhibit increase in blood pressure by regulating cardiovascular sympathetic neurons in the hypothalamic arcuate nucleus and ventrolateral periaqueductal gray (vlPAG)^[66-67]. For acute respiratory distress syndrome, electroacupuncture stimulates ST36 to activate $\alpha 7$ nicotinic acetylcholine receptor ($\alpha 7nAChR$) in lung tissue through sciatic nerve

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and cervical vagus nerve, thereby exerting lung protection^[68]. Electroacupuncture at ST36 and BL13 can alleviate pulmonary inflammation and improve pulmonary function in chronic obstructive pulmonary disease^[69]. Electroacupuncture and moxibustion significantly improve the abnormal activity of sympathetic nerves in chronic kidney disease rats and reduce the occurrence of proteinuria^[70]. Electroacupuncture at ST36 acupoint can increase vagus nerve activity, inhibit systemic inflammation, reduce inflammatory infiltration of the pancreas in acute pancreatitis, up-regulate $\alpha 7nAChR$ expression, and exert cholinergic anti-inflammatory effect^[71]. Transcutaneous electrical acustimulation can improve hypotensive lower esophageal sphincters pressure in patients with gastroesophageal reflux disease (GERD), which is mainly related to an enhanced vagal tone^[72].

Clinical research on acupuncture analgesia in autonomic nerve regulatory pathway

Traditional Chinese acupuncture and moxibustion have long been used to treat various diseases. Recently, a large number of clinical studies have been conducted on various pain diseases such as migraine, visceral pain, neck and shoulder pain, and lower back pain (Table 2).

Acupuncture for the treatment of migraine

Migraine is a chronic sympathetic disorder characterized by the relative depletion of norepinephrine stores and increased release of dopamine, prostaglandin, and adenosine^[83-84]. Acupuncture has been clinically proven to relieve migraine and autonomic symptoms^[85]. Acupuncture at Baihui (GV20), Shuaigu (GB8), Fengchi (GB20), Tianrong (SI17), and other points can reduce sympathetic nerve activity, reduce heart rate variability low-frequency power, and relieve pain in migraine patients^[14,73-74].

Additionally, various neuroregulatory techniques (vagus nerve stimulation and transcutaneous electrical nerve stimulation), including acupuncture, can relieve migraine symptoms^[86-87]. For example, transcutaneous vagus nerve stimulation can directly regulate vagus nerve activity and effectively prevent and treat migraine^[88-89]. The mechanism by which ear acupuncture and transcutaneous auricular vagus nerve stimulation (taVNS) relieve migraine symptoms may be related to the regulation of abnormal function of the amygdala (AMG) and pain network^[80,90-91]. Further studies have shown that taVNS at 1 and 20 Hz has different modulatory effects on the nucleus solitarius and locus coeruleus^[92-93].

Acupuncture treatment of visceral pain

Visceral pain can be clinically observed in gastrointestinal disorders such as functional bowel disease and inflammatory bowel disease. Gastrointestinal endogenous innervation is controlled by the ENS, and exogenous nerves include sympathetic and parasympathetic nerves^[94-95]. Studies have found that the ENS brain-gut axis plays a key role in visceral pain^[96]. Acupuncture treats visceral pain in patients with IBS by actively regulating gastrointestinal motility and visceral hypersensitivity^[75-76]. Electroacupuncture can activate the ENS, causing the brain-pituitary axis to release different levels of nerve substances, inhibit the inflammatory response or promote damage repair, interfere with peripheral sensory nerve impulses, and relieve pain^[97]. It has been confirmed that ST25 and Shangjuxu (ST37) electroacupuncture may play a therapeutic role by regulating brain-gut axis function in patients with IBS^[77]. Similarly, the transcutaneous acupoint electrical stimulation of (TEAS) ST36, ST37, LI4, and PC6 may regulate gastrointestinal function and inhibit pain through the cerebral and intestinal axis^[78].

