

Review Article

Effects of acupuncture on gastrointestinal function and related clinical indicators in patients with sepsis: a meta-analysis

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Received June 30, 2026; Accepted August 12, 2026; Epub October 15, 2026; Published October 30, 2026

Abstract: Objective: To evaluate the efficacy and safety of acupuncture in the treatment of gastrointestinal dysfunction in patients with sepsis. Methods: Randomized controlled trials (RCTs) comparing acupuncture or electroacupuncture plus routine care versus routine care alone for sepsis-associated gastrointestinal dysfunction were systematically retrieved from electronic databases up to March 2026. Meta-analyses were performed using RevMan 5.4 software. Results: A total of 23 RCTs involving 1572 patients were included. Acupuncture significantly reduced gastrointestinal dysfunction scores (standardized mean difference [SMD]=-0.86, 95% confidence interval [CI]: -1.25 to -0.46, $P<0.0001$), decreased inflammatory biomarkers (procalcitonin and high-sensitivity C-reactive protein), improved the overall clinical response rate (odds ratio [OR]=3.15, 95% CI: 1.62 to 6.13, $P=0.0007$), and did not increase the incidence of adverse events (descriptive summary of 23 trials). Conclusion: Acupuncture combined with routine care was safe and effective in alleviating gastrointestinal dysfunction in patients with sepsis. This study was prospectively registered on PROSPERO (CRD420261466061) and reported following PRISMA guidelines.

Keywords: Sepsis, gastrointestinal dysfunction, acupuncture, intestinal barrier, inflammation, clinical efficacy, safety

Introduction

Sepsis is defined as life-threatening organ dysfunction resulting from a dysregulated host response to infection, and remains a leading cause of high morbidity and mortality in intensive care units worldwide. Approximately 48.9 million new cases are estimated to occur globally each year, with mortality rates ranging from 25% to 50% [1, 2]. Gastrointestinal dysfunction is one of the earliest and most common complications of sepsis, affecting nearly 60% of septic patients. By disrupting intestinal barrier integrity, promoting bacterial translocation, and exacerbating systemic inflammatory response and immune paralysis, gastrointestinal dysfunction acts as a critical driver of disease progression [3, 4]. The pathophysiologic mechanisms underlying sepsis-associated gastrointestinal dysfunction are complex and multifaceted, involving intestinal hypoperfusion, oxidative stress, excessive release of pro-

inflammatory cytokines, and disruption of tight junction proteins, which collectively impair gastrointestinal motility, barrier function, and immune homeostasis [5, 6].

Currently, standard treatments for sepsis-induced gastrointestinal dysfunction are primarily supportive, including early enteral nutrition, prokinetic agents, and infection control. However, these regimens show limited efficacy in reversing intestinal barrier injury or improving long-term prognosis [7, 8]. As a cornerstone therapy of traditional Chinese medicine, acupuncture has been widely adopted in intensive care settings due to its anti-inflammatory, immunomodulatory, and gastrointestinal regulatory properties [9, 10]. Preclinical studies have confirmed that acupuncture protects intestinal barrier function in septic animal models by inhibiting the nuclear factor- κ B (NF- κ B) signaling pathway, reducing pro-inflammatory cytokine secretion, and upregulating tight

junction protein expression [11, 12]. Moreover, multiple clinical randomized controlled trials have demonstrated that acupuncture can enhance gastrointestinal motility, reduce intra-abdominal pressure, and shorten the time to achieve target enteral caloric intake in septic patients [13, 14].

Nevertheless, existing systematic reviews on acupuncture for sepsis predominantly focus on overall mortality or inflammatory markers, with limited comprehensive evaluation of gastrointestinal-specific outcomes such as gastrointestinal function scores and enteral feeding tolerance [15]. Moreover, the precise mechanisms underlying the intestinal protective effects of acupuncture in septic patients remain incompletely understood, and the quality of evidence from individual randomized controlled trials varies considerably. Therefore, this systematic review and meta-analysis aimed to synthesize available data on gastrointestinal function, inflammatory responses, clinical efficacy, and adverse events, with the goal of comprehensively evaluating the efficacy and safety of acupuncture in treating gastrointestinal dysfunction in patients with sepsis. The findings should provide high-quality evidence to support the clinical application of acupuncture as an adjunctive therapy for sepsis-induced gastrointestinal dysfunction and to offer novel insight into the pathophysiologic mechanisms of sepsis-associated gastrointestinal injury.

Materials and methods

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and prospectively registered on the International Prospective Register of Systematic Reviews (PROSPERO; registration number: CRD4202-61466061).

Literature search strategy

Four electronic databases - PubMed, Embase, the Cochrane Library, and China National Knowledge Infrastructure (CNKI) - were systematically searched from their inception to March 2026. The search strategy combined Medical Subject Headings (MeSH) and free-text terms. English search terms included “acupuncture”, “electroacupuncture”, “sepsis”, “sep-

tic gastrointestinal dysfunction”, and “gastrointestinal function”. Corresponding Chinese translations of these terms were used for the CNKI search. To supplement the electronic search, we manually screened the reference lists of relevant reviews, conference proceedings, and included studies to identify any additional eligible records.

