

Relationship between acupuncture and the autonomic nervous system

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As a bidirectional link between the brain and other organs, the autonomic nervous system (ANS) plays a pivotal role in internal environment homeostasis, both through its sensing and modulatory roles. From the principles of modern anatomy and physiology, investigating the correlation between the body's surface and internal organs in the context of the nervous system can offer valuable insights into the mechanisms underlying the efficacy of acupuncture. The distribution of the ANS throughout the body may serve as a potential conduit or "highway" through which the therapeutic effects of acupuncture are conveyed^[1-2].

The ANS comprises an intricate neuro-endocrine-immune network that integrates interoceptive information and responds with appropriate adaptive modulatory feedback, thereby maintaining homeostasis^[3]. A salient feature of ANS is that a given input drives two opposing legs (positive *vs.* negative) to influence the organs' functions^[4], which is aligned with the bidirectional regulatory effects and holistic principles emphasized in acupuncture. Additionally, somatosensory autonomic pathways driven by specific acupoints form a modern neuroanatomical basis for long-range modulation of internal organ^[5-6]. Therefore, it is time to evaluate the potential mechanisms of acupuncture on the ANS in both laboratory and clinical settings.

The autonomic responses to the sympathetic and parasympathetic systems are often antagonistic, which provides tighter control than a single autonomic system. According to traditional Chinese medicine theory, acupuncture is believed to restore the balance of *yin* and *yang*, indicating that the effect of acupuncture on the ANS is characterized by bidirectionality^[7]. Acupuncture may be a potential therapeutic regimen to control the balance of the ANS *via* exciting/inhibiting sympathetic or vagal nerves.

Currently, research on the regulation of ANS by acupuncture, especially electroacupuncture at the extremities and head acupoints, predominantly focuses on cardiovascular, gastrointestinal, inflammatory, and pain-related disorders^[8]. Upper limb acupoints, such as *Neiguan* (PC6), are the most commonly used acupoints in cardiovascular diseases, which have the potential to regulate sympathetic nerve activity *via* the median nerve^[9]. By contrast, lower limb acupoints, such as *Zusanli* (ST36), the most commonly used acupoints in gastrointestinal disorders, are able to drive nerve *via* the sciatic nerve^[10]. Collectively, the effects of acupuncture on the ANS are influenced by, even dependent upon, the chosen acupoints, stimulatory frequency and intensity, type of diseases, frequency of treatment, and other factors^[11].

Overall, clinical and basic studies have indicated that acupuncture, as a promising treatment to alter ANS activity, has acupoint specificity and parameter-dependent effects. We argue that upper limb/abdominal acupoints and lower limb acupoints should not be narrowly defined as activating sympathetic or vagal nerves, respectively. Before the conclusion that acupuncture is an effective or in-clinical modality is reached, stimulation parameters should be further reinforced. Furthermore, many challenges and knowledge gaps remain to be studied regarding the interplay between different brain areas with responses to organ functions and acupuncture stimulation, which will assist in revealing the central-control mechanisms in future acupuncture-ANS studies.

Conflict of interest statement

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Author contributions

Cunzhi Liu drafted and approved the manuscript.

Ethical approval of studies and informed consent

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Data availability

Not applicable.

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