Perioperative
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PERSPECTIVE

Acupuncture across the perioperative chronic pain pathway: A precision-medicine perspective

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1 INTRODUCTION

Acupuncture originates from traditional Chinese medicine. It is a needling therapy based on meridians and the flow of qi and blood. Since the 20th century, both manual acupuncture and electroacupuncture have been increasingly incorporated into biomedical research and clinical pain management. Pain relief has become a major concern for perioperative patients. Many surgical patients already have chronic musculoskeletal pain, neuropathic pain, headache, or cancer-related pain before surgery. They may also have anxiety, sleep disturbances, functional limitations, and long-term analgesic use. Together, these factors can complicate acute postoperative pain control, slow recovery, and increase the risk of persistent postsurgical pain. Therefore, perioperative care requires interventions that address pre-existing pain and promote postoperative recovery.

In this context, acupuncture has shown moderate and lasting efficacy for various chronic pain conditions [1]. Perioperative systematic reviews also suggest that acupuncture may help reduce postoperative pain and opioid consumption [2, 3]. However, large variations in treatment protocols, patient populations, surgical procedures, control interventions, and outcome measures make these findings difficult to generalize. Thus, current evidence supports acupuncture's potential efficacy in specific settings, but it does not identify which patients are most likely to respond or clarify how acupuncture should be integrated into perioperative care.

A precision medicine framework may help overcome these limitations and move beyond the broad question of "Does acupuncture work?" More clinically relevant questions include: which patient phenotypes are most likely to benefit, which stimulation parameters activate the intended mechanisms, when treatment should be delivered, and which outcomes justify adding it to existing multimodal analgesia regimens. In this framework, traditional concepts can serve as clinical heuristics for generating hypotheses, while biological mechanisms and clinical effectiveness must be tested empirically.

Therefore, this opinion article first translates traditional concepts like meridians and Qi-blood into testable neurobiological pathways. It then examines existing clinical evidence and the biopsychosocial factors that may influence treatment response. Finally, it proposes a comprehensive perioperative treatment plan and outlines three research priorities: mechanism validation, prediction of treatment response, and implementation of clinical pathways.

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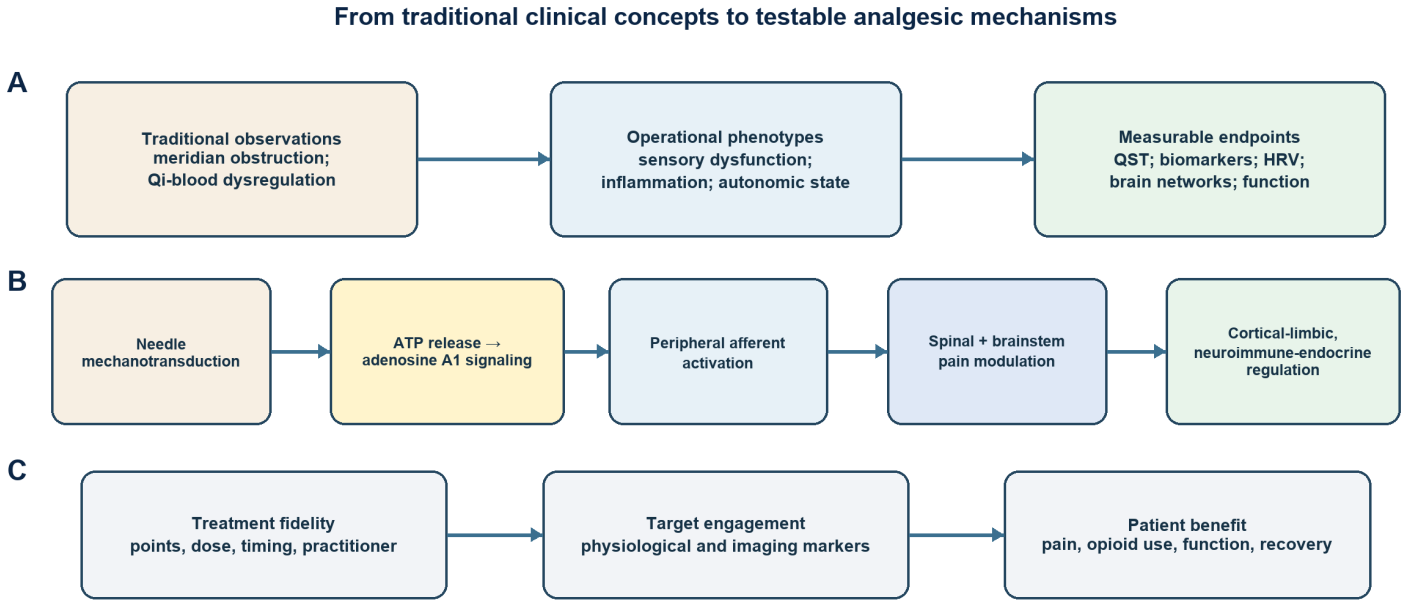