Inclusion and exclusion criteria

Study design: Published randomized controlled trials (RCTs) in China and abroad were included, with language restricted to Chinese and English.

Participants: Adult patients (age ≥ 18 years) diagnosed with sepsis in accordance with the Sepsis-3 criteria from the Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock 2021 [16]. No restrictions were imposed on gender, race, or disease course.

Interventions: The experimental group received acupuncture or electroacupuncture therapy (acupuncture alone or acupuncture combined with routine standard care). The control group received routine standard care, sham acupuncture or placebo treatment.

Outcome measures: (1) Primary outcome measures: Gastrointestinal function scores (including gastrointestinal dysfunction score and effective improvement rate of gastrointestinal function). (2) Secondary outcome measures: ① Gastrointestinal tolerance indicators: intra-abdominal pressure, bowel sounds, time to reach target caloric intake of enteral nutrition; ② Inflammatory biomarkers: PCT, TNF- α , hs-CRP; ③ Overall clinical response rate; ④ Incidence of adverse events.

Exclusion criteria: ① Non-randomized controlled trials (e.g., case reports, reviews, animal experiments); ② Duplicate publications; ③ Studies with incomplete data from which valid data cannot be extracted; ④ Studies combining acupuncture with other non-pharmacologic therapies where the independent effect of acupuncture cannot be separated.

Literature screening and data extraction

Two researchers independently completed literature screening and data extraction, followed

by cross-checking. Any discrepancies were resolved via group discussion or arbitration by a third reviewer. The extracted information covered three categories: ① Basic characteristics of included studies (authors, publication year, sample size, interventions, treatment course, etc.); ② Data of outcome measures (mean values, standard deviations, event counts, etc.); ③ Information for methodological quality assessment.

Methodological quality assessment

The Cochrane Risk of Bias Tool 2.0 (RoB 2.0) was adopted to evaluate the methodological quality of included RCTs, covering seven domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, completeness of outcome data, selective reporting, and other sources of bias. Each domain was rated as low risk of bias, high risk of bias, or unclear risk of bias.

Statistical analysis

Meta-analyses were performed using RevMan 5.4 software. For dichotomous outcomes, risk ratio (RR) or risk difference (RD) with corresponding 95% confidence intervals (CIs) were reported as effect sizes. For continuous outcomes, standardized mean difference (SMD) with Hedges' adjusted g was employed to standardize effect sizes across different measurement instruments; mean difference (MD) was applied only when the same measurement scale was used across all included studies for a given outcome. Specifically, for objective indicators with unified measurement units (e.g., intra-abdominal pressure, bowel sounds, and procalcitonin), MD was adopted to preserve clinical interpretability; for other continuous outcomes, SMD was used to harmonize effect sizes across heterogeneous scales.

The χ^2 test and I^2 statistic were used to assess between-study heterogeneity. A fixed-effect model was selected when $I^2 < 50\%$ and $P > 0.1$; a random-effect model was uniformly adopted if $I^2 \geq 50\%$ or $P \leq 0.1$. Sensitivity analysis by omitting individual studies one by one was conducted to trace sources of heterogeneity. Funnel plots were generated for primary outcomes to assess publication bias. A P -value < 0.05 was considered significant.

For outcomes with a limited number of included studies or small total sample sizes, the analyses may be subject to low statistical power and increased heterogeneity. When the initial pooled analysis yielded $I^2 > 90\%$, sensitivity analysis was prioritized to identify outlier studies driving heterogeneity. If heterogeneity was substantially reduced and the direction of the pooled effect remained stable after excluding outliers, quantitative pooled results were retained; if heterogeneity could not be adequately alleviated, only qualitative descriptive summaries were presented, with systematic elaboration on potential sources of heterogeneity. For safety outcomes with a high proportion of zero-event studies, meta-analysis was not performed; instead, descriptive summaries were presented to avoid biased estimation and overinterpretation of sparse event data.

Results

Overview of included studies

The literature screening procedure of this meta-analysis was conducted in accordance with the PRISMA 2020 statement. A total of 450 records were initially retrieved, including 438 articles from electronic databases and an additional 12 records identified by reviewing reference lists and other supplementary sources. After duplicate removal, 392 articles remained. Totally 328 irrelevant records were excluded after preliminary screening based on titles and abstracts, and the full texts of the remaining 64 articles were assessed for eligibility. Upon full-text evaluation, 21 non-randomized controlled trials, 8 studies with participants failing to meet the diagnostic criteria for sepsis-associated gastrointestinal dysfunction, 7 trials without acupuncture-related interventions, and 2 duplicate publications were excluded. Ultimately, 23 RCTs involving 1572 patients with sepsis-associated gastrointestinal dysfunction were included in this analysis. The detailed screening flow chart is presented in **Figure 1**. All included trials were carried out in mainland China and published between 2015 and 2026. The sample size of individual studies ranged from 40 to 118 participants, with a median sample size of 60. Most studies were published in Chinese, while 5 trials were reported in English.

