

Application and Research Progress of Acupuncture in Neurological Management of Critically Ill Patients

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Abstract

Neurological management constitutes one of the core components of the critical care medicine diagnostic and therapeutic system, permeating the entire trajectory of critically ill patient care. It primarily centers on three pivotal objectives: the optimization of analgesia and sedation, the prevention and treatment of delirium, and the facilitation of awakening in patients with consciousness disorders. With the deepening of research into acupuncture's mechanisms of action and the accumulation of clinical evidence, its unique value in the neurological management of critically ill patients has become increasingly prominent, emerging as a key direction for the integration of traditional medicine and modern critical care medicine. This article systematically synthesizes findings from recent animal experiments and clinical studies, summarizing acupuncture's application value in assisting analgesia and sedation, ameliorating delirium, and promoting consciousness recovery from three dimensions—mechanism of action, clinical evidence, and application standards. In doing so, it aims to provide theoretical and practical support for constructing a novel integrated traditional Chinese and Western medicine paradigm for the neurological management of critically ill patients.

Keywords: acupuncture; neurological management; critically ill patients

Introduction

Patients in the intensive care unit (ICU) frequently confront complex pathological conditions characterized by multi-organ dysfunction. As the body's regulatory hub, the stability of neurological function has a direct impact on treatment success rates and long-term prognosis^[1]. Currently, numerous unresolved clinical challenges persist in the neurological management of critically ill

patients. Analgesia and sedation serve as foundational therapeutic interventions for ICU patients, with their core objective being to balance "pain control" against "organ protection"^[2]. However, significant challenges persist in clinical practice. Uncontrolled pain can trigger sympathetic hyperactivity, leading to blood pressure fluctuations, increased myocardial oxygen consumption, and even elevated intracranial pressure^[3]. Additionally, the prolonged use of opioid medications

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(such as morphine) and sedatives (such as propofol, dexmedetomidine) carries risks of adverse effects, including respiratory depression, circulatory instability, and gastrointestinal dysmotility^[4-6].

Moreover, drug accumulation stands as an independent risk factor for delirium^[7]. Evidence indicates that adverse reactions to analgesic and sedative medications contribute to prolonged mechanical ventilation in 30% to 40% of ICU patients, significantly increasing both hospitalization costs and mortality risk^[8]. Delirium represents the most prevalent neurological complication in the ICU, with an incidence of 60% to 80% among mechanically ventilated patients and over 85% among elderly critically ill patients. It not only directly increases short-term mortality by two to threefold but also raises the risk of long-term cognitive impairment by more than 50%^[9]. Although contemporary medical research has identified inflammatory responses, neurotransmitter imbalances (such as dopamine-acetylcholine dysregulation), and disruptions in sleep-wake cycle as key contributing factors to delirium, there are currently no guideline-recommended specific therapeutic agents available^[10]. Traditional antipsychotics may alleviate symptoms of agitation but do not reduce the duration of delirium and pose cardiovascular risks, including QT interval prolongation. Additionally, primary conditions including traumatic brain injury, stroke, and severe infection often induce consciousness disorders in critically ill patients, ranging from somnolence and stupor to vegetative states. If a consciousness disorder persists beyond 72 h, the long-term awakening rate drops below 30%, and 90% of survivors suffer from severe neurological sequelae^[11].

Current clinical interventions, including neuromodulation therapy (such as transcranial magnetic stimulation) and pharmacologically induced awakening (such as naloxone), demonstrated limited efficacy and are plagued by issues like operational complexity and numerous contraindications, underscoring an urgent need for safe and effective supplementary treatment strategies^[12]. In this context, acupuncture, a traditional therapy with a history exceeding 2000 years, represents a novel perspective for addressing the challenges of neurological management in critical care. This is attributed to its characteristics of “holistic regulation and multi-targeted intervention”^[13]. Contemporary anatomical research suggests that the

meridian system targeted by acupuncture may correspond to the human neuro-vascular-lymphatic network and interstitial tissue spaces. Through the stimulation of acupoints, acupuncture modulates neurotransmitter release, improves microcirculation, and exerts anti-inflammatory effects. These mechanisms closely align with the pathophysiological processes of neurological disorders in critical illness^[14].