Figure 1. Mechanistic translation of acupuncture analgesia. (A) Traditional observations are reframed as measurable clinical phenotypes without asserting direct equivalence; (B) A testable cascade links needle mechanotransduction to ATP/adenosine signaling, peripheral afferents, spinal–brainstem control, and cortical–limbic and neuro–immune–endocrine regulation; (C) Treatment fidelity and target engagement should be connected to patient-level outcomes. A1, adenosine A1 receptor subtype; ATP, adenosine triphosphate; HRV, heart rate variability; QST, quantitative sensory testing.

2 TRANSLATING TRADITIONAL CONCEPTS INTO TESTABLE MECHANISMS

Traditional descriptions of meridian obstruction and impaired Qi-blood movement can be interpreted, without claiming equivalence, as clinical observations of altered somatosensory signaling, tissue perfusion, autonomic regulation, and inflammatory state. Needling deforms local tissue and activates sensory afferents; experimental work identifies transient extracellular ATP mobilization and downstream adenosine A1-receptor signaling as plausible peripheral initiators of analgesia [4, 5]. Ascending input may then recruit spinal inhibition, brainstem descending control, hypothalamic-pituitary-adrenal and autonomic responses, and distributed cortical-limbic networks involved in pain, salience, expectation, and affect [6, 7]. These neuro-immune-endocrine processes provide a modern, falsifiable vocabulary for selected features historically described as regulating meridians and Qi-blood (**Figure 1**). They do not validate every traditional construct, and animal, imaging, and clinical evidence should not be conflated. The translational priority is to link dose and treatment fidelity to target engagement and patient-level benefit.

3 CLINICAL RELEVANCE AND INDIVIDUALIZED RESPONSE

3.1 Evidence relevant to perioperative chronic pain

The evidence base is strongest for symptomatic improvement in common chronic pain conditions, but average effects do not establish perioperative value for every patient. Individual-patient meta-analysis supports benefit over sham and no-acupuncture controls, and a pragmatic trial found electroacupuncture and auricular acupuncture superior to usual care for chronic musculoskeletal pain in cancer survivors [1, 8]. In surgical populations, meta-analyses report signals for lower pain intensity, opioid use, or opioid-related adverse effects, yet heterogeneity in procedures, timing, points, stimulation, controls, and outcome windows limits generalization [2, 3]. Evidence after knee arthroplasty is mixed, illustrating why procedure-specific conclusions and standardized outcomes are necessary [9]. Accordingly, acupuncture should be considered an adjunct, not a replacement for regional anesthesia, pharmacological analgesia, rehabilitation, or psychological care.