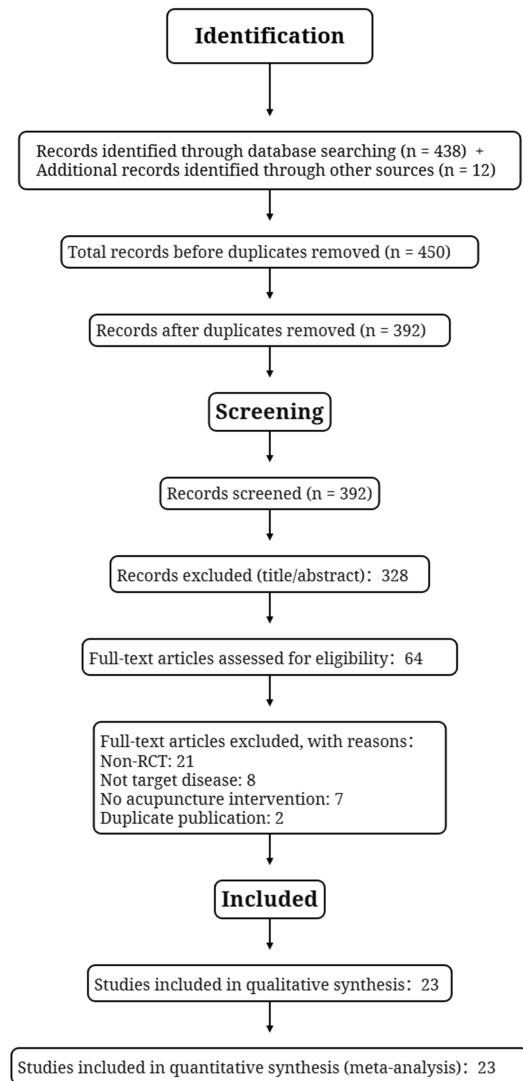


Figure 1. PRISMA flow diagram showing the process of literature screening for included studies. This systematic review and meta-analysis was prospectively registered on PROSPERO (Registration number: CRD420261466061) and reported in accordance with the PRISMA guidelines.

All studies compared the therapeutic effects of acupuncture-related interventions (including manual acupuncture, electroacupuncture, transcutaneous electrical acupoint stimulation (TEAS), intradermal embedding needle, abdominal acupuncture, etc.) combined with routine standard care versus routine standard care alone. Only one trial adopted sham acupuncture as the control measure. In terms of intervention duration, most studies adopted a treatment course of 5 to 7 days; several trials extended the course to 10-14 days, with the longest course reaching 28 days. The interven-

tion frequency was mostly 1 to 2 sessions per day. The most frequently selected acupoints included Zusanli (ST36), Shangjuxu (ST37), Tianshu (ST25), Zhongwan (CV12), Neiguan (PC6), and others.

The outcome indicators reported in the included studies mainly covered: ① Gastrointestinal function-related indicators (gastrointestinal dysfunction score, frequency of bowel sounds, intra-abdominal pressure (IAP), feeding intolerance, time to achieve target enteral nutrition); ② Inflammatory biomarkers (TNF- α , PCT, hs-CRP); ③ Disease severity scores (APACHE II score, SOFA score); ④ Clinical outcomes (28-day mortality, ICU length of stay, clinical response rate); ⑤ Safety indicator (incidence of adverse events). Detailed characteristics of each included study (sample size, mean age, intervention protocols, acupoints, outcome indicators, etc.) are shown in **Table 1**.

The Cochrane Risk of Bias Tool was used to assess the methodological quality of the included studies. Overall, the methodological quality of the included trials was moderate. Most studies presented a low risk of bias in terms of random sequence generation, completeness of outcome data and other sources of bias. Nevertheless, all trials carried a high risk of performance bias, as blinding of participants and researchers was unfeasible in acupuncture trials. The risk of bias remained unclear in most studies regarding allocation concealment, blinding of outcome assessors, and selective reporting. The above results are illustrated in **Figures 2 and 3**.

Gastrointestinal function-related indicators

Gastrointestinal dysfunction is one of the most prevalent complications in patients with sepsis and a critical factor affecting patient prognosis. This meta-analysis took the gastrointestinal dysfunction score as the primary outcome indicator, and further comprehensively evaluated the improving efficacy of acupuncture on gastrointestinal function among septic patients from multiple dimensions including the effective improvement rate of gastrointestinal function, intra-abdominal pressure, and achievement of target enteral nutrition.