The core applications of acupuncture in neurological care of critically ill patients

Assisting analgesia and sedation

The therapeutic value of acupuncture in providing analgesia and sedation for critically ill patients is predominantly evidenced by its ability to enhance synergistic efficacy and reduce both toxicity and dosage. This is achieved through the activation of endogenous analgesic pathways, leading to decreased medication dosages and lower rates of adverse reactions^[15]. Currently, three principal analgesic mechanisms of acupuncture have been identified^[16]. Firstly, the Gate Control Theory indicates that acupoint stimulation could activate A β fibers, which in turn inhibit the transmission of nociceptive signals within the spinal dorsal horn, thus blocking the ascending pain pathways. Secondly, acupuncture engages the endogenous opioid system by promoting the release of opioid neurotransmitters, such as enkephalin and endorphin, within both the central and peripheral nervous systems, and it could be antagonized by naloxone. Thirdly, acupuncture modulates neurotransmitter release through the activation of the periaqueductal gray-rostral ventromedial medulla-spinal dorsal horn pathway. This pathway regulates the secretion of monoamine neurotransmitters, including serotonin and norepinephrine, thereby enhancing the efficacy of the descending inhibitory system.

In recent years, numerous high-quality studies have corroborated the clinical efficacy of acupuncture in neurological management. Specifically, a randomized controlled trial (RCT) involved 45 ICU patients with postoperative pain was conducted to investigate the analgesic effect of the acupuncture. The study utilized acupoints, including Hegu (LI4), Taichong (LR3), Neiguan (PC6), Zusanli (ST36), and auricular points (Shenmen, Sympathetic, etc.), with needle retention for 20 min once daily for 3 consecutive days. The results

indicated a reduction in patients' scores by an average of 2.56 points from baseline on the first day of treatment. Additionally, the morphine dosage decreased from 21.44 mg to 13.50 mg by the third day, representing a 37% reduction^[17]. Similarly, another RCT trail involved 80 elderly mechanically ventilated patients revealed that acupuncture at Neiguan, Hegu, Yintang (GV29), and Baihui (GV20) administered twice daily could shorten the time to achieve analgesia and sedation targets by 12.6 h, increase the 30-min compliance rate for the Critical-Care Pain Observation Tool (CPOT) score by 42%, and reduce the dosages of dexmedetomidine and propofol by 28% and 31%, respectively^[18]. Moreover, a meta-analysis incorporating 12 RCT studies revealed that acupuncture combined with conventional analgesia and sedation therapy could significantly reduce the VAS scores by 1.89 points in ICU patients, decrease opioid consumption by 32.6%, and shorten the duration of mechanical ventilation by 2.1 days, without increasing the risk of adverse events, such as bleeding or infection^[19]. Consequently, based on both literature reports and our center's clinical experience, it is recommended that systemic acupoints for auxiliary analgesia and sedation prioritize the key analgesic points like Hegu, Neiguan, and Zusanli, which could be complemented by auricular points including Shenmen, Sympathetic, and Thalamus. Manual acupuncture with needle retention is available for awake patients, whereas electroacupuncture stimulation with a frequency of 2–10 Hz and an intensity sufficient to induce slight local muscle tremor is recommended for patients who are comatose or undergoing mechanical ventilation. It is recommended to commence the intervention shortly after ICU admission, with treatments administered 1–2 times daily for 20–30 min per session, over a course of 3–7 consecutive days.

Improving delirium

Acupuncture exhibits a bidirectional regulatory function in the management of delirium intervention, as it not only decreases its incidence through early intervention but also reduces the duration of already established delirium. The primary mechanisms underlying this effect are centered on neurotransmitter balance, anti-inflammatory actions, and the restoration of sleep^[20]. At the contemporary medical perspective, these mechanisms could be categorized into three main aspects. Firstly, there is the regulation of neurotransmitter homeostasis^[21].

Electroacupuncture stimulation at the Baihui (GV20) point activates the vagus nerve-locus coeruleus pathway, facilitating the orderly release of neurotransmitters by noradrenergic neurons and rectifying the imbalance between excessive dopamine activation and insufficient acetylcholine. Animal studies have demonstrated that activation of this pathway increases acetylcholine levels in the rat prefrontal cortex by 40%. Secondly, acupuncture demonstrates anti-inflammatory effects and provides protection to the blood-brain barrier^[22]. It inhibits the release of pro-inflammatory cytokines such as TNF- α and IL-6 in peripheral blood. Clinical studies have shown that the levels of these inflammatory cytokines in the acupuncture group were reduced by 28% to 35% compared to the control group after a 3-day intervention. Meanwhile, there was an upregulation in the expression of Claudin-5, a biomarker of the blood-brain barrier, suggesting a reduction in the infiltration of inflammatory factors into the brain. Thirdly, acupuncture could regulate the melatonin secretion by the pineal gland and influence the function of the hypothalamic-pituitary-adrenal axis, ultimately restoring the sleep-wake rhythms^[23]. This intervention results in an extension of slow-wave sleep duration, increasing from 18 min per night to 42 min per night. Additionally, it enhances the melatonin-to-cortisol ratio and alleviates the “day-night reversal” sleep disturbances frequently observed in patients within intensive care units.