3.2 Psychological, social, and cultural modifiers

Psychological distress, expectations, self-efficacy, sleep, social support, and cultural familiarity can influence pain reporting, adherence, and contextual response. These factors should be collected briefly rather than treated as competing explanations for analgesia. Preoperative screening can identify anxiety, catastrophizing, low self-efficacy, prior acupuncture experience, treatment preference, logistical barriers, and willingness to complete repeated sessions. Such variables may improve efficacy prediction, support shared decisions, and guide individualized choices among manual, electroacupuncture, or auricular protocols. Risk models for chronic pain already show the predictive contribution of mental health, sleep, and anthropomet-

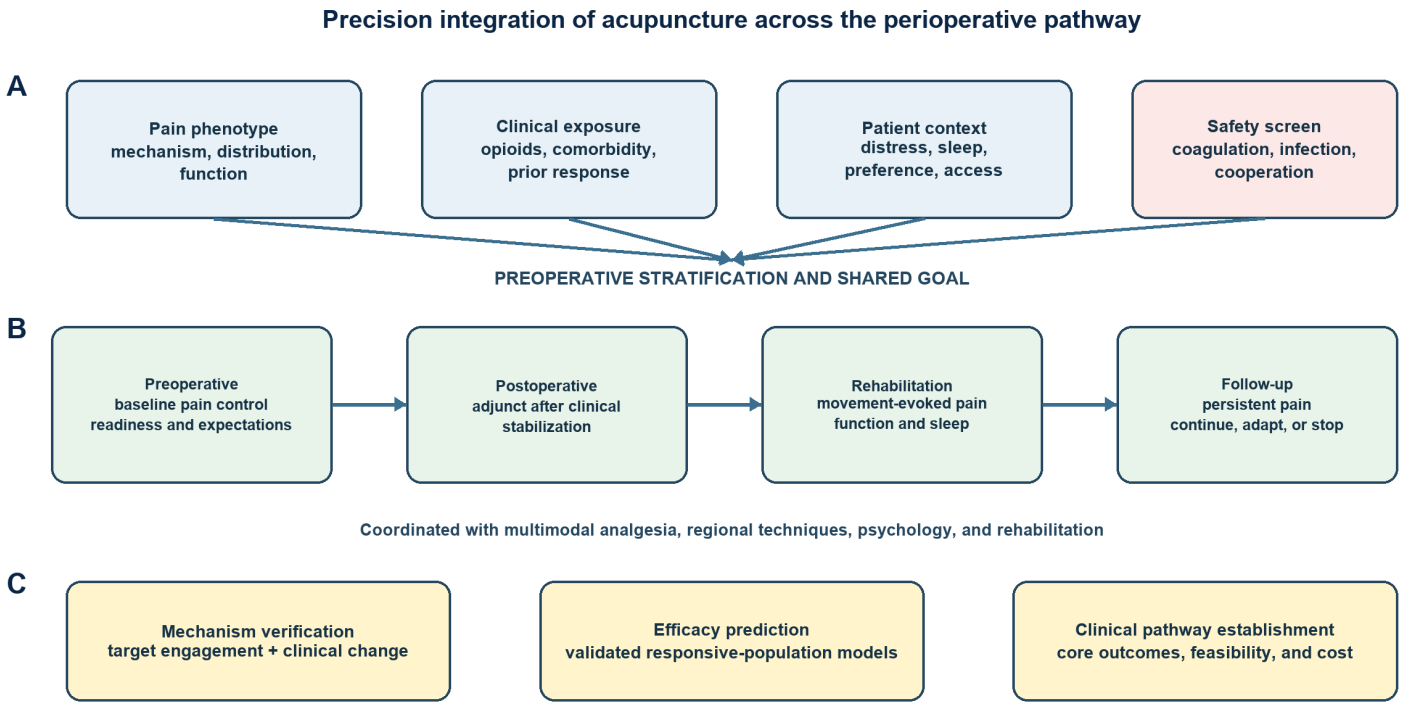


Figure 2. Precision integration of acupuncture across the perioperative pathway. (A) Preoperative selection combines pain phenotype, clinical exposure, patient context, and safety; (B) Delivery is coordinated across preoperative care, postoperative recovery, rehabilitation, and follow-up; (C) Research priorities are mechanism verification, efficacy prediction, and clinical pathway establishment.

ric variables; acupuncture-specific models should test whether adding sensory phenotype, analgesic exposure, and neuroimaging or physiological markers improves transportable prediction [10]. This biopsychosocial assessment connects patient context directly to treatment design and follow-up.