Table 2
Clinical research of acupuncture analgesia in autonomic nerve regulatory pathway

Disease	Acupoints	ANS	Mechanism
Migraine ^[14,73-74]	GV20, GB8 GB20, SI17	Sympathetic	Decreasing heart rate variability low-frequency power to relieve pain
Irritable bowel syndrome ^[75-76]	DU20, EX-HN3, ST36, ST37, SP6, ST25, LR3	Enteric nervous	Influencing the expression of TRPV1 and microRNA-199 to relieve the status of visceral hypersensitivity
Irritable bowel syndrome ^[77]	ST25, ST37	Enteric nervous	Activating the ACC brain region and regulating the brain-gut axis to improve irritable bowel syndrome
Postoperative gastrointestinal dysfunction ^[78]	LI4, PC6, ST36, ST37	Enteric nervous	Transcutaneous electrical acupoint stimulation may regulate gastrointestinal function and inhibit pain through the cerebral and intestinal axis
Chronic pain&depressive ^[79]	GV20, EX-HN3	Parasympathetic	taVNS combined with electroacupuncture produces similar positive effects on depressive and pain symptoms in patients with depression and chronic pain, which last for at least 8 weeks
Acute and chronic pain ^[80]	Auricular acupuncture: Shenmen, lung, thalamus, uterus, heart	Parasympathetic	Activating the vagus innervated area of the ear
Low back pain ^[81]	UB-23/24/36/37/40/57/60, GB-30/34, GV4	Sympathetic	Reversing the state of abnormal autonomic function and relieve pain
Low back pain ^[82]	ST36, BL25, GB30, BL40, GB34	Sympathetic	A activates the sympathetic nervous system and induces the release of epinephrine, which could ameliorate inflammation and protect muscular tissue in addition to relieving pain

ACC: Anterior cingulate cortex; TRPV1: Transient receptor potential vanilloid 1; taVNS: Transcutaneous auricular vagus nerve stimulation.

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Acupuncture for other pain

Studies have shown that taVNS combined with electroacupuncture GV20 and Yintang (EX-HN3) is effective in improving symptoms in patients with depression and chronic pain^[79]. Acupuncture stimulates the auricular point area innervated by the vagus nerve (Shen gate, lung, thalamus, uterus, heart, etc.), which can effectively relieve pain^[80]; Acupuncture of trigeminal nerve anatomy distribution-related points Sibai (ST2), Cuanzhu (BL2), Yuyao (EX-HN4), and Taiyang (EN-HN5) can effectively relieve trigeminal nerve autonomy headache, such as cluster pain^[81].

Neck and shoulder pain and chronic lower back pain are associated with ANS dysfunction. Studies have shown that systemic sympathetic activity increases in patients with chronic low back pain^[99]. Excessive sympathetic activity aggravates myofascial trigger points for spontaneous local pain in patients with chronic neck and shoulder pain^[100]. In patients with lower back pain, vagal nerve tone is significantly reduced, sympathetic nerve activity is significantly increased, and electroacupuncture can reverse abnormal autonomic nerve function and relieve pain^[81]. In addition, electroacupuncture can also activate the sympathetic nervous system, promote the release of adrenaline, and play an anti-inflammatory and analgesic role^[82].

In addition to the differences in autonomic nervous function in the type, nature, and location of pain, different acupoint stimulations and durations also affect autonomic nervous function changes, such as acupuncture in healthy subjects, in the 25-minute stimulation period and 60 minutes after stimulation, stimulation of auricular points mainly increases parasympathetic nerve activity; stimulation of the left LI4 increases sympathetic and parasympathetic nerve function; however, acupuncture to the right LI4 does not show any changes during the

25-minute stimulation period, and a significant increase in sympathetic and parasympathetic activity is only observed 60 minutes after stimulation^[101].

Animal experiment of acupuncture analgesia in the autonomic nervous regulation pathway

Acupuncture regulates autonomic nerves to treat visceral pain, inflammatory pain, somatic pain, etc. Many neurotransmitters, neuropeptides, and cytokines are involved in the analgesic process of acupuncture (Table 3).

Acupuncture treatment of visceral pain

Visceral pain is most common in IBS, and this animal model is commonly used. The harmful stimuli act on the gastrointestinal mucosal receptors, pass to the primary sensory neurons of the DRG, and project to the somatosensory cortex, anterior cingulate cortex (ACC), and insular cortex of the brain, resulting in visceral pain^[112].