Recently, multiple studies have validated the efficacies of acupuncture in both the prevention and treatment of delirium. For example, a study involved 30 ICU patients with cardiovascular diseases revealed that the application of daily acupuncture at specific acupoints, including Baihui (GV20), Yintang (GV29), Shenmen (HT7), and Taixi (KI3), in conjunction with conventional treatment, could reduce the incidence of delirium from 37.9%–6.6% after one week, while it led to a 70% reduction in agitation symptoms^[24]. Another study utilized a syndrome differentiation-based approach for acupoint selection, categorizing 120 delirium patients into six distinct TCM syndrome types, such as “blazing fire-heat” and “phlegm-fire disturbing the heart”. Tailored acupoint regimens were then applied, including the use of Quchi and Dazhui for the “blazing fire-heat” type. The finding showed that the acupuncture group achieved delirium remission 2.3 days earlier and experienced 3.1 additional delirium-free days within a 7-day period compared to

the control group^[25]. Additionally, a systematic review of 20 studies indicated that acupuncture reduced delirium incidence among ICU patients by 41% and shortened its duration by an average of 1.9 days. The protective effect was particularly notable in high-risk groups, such as elderly individuals and those requiring mechanical ventilation^[26]. For the high-risk delirium patients, including the elderly, individuals undergoing major surgery, and mechanically ventilated patients, it is recommended to initiate acupuncture within 24 h of ICU admission, once daily for 5–7 consecutive days. In cases where delirium is already established, the frequency of acupuncture can be increased to twice daily, prioritizing acupoints like Baihui (GV20), Yintang (GV29), and Shenmen (HT7), with electroacupuncture frequency raised to 10–20 Hz. For patients with the TCM syndrome of phlegm-heat disturbing the heart, the inclusion of Fenglong and Neiting is recommended. Conversely, for those with qi-blood deficiency, the addition of Zusanli and Qihai is suggested. These modifications are intended to further enhance the therapeutic efficacy of the treatment.

Promoting consciousness improvement

The application of acupuncture in the revival of patients with consciousness disorders is grounded in the TCM theory of “resuscitating the mind and activating collaterals”^[27]. Contemporary studies have confirmed its efficacy in enhancing neurological function through multi-dimensional mechanisms, thereby presenting a novel therapeutic option for patients in comatose states following traumatic brain injury or stroke. The core mechanisms of acupuncture-induced awakening can be categorized into macro and micro levels. On the macro level, acupuncture enhances cerebral blood perfusion, as evidenced by a 25% to 30% increase in middle cerebral artery blood flow velocity, observed via transcranial Doppler. It also modulates cerebral glucose metabolism, with PET-CT scans indicating heightened metabolic activity in key brain regions such as the prefrontal cortex and thalamus, and activates essential brain areas including the reticular activating system and the default mode network^[28–30]. On the micro level, acupuncture inhibits pro-inflammatory pathways, such as TLR4/NF-κB, thereby reducing neuronal apoptosis. It also modulates the expression of autophagy-related proteins, such as Beclin-1 and LC3, to facilitate the repair of the neural injury microenvironment. Furthermore, acupuncture

promotes the release of neurotrophic factors, including brain-derived neurotrophic factors (BDNF), which accelerates synaptic remodeling^[31–33].