Taken together, current evidence supports selective evaluation within multimodal care, while its heterogeneity argues against routine, protocol-free adoption.

4 A PRECISION PERIOPERATIVE CLINICAL PATHWAY

A practical pathway should connect patient selection, intervention fidelity, safety, and outcomes across the surgical episode (**Figure 2**).

4.1 Preoperative stratification and shared planning

Before surgery, the perioperative team should define pain mechanism and distribution, baseline function, opioid and non-opioid exposure, psychosocial risk, prior response and preference, and contraindications such as local infection, unstable coagulation, or inability to cooperate. The treatment aim should be explicit: reduce baseline pain, facilitate opioid tapering, improve sleep or anxiety, or prepare for postoperative rehabilitation. Protocols should specify points, laterality, depth, manual or electrical stimulation, frequency, session number, practitioner credentials, and co-interventions.

4.2 Delivery, monitoring, and multidisciplinary follow-up

Acupuncture may be scheduled preoperatively, after surgery when clinically stable, or during rehabilitation according to the target and procedure. It should be coordinated with anesthesiologists, surgeons, pain clinicians, acupuncturists, nursing staff, psychologists, and rehabilitation therapists. Core outcomes should include pain at rest and movement, opioid consumption in morphine equivalents, opioid-related adverse effects, function, sleep, recovery quality, length of stay, complications, and persistent postsurgical pain. Adverse events and treatment adherence require the same prospective documentation as other analgesic components. A predefined stop rule is appropriate when repeated sessions produce no meaningful benefit. This pathway makes acupuncture auditable and keeps escalation to established therapies timely.

The value of integration therefore depends on measurable incremental benefit, feasibility, and safety rather than on tradition alone.

5 FUTURE PERSPECTIVES AND CONCLUSION

5.1 Mechanism verification

Mechanistic trials should combine credible controls with treatment-fidelity measures and prespecified target-engagement endpoints. Peripheral ATP/adenosine signals, autonomic indi-

ces, inflammatory mediators, quantitative sensory testing, and brain-network measures should be linked to clinical change rather than reported as isolated correlates.

5.2 Therapeutic efficacy prediction

Prospective, externally validated models should identify responsive populations using parsimonious clinical, psychosocial, sensory, and treatment variables. Neuroimaging or machine learning should be retained only when they add reproducible value beyond bedside predictors [6, 7].

5.3 Integrated clinical pathway establishment

Pragmatic multicenter studies should embed standardized acupuncture protocols within procedure-specific multimodal pathways and evaluate patient-centered recovery, opioid exposure, implementation burden, and cost. Reporting should distinguish chronic pain treatment from prevention of persistent postsurgical pain and should document practitioner expertise and co-interventions.

Future research should shift from repeatedly verifying general effectiveness to identifying responsive populations, deciphering functional mechanisms, and integrating acupuncture into multidisciplinary chronic pain management across the perioperative continuum. This agenda positions acupuncture as a testable, selectively applied component of precision analgesia rather than a universal alternative.

DECLARATIONS

Author contributions

Yonglong Chang: conceptualization, literature review, writing-original draft, visualization, and revision. Anqi Lv: literature review, writing-original draft, and revision. Sifang Zhang: conceptualization, supervision, and critical revision. Zhiheng Lin: conceptualization, supervision, and critical revision. All authors read and approved the final manuscript.

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Consent for publication

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Originality and exclusive submission

The work has not been previously published in whole or in part, excluding any abstract, lecture, or thesis where applicable, and it is not under consideration by another journal.

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