Studies on the peripheral mechanisms of acupuncture in relieving gastrointestinal visceral pain have focused on neurons, afferent fibers, and related neurotransmitters. Innervation of the DRG in rats with IBS by ST25 electroacupuncture is similar to that in the colon, with double-labeled positive neurons in the DRG and retrograde-labeled neurons in the anterior horn of the spinal cord^[102]. In conclusion, the sympathetic ganglion may be an important part of electroacupuncture in the regulation of visceral hypersensitivity. In addition, ST36 and ST25 acupuncture can reduce sympathetic nerve activity and relieve visceral pain in rats with IBS^[113]. Some scholars have used inferior septal vagotomy to determine whether the vagus nerve afferent can regulate visceral pain^[114]. In addition, regulating the activity of the vagus nerve by auricular vagal nerve stimulation (AVNS) can

Table 3
Animal experiment of acupuncture analgesia in autonomic nervous regulation pathway

Disease	Acupoints	ANS	Mechanism
Visceral pain ^[102]	ST25	Sympathetic	Improving irritable bowel by reducing visceral sensory impulses by affecting sensory neurons in the dorsal horn of the spinal cord and DRG
Visceral pain ^[103-105]	ST36, ST25	Sympathetic	Electroacupuncture decreases the number of mast cells in colon mucosa and decreases Substance P, vasoactive intestinal polypeptide, NMDA receptor and expression of corticotropin-releasing hormone, thereby reducing visceral hypersensitivity in rats with IBS.
Visceral pain ^[106]	ST36, ST37	Parasympathetic	Regulating the activity of endogenous opioid peptides in the spinal cord to inhibit the release of pain-sensing neurotransmitters, thereby achieving the purpose of alleviating visceral pain
Ileitis-induced visceral hypersensitivity ^[107]	ST36	Parasympathetic	Inhibiting JAK2/STAT3 signal pathway of PAG-RVM-SCDH axis to attenuating visceral hypersensitivity
Plantar inflammatory pain ^[108]	ST36	Sympathetic	Low-frequency electroacupuncture acts through sympathetic postganglionic neurons, while high-frequency electroacupuncture inhibits through the vagus-adrenal axis
Inflammatory pain ^[59]	ST36, GB34	Sympathetic	Increase the level of sympathetic neurotransmitter norepinephrine in the joint synovium, inhibit the release of inflammatory factors, thereby reducing pain
Arthritis ^[109]	ST36	Parasympathetic	Activating the sciatic-vascular network, reducing the levels of joint neutrophils and systemic inflammatory cytokines, and relieving joint inflammation pain
Referred pain ^[110]	PC6	Sympathetic	Exciting sympathetic nerves, blocking α 2 adrenoceptor sympathetic-sensory coupling and attenuating the effect of electrical stimulation on cardiac function.
Fibromyalgia ^[111]	ST36	Sympathetic	Downregulation of TRPV1-PERK signaling in AMG, somatosensory cortex, and thalamus to attenuate neuroinflammation, thereby reducing hyperalgesia with fibromyalgia

AMG: Amygdala; DRG: Dorsal root ganglion; IBS: Irritable bowel syndrome; JAK2/STAT3: Janus kinase 2/signal transducers and activators of transcription 3; NMDA: N methyl D aspartate.