Gastrointestinal dysfunction score: Seven RCTs (n=506) [16-20, 31, 37] assessing the

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Table 1. Characteristics of included randomized controlled trials

Ref. (Year)	Country	Language	Sample size (T/C)	Intervention	Control	Intervention details (frequency/duration)	Acupoints	Outcomes
Xiao et al., 2015 [34]	China	English	30/30	Manual Acupuncture	Usual Care	6 days	ST36, GB34, PC6, CV4	APACHE II, ICU stay, Readmission rate, 28 d mortality
Yang et al., 2016 [35]	China	English	29/29	Electroacupuncture	Routine Treatment	7 days	ST36, RN4	APACHE II, 28-day Mortality
Meng et al., 2018 [37]	China	English	41/41	Electroacupuncture	Routine Treatment	5 days	ST36, ST37	IAP, APACHE II, SOFA, ICU stay, 28-day mortality
Meng et al., 2018 [33]	China	English	35/36	Electroacupuncture	Routine Treatment	5 days	ST36, ST37	APACHE II, I-FABP, D-lactate, Citrulline, PCT, ICU stay, 28-day mortality
Li et al., 2019 [31]	China	English	59/59	Acupuncture at Jiaji (EX-B2) + routine standard treatment	Routine Treatment	10 days	EX-B2	APACHE II, Gastrointestinal Dysfunction Score, hs-CRP, Clinical Effective Rate
Wang et al., 2020 [36]	China	English	27/28	TEAS	Usual Care	7 days	GB30, ST32, ST36, GB39, LR3	Gastrocnemius angle, ICU stay, Hospital stay, In-hospital mortality, 28 d mortality, Adverse events
Liu H et al., 2022 [29]	China	English	24/25	Transcutaneous electrical acupoint stimulation (TEAS) + conventional care	Conventional care	30 min, twice daily, 2 Hz/10 Hz, until EN target reached, 5 days	ST25, ST37, ST41, SP8, ST36, CV12, SP15	APACHE II, Time to EN target, AGI grade, ICU stay, Hospital stay
Xu et al., 2026 [32]	China	Chinese	47/43	Manual Acupuncture	Sham Acupuncture	7 days	ST36, PC6, LR3, CV12	AGIUS, GRV, Time to target calories, SOFA, PCT, 28 d mortality
Hu et al., 2015 [17]	China	Chinese	30/30	Electroacupuncture	Routine Treatment	7 days	ST36, CV4, ST25	PCT, CRP, IAP, Gastrointestinal Dysfunction Score, 28 d mortality
Wang et al., 2019 [23]	China	Chinese	27/28	Electroacupuncture	Routine Treatment	5 days	CV12, CV10, CV6, CV4, ST23, ST26, SP15, ST25	APACHE II, PCT, CRP, IAP, Gastrointestinal Dysfunction Score, 28 d mortality
Lian et al., 2021 [25]	China	Chinese	35/35	Electroacupuncture	Routine Treatment	7 days	CV13, CV12, CV10, CV6, CV4, ST36, ST37, ST39, ST25, SP15	APACHE II, SOFA, IAP
Chang et al., 2021 [16]	China	Chinese	20/20	Acupuncture	Routine Treatment	7 days	ST36, CV12, PC6, ST25	APACHE II, SOFA, PCT, AGIUS, Gastrointestinal Dysfunction Score
Peng et al., 2022 [26]	China	Chinese	65/65	Fuyuan acupuncture	Routine Treatment	14 days	CV13, CV12, CV10, ST25, GB34, ST36	IAP, Bowel sounds, ICU, APACHE II
Sun et al., 2024 [22]	China	Chinese	27/26	Electroacupuncture	Routine Treatment	14 days	CV4, CV6, CV12, ST25, ST36, ST37, SP9	IAP, Bowel sounds, Time to target calories, CRP, PCT, APACHE II, SOFA, 28 d mortality
Liu K et al., 2022 [18]	China	Chinese	30/30	Abdominal electroacupuncture	Routine Treatment	14 days	CV12, CV10, CV4, CV6, ST36, ST26, ST23, SP15, ST25	Gastrointestinal Dysfunction Score, CRP, PCT, Total effective rate
Wang et al., 2021 [20]	China	Chinese	50/50	Electroacupuncture	Routine Treatment	7 days	ST25, ST37, ST41, SP8, ST36, CV12, SP15	Bowel sounds, IAP, CRP, PCT, Gastrointestinal Dysfunction Score, APACHE II