Recently, numerous studies and meta-analyses have confirmed the awakening efficacy of acupuncture. A retrospective cohort study involving 15440 patients with new-onset traumatic brain injury revealed that the incidence of dementia in patients receiving acupuncture was 6.11 per 1000 person-years, which is significantly lower than the 9.64 per 1000 person-years in the non-acupuncture cohort. Furthermore, patients who underwent more than five acupuncture sessions exhibited a 42% reduction in risk^[34]. Additionally, a meta-analysis of 34 clinical studies demonstrated that the integration of acupuncture with conventional treatment resulted in an increase of 2.8 points in the Glasgow Coma Scale (GCS) score for post-stroke coma patients, an improvement in the awakening rate by 31%, and a reduction in the National Institutes of Health Stroke Scale (NIHSS) score by 4.2 points^[35]. Similarly, another study on patients with coma after traumatic brain injury demonstrated that 58% of individuals in the acupuncture group achieved a Glasgow Outcome Scale (GOS) score of ≥ 3 at 4 weeks post-treatment. This outcome was significantly higher than the 32% observed in the control group, with a notable reduction in awakening time by 10.5 days^[36]. For clinical awakening purposes, it is recommended to prioritize “mind-resuscitating” acupoints, including Baihui (GV20), Renzhong (GV26), Neiguan (PC6), and Yongquan (KI1). The sparrow-pecking needling technique is specifically advised for Renzhong (GV26). Electroacupuncture stimulation is preferred, with parameters set at a frequency of 50–100 Hz and an intensity sufficient to induce slight limb twitching. The treatment protocol involves administering session once daily for 30 min each, with a period of 4 consecutive weeks as one course. Besides, combining acupuncture with transcranial magnetic stimulation and hyperbaric oxygen therapy may produce a synergistic effect, further improving the awakening rate^[37].

The safety and standardization of acupuncture in critical care

Safety assessment

Considering the presence of coagulation disorders and

immunosuppression in critically ill patients, it is essential to implement stringent safety risk control for acupuncture treatment^[38]. Current evidence indicates that when acupuncture is performed under standardized operation, the incidence of adverse reactions to acupuncture among ICU patients is only 0.3%–0.5%, primarily consisting of local subcutaneous hemorrhage (0.2%) and mild pain (0.1%), with no reports of severe adverse events such as pneumothorax or infection^[39]. Importantly, the crucial safety measures include assessing coagulation function before treatment, ensuring that acupuncture is only be conducted if INR is less than 1.5 and platelet count exceeds $50 \times 10^9/L$, using disposable sterile needles, and avoiding blood vessel-rich areas and wound sites.

Standardized implementation

For evaluation and screening, it is imperative to develop a checklist for acupuncture indication assessment to clarify primary indications, such as dependence on analgesic-sedative medications, elevated delirium risk, and consciousness disorders persisting for more than 72 h, while simultaneously excluding contraindications like unstable vital signs with systolic blood pressure below 90 mmHg and persistently elevated intracranial pressure exceeding 20 mmHg. In teams of interdisciplinary collaboration, it is essential to establish a collaborative team comprising ICU physicians, acupuncturists, and specialized nurses^[40]. This team will be responsible for devising treatment plans and closely monitoring vital signs during the treatment. For quality control, the three fundamental principles, including standardized acupoint localization, individualized stimulation parameters, and quantitative efficacy evaluation, must be adhered to ensure the standardization of treatment practices.

Discussion

Extensive research has now fully confirmed that acupuncture offers clear clinical benefits in the neurological management of critically ill patients, particularly in three primary domains. For analgesia and sedation, acupuncture reduces medication dosages while improving treatment compliance. For the prevention and management of delirium, acupuncture decreases the incidence and shortens the duration of symptoms. And for awakening patients with consciousness disorders, acupuncture contributes to improve neurological outcomes.

The multi-targeted and multi-pathway mechanisms of acupuncture are well-aligned with the contemporary critical care medicine paradigm of “precision regulation and holistic protection”^[41]. Nevertheless, the integration of acupuncture into critical care practice is hindered by several challenges, including a lack of multi-center, large-sample randomized controlled trials, insufficient detailed molecular biological investigations into its mechanisms, and variability in acupoint selection and stimulation parameters across different studies^[42].

Future research for acupuncture should focus on three critical areas. Firstly, it should involve conducting subgroup analyses targeting different disease types, such as traumatic brain injury and sepsis, in order to identify the optimal patient populations for acupuncture. Secondly, it is essential to integrate advanced technologies, such as single-cell sequencing and brain connectomics, to unravel the core molecular mechanisms through which acupuncture regulates neurological functions. Thirdly, efforts should be directed towards developing evidence-based clinical pathways to facilitate the incorporation of acupuncture into comprehensive neurological management protocols for critically ill patients. As the integration of traditional Chinese medicine with Western medical practices advances in critical care settings, acupuncture is well-positioned to become a fundamental component of neurological management for critically ill patients, offering an innovative therapeutic approach to enhance patient outcomes and reduce the prevalence of long-term neurological disorders.

Author contributions

Weishuo Zhang and Tao Li conceived and designed this article. Weishuo Zhang, Yan Liu, Yunxia Hu, Qian Liu, and Shupeng Wang collected and collated information. Weishuo Zhang drafted the manuscript. Weishuo Zhang, Jun Duan, and Tao Li revised this manuscript critically. All authors approved the final manuscript.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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