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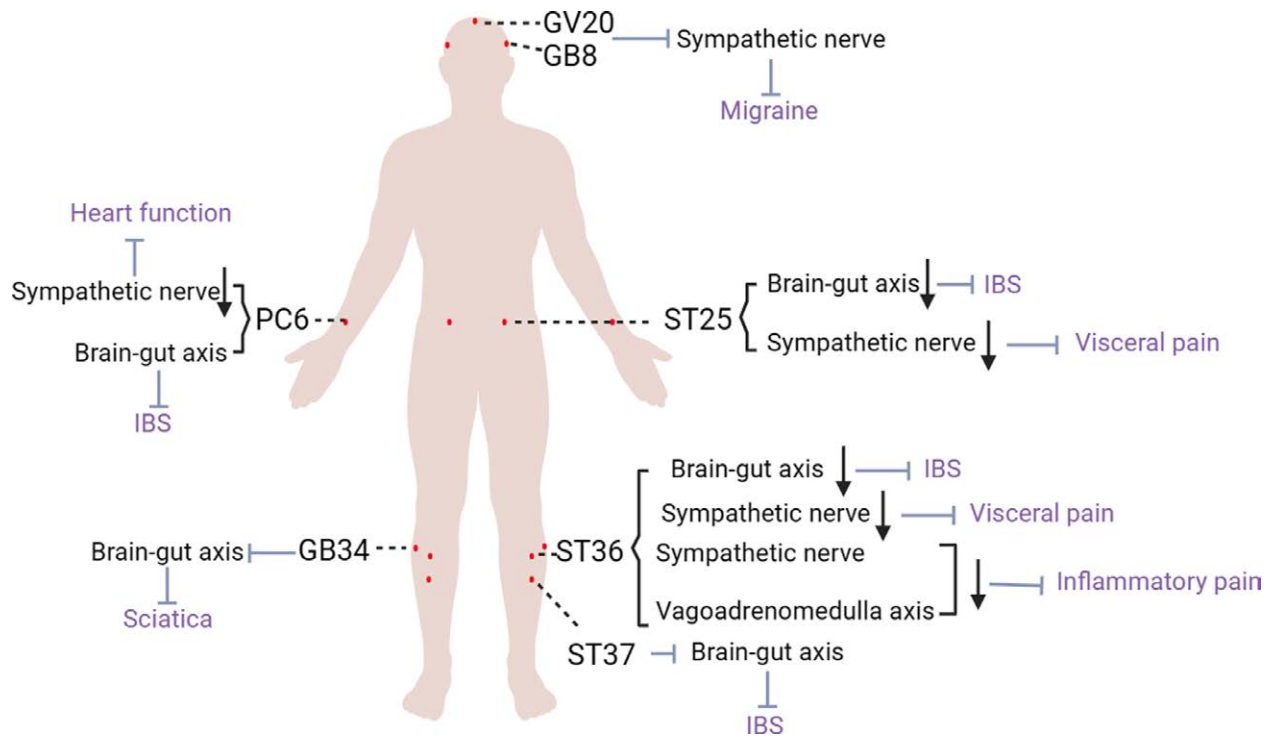


Figure 3. Related regulatory mechanisms of common electroacupuncture acupoint analgesia. IBS: Irritable bowel syndrome.

GB34, ST36, etc, among which ST36 is the most commonly used and effective acupoint in acupuncture analgesia research (Figure 3).

Conclusions and future perspectives

The structure and function of the ANS are relatively complex, and their application in acupuncture research needs to be deepened, especially in clinical research. Currently, the application of acupuncture in ANS regulation mainly focuses on inflammatory diseases, gastrointestinal disorders, chronic pain, depression, and cognitive disorders, while in terms of pain, it mainly focuses the research and application in migraine, visceral pain, cancer pain, and autonomic nerve-related pain. In acupuncture for autonomic nervous regulation, the application points mainly include ST36, auricular point, PC6, LI4, ST25, and Shu-back point. In-depth animal experiment in the future should explore the difference or specificity of autonomic nervous function regulation when acupuncture points in different parts are stimulated. In terms of clinical research, it is expected that studies will apply more accurate and intuitive evaluation and analysis methods to analyze changes in autonomic nervous function during acupuncture intervention and further clarify the effect and specific action path of acupuncture regulation of the ANS.

Conflict of interest statement

The authors declared no conflict of interest.

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Author contributions

Lina Pang conceived and wrote the manuscript. Xiaomei Chen helped with the figure and drafted the manuscript. Yanyan Lan, Qiuling Huang, Xiangmei Yu, Lu Qi, and Zhifu Wang revised the manuscript. All authors have read and approved the final manuscript.

Ethical approval of studies and informed consent

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Data availability

All data generated or analyzed during this study are included in this manuscript.

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