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Wei et al., 2017 [27]	China	Chinese	20/21	Fuyuan acupuncture	Routine Treatment	28 days	CV13, CV12, CV10, ST25, ST36, GB34	Bowel sounds, IAP, APACHE II, SOFA, PCT, CRP, 28d mortality
Yu et al., 2015 [28]	China	Chinese	46/44	Acupuncture	Routine Treatment	5 days	ST36, ST37, CV12, CV6, ST25, PC6	IAP, APACHE II, Gastrointestinal Dysfunction Score
Zhuo et al., 2017 [24]	China	Chinese	35/35	Electroacupuncture	Routine Treatment	7 days	ST36, ST37, ST25, CV12, PC6, CV6	Bowel sounds, Gastrointestinal Dysfunction Score
Sun et al., 2021 [21]	China	Chinese	30/30	Electroacupuncture	Routine Treatment	7 days	ST36, ST25, ST37	CRP, PCT, Bowel sounds, IAP, APACHE II, AGI
Cheng et al., 2021 [38]	China	Chinese	31/32	Acupuncture	Routine Treatment	7 days	CV12, ST25, ST36, ST37, ST39	APACHE II, SOFA, PCT, CRP
Liu et al., 2025 [19]	China	Chinese	29/28	Press-needle (thumbtack needle) therapy	Routine Treatment	7 days	ST25, ST36, ST37, CV12, CV6	Gastrointestinal Dysfunction Score, IAP, Gastrointestinal Dysfunction Score, WBC, hs-CRP, APACHE II, SOFA
Wang et al., 2019 [30]	China	Chinese	20/20	Acupuncture	Routine Treatment	7 days	CV13, CV12, CV10	APACHE II, SOFA, Bowel sounds, IAP, PCT, CRP, 28 d mortality

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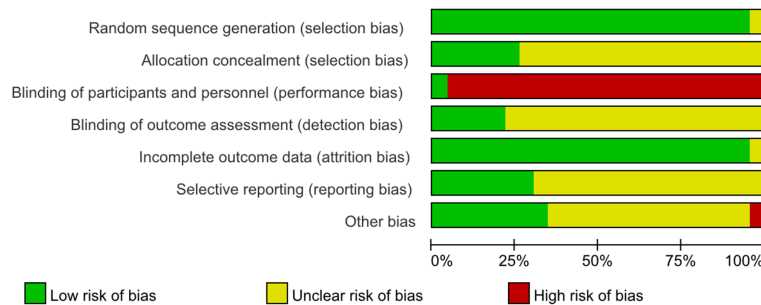


Figure 2. Risk of bias graph of included studies. Risk of bias graph presenting the proportion of included studies with low, unclear, and high risk of bias across seven bias items. The vertical axis represents each risk of bias item, while the horizontal axis represents the percentage of included studies.

effect of acupuncture/electroacupuncture plus routine care on the gastrointestinal dysfunction score showed substantial heterogeneity ($\chi^2=89.95$, $df=6$, $P<0.00001$, $I^2=93\%$); thus, a random-effects model was applied. The pooled SMD was -1.29 (95% CI: -2.06 to -0.51, $Z=3.25$, $P=0.001$), favoring the intervention (**Figure 4**).

Sequential leave-one-out sensitivity analyses were performed to explore heterogeneity sources. Excluding Wang 2021 [20] - whose effect estimate (SMD=-3.98) was an extreme outlier - reduced I^2 from 93% to 72% ($\chi^2=17.85$, $df=5$, $P=0.003$), with a recalculated SMD of -0.86 (95% CI: -1.25 to -0.46, $Z=4.23$, $P<0.0001$). Further excluding Liu K 2022 [18] lowered I^2 to 64% ($\chi^2=11.09$, $df=4$, $P=0.03$), yielding an SMD of -0.74 (95% CI: -1.15 to -0.34, $Z=3.60$, $P=0.0003$). The effect direction and statistical significance remained consistent across all sensitivity models, supporting the robustness of the primary finding.

Effective improvement rate of gastrointestinal function: Six RCTs ($n=370$) [19, 21-24, 28] evaluating the effective improvement rate of gastrointestinal function showed no significant heterogeneity ($\chi^2=3.60$, $df=5$, $P=0.61$, $I^2=0\%$); thus, a fixed-effect model (Mantel-Haenszel) was applied. The pooled RD was 0.23 (95% CI: 0.14 to 0.32, $Z=5.24$, $P<0.00001$), favoring the acupuncture/electroacupuncture combined with routine care over routine care alone (**Figure 4**).

Intra-abdominal pressure (IAP): Twelve RCTs ($n=708$) [17, 19-23, 25, 27, 28, 30, 33] assessed the effect of acupuncture/elec-

troacupuncture plus routine care on IAP in postoperative gastrointestinal dysfunction. Substantial heterogeneity was detected ($\chi^2=46.77$, $df=10$, $P<0.00001$, $I^2=79\%$); thus, a random-effects model was applied. The pooled MD was -2.03 (95% CI: -2.62 to -1.44, $Z=6.75$, $P<0.00001$), favoring the intervention (**Figure 5**).

Sensitivity analysis excluding Sun 2021 [21] reduced I^2 to 67%, with a recalculated MD of -1.87 (95% CI: -2.40 to -1.33, $Z=6.85$, $P<0.00001$). The effect direction and statistical significance remained unchanged, supporting the robustness of the primary finding.

Bowel sounds (times per minute): Six RCTs ($n=349$) [17, 20, 23, 27, 29, 30] assessed the effect of acupuncture/electroacupuncture plus routine care on bowel sound frequency in postoperative gastrointestinal dysfunction. Moderate heterogeneity was detected ($\chi^2=15.89$, $df=5$, $P=0.007$, $I^2=69\%$); thus, a random-effects model was applied. The pooled MD was 0.84 (95% CI: 0.52 to 1.16, $Z=5.14$, $P<0.00001$), favoring the intervention (**Figure 5**).

Sensitivity analysis excluding Wang 2021 [20] reduced I^2 to 5% ($\chi^2=4.21$, $df=4$, $P=0.38$), with a recalculated MD of 0.67 (95% CI: 0.44 to 0.90, $Z=5.68$, $P<0.00001$). The effect direction and statistical significance remained unchanged, supporting the robustness of the primary finding.

Time to reach target enteral nutrition calories: Three RCTs ($n=269$) [26, 29, 32] assessed the effect of acupuncture/electroacupuncture plus routine care on time to target enteral nutrition calories in sepsis-induced gastrointestinal dysfunction. Substantial heterogeneity was detected ($\chi^2=19.39$, $df=2$, $P<0.0001$, $I^2=90\%$); thus, a random-effects model was applied. The pooled MD was -0.56 (95% CI: -1.18 to 0.06, $Z=1.76$, $P=0.08$), showing no significant difference between groups (**Figure 5**).

Sensitivity analysis excluding Xu 2026 [33] reduced I^2 to 68% ($\chi^2=3.08$, $df=1$, $P=0.08$),

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Chang2021	+	?	+	+	+	?	+
Cheng2021	+	+	+	+	+	?	+
Hu2015	+	?	+	+	+	?	+
Li2019	+	+	+	+	+	+	+
Lian2021	+	?	+	+	+	+	+
Liu2025	+	+	+	+	+	+	+
Liu H2022	+	+	+	+	+	+	+
Liu K2022	?	?	+	+	+	?	+
Meng2018a	+	?	+	+	+	+	+
Meng2018b	+	?	+	+	+	+	+
Peng2022	+	?	+	+	+	?	+
Sun2021	+	?	+	+	+	?	+
Sun2024	+	?	+	+	+	?	+
Wang2019	+	?	+	+	+	?	+
Wang2020	+	?	+	+	+	?	+
Wang2021	+	?	+	+	+	?	+
WangXP2019	+	?	+	+	+	?	+
Wei2017	+	?	+	+	+	?	+
Xiao2015	+	?	+	+	+	?	+
Xu2026	+	+	+	+	+	+	+
Yang2016	+	+	+	+	+	?	+
Yu2015	+	?	+	+	+	?	+
Zhuo2017	+	?	+	+	+	?	+

Figure 3. Risk of bias summary of included randomized controlled trials. Risk of bias summary of the included randomized controlled trials investigating acupuncture versus conventional treatment for sepsis-associated gastrointestinal dysfunction. Each plot represents the risk of bias judgment for each included study. Green circles indicate low risk of bias, yellow circles indicate unclear risk of bias, and red circles indicate high risk of bias.

with a recalculated MD of -0.26 (95% CI: -0.66 to 0.14, Z=1.26, P=0.21). The effect remained non-significant across sensitivity models.

Due to insufficient eligible studies, meta-analysis was not performed for other outcomes. One trial [32] reported significantly reduced gastric residual volume (GRV) in the acupuncture group (MD=-6.39, 95% CI: -8.87 to -3.91, P<0.001). Another trial [29] reported an increased gastric antral motility index (MI) with acupuncture (MD=31.68, 95% CI: 14.87 to 48.49, P=0.0002). These single-study findings suggest benefits of acupuncture on gastric function in septic patients, warranting further validation.

Inflammatory response

Two inflammatory biomarkers (PCT and hs-CRP) were assessed to evaluate the regulatory effect of acupuncture/electroacupuncture on systemic inflammation in patients with postoperative gastrointestinal dysfunction.

Procalcitonin (PCT): Nine RCTs (n=577) [17, 18, 20, 21, 23, 27, 30, 32, 37] assessed the effect of acupuncture/electroacupuncture plus routine care on serum PCT levels in postoperative gastrointestinal dysfunction. Extreme heterogeneity was detected ($\chi^2=118.68$, df=8, P<0.00001, $I^2=93\%$); thus, a random-effects model was applied. The pooled MD was -2.02 (95% CI: -3.12 to -0.92, Z=3.61, P=0.0003), favoring the intervention (**Figure 6**).

Sequential leave-one-out sensitivity analyses were performed to explore heterogeneity sources. Excluding Sun 2021 [21] (extreme effect size) reduced I^2 to 87%; further excluding WangXP 2019 [23] (estimate crossed the null) lowered I^2 to 63%, yielding a recalculated MD of -2.06 (95% CI: -2.73 to -1.40, Z=6.07, P<0.00001). The effect direction and statistical significance remained consistent across sensitivity models, supporting the robustness of the primary finding.

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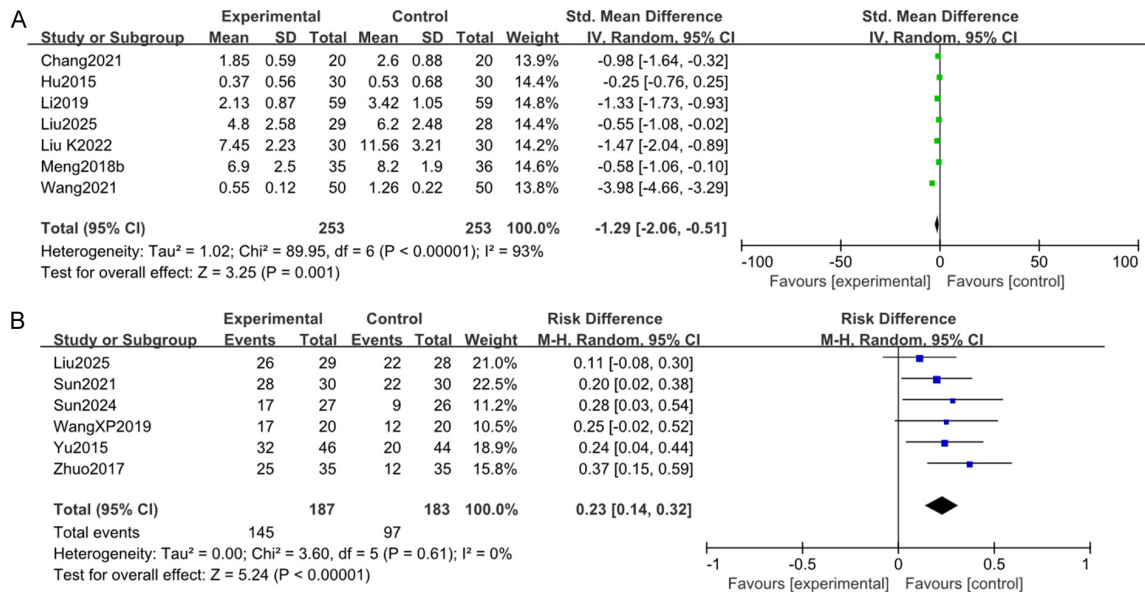


Figure 4. Meta-analysis of gastrointestinal function outcomes between acupuncture combined with conventional therapy and conventional therapy alone in patients with sepsis-induced gastrointestinal dysfunction. A. Forest plot comparing the post-treatment gastrointestinal dysfunction score. B. Forest plot comparing the clinical improvement rate of gastrointestinal function.

High-sensitivity C-reactive protein (hs-CRP): Five RCTs ($n=275$) [17, 18, 23, 30, 32] assessed the effect of acupuncture/electroacupuncture plus routine care on serum hs-CRP levels in sepsis-associated gastrointestinal dysfunction. Moderate heterogeneity was detected ($\chi^2=13.44$, $df=4$, $P=0.009$, $I^2=70\%$); thus, a random-effects model was applied. The pooled MD was -18.29 (95% CI: -27.93 to -8.65, $Z=3.72$, $P=0.0002$), favoring the intervention (Figure 6).

Sensitivity analysis excluding WangXP 2019 [23] reduced I^2 to 47% ($\chi^2=5.64$, $df=3$, $P=0.13$), with a recalculated MD of -23.20 (95% CI: -30.30 to -16.09, $Z=6.40$, $P<0.00001$). The effect direction and statistical significance remained unchanged, supporting the robustness of the primary finding.

Disease severity and prognosis

Five indicators reflecting disease severity and prognosis were analyzed, including APACHE II score, SOFA score, ICU length of stay, total hospital stay, and 28-day mortality.

APACHE II score: Eleven RCTs ($n=750$) [17, 19-21, 23, 25, 27, 28, 31, 35, 38] assessed the effect of acupuncture/electroacupuncture

plus routine care on APACHE II scores in post-operative gastrointestinal dysfunction. Moderate-to-substantial heterogeneity was detected ($\chi^2=38.32$, $df=10$, $P<0.0001$, $I^2=74\%$); thus, a random-effects model was applied. The pooled MD was -2.74 (95% CI: -3.70 to -1.78, $Z=5.58$, $P<0.00001$), favoring the intervention (Figure 7).

Sensitivity analysis excluding Cheng 2021 [38] reduced I^2 to 54% ($\chi^2=19.73$, $df=9$, $P=0.02$), with a recalculated MD of -3.25 (95% CI: -3.99 to -2.51, $Z=8.60$, $P<0.00001$). The effect direction and statistical significance remained unchanged, supporting the robustness of the primary finding.

SOFA score: Seven RCTs ($n=436$) [19, 23, 25, 27, 32, 33, 38] assessed the effect of acupuncture/electroacupuncture plus routine care on SOFA scores in postoperative gastrointestinal dysfunction. Substantial heterogeneity was detected ($\chi^2=45.26$, $df=6$, $P<0.00001$, $I^2=87\%$); thus, a random-effects model was applied. The pooled MD was -1.25 (95% CI: -2.37 to -0.13, $Z=2.19$, $P=0.03$), favoring the intervention (Figure 7).

Sensitivity analysis excluding Lian 2021 [25] reduced I^2 to 68% ($\chi^2=15.41$, $df=5$, $P=0.009$),

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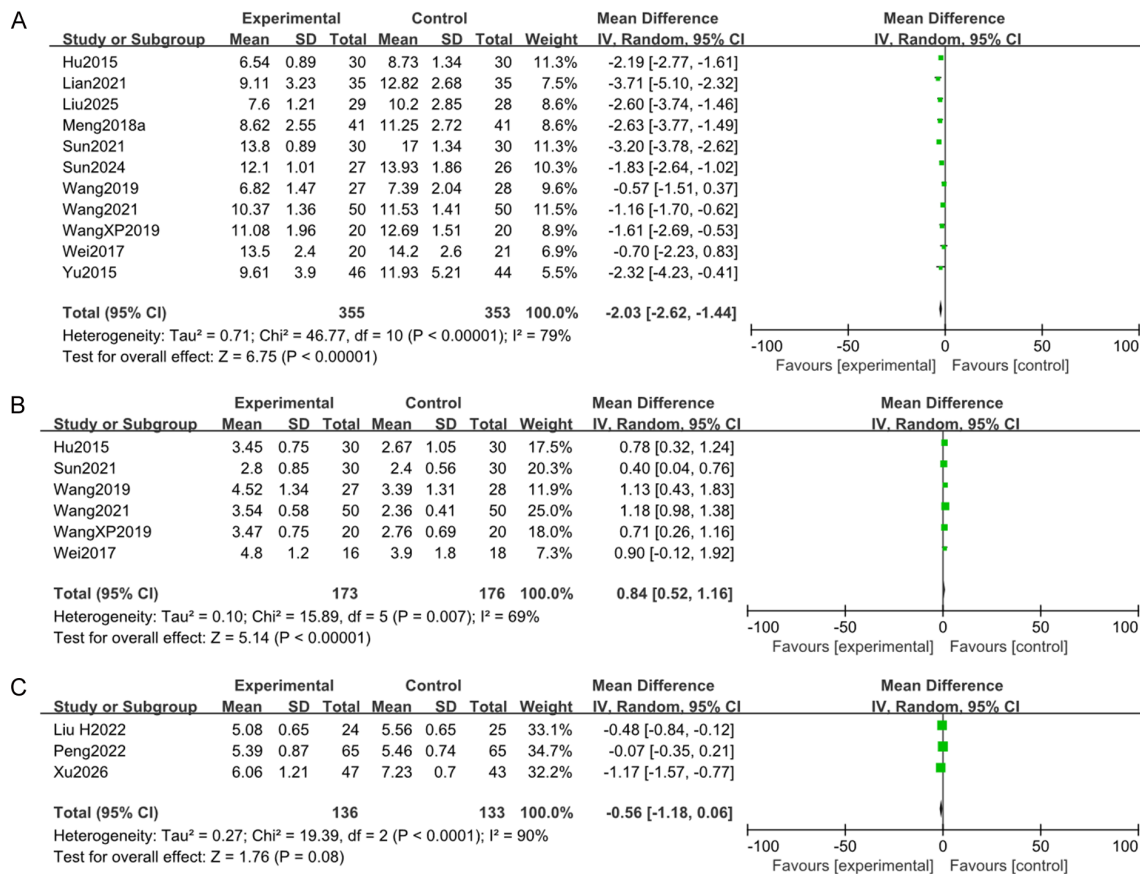


Figure 5. Forest plots of the effects of acupuncture on gastrointestinal function-related outcomes in patients with sepsis. A. Intra-abdominal pressure (IAP). B. Bowel sounds (times/min). C. Time to enteral nutrition target calories.

with a recalculated MD of -0.79 (95% CI: -1.71 to 0.13, $Z=1.68$, $P=0.09$). The effect was no longer significant after excluding this study, indicating that the primary finding was not robust to single-study exclusion.

Length of ICU stay and total hospital stay: Six RCTs ($n=447$) [26, 29, 33, 34, 36, 37] assessed the effect of acupuncture/electroacupuncture plus routine care on ICU length of stay in sepsis-related gastrointestinal dysfunction. Substantial heterogeneity was detected ($\chi^2=25.58$, $df=5$, $P=0.0001$, $I^2=80\%$); thus, a random-effects model was applied. The pooled MD was -0.92 (95% CI: -1.64 to -0.20, $Z=2.50$, $P=0.01$), favoring the intervention (**Figure 7**). Sensitivity analysis excluding Peng 2022 [26] reduced I^2 to 45% ($\chi^2=7.23$, $df=4$, $P=0.12$), with a recalculated MD of -1.22 (95% CI: -1.78 to -0.67, $Z=4.30$, $P<0.0001$). The effect direction and statistical significance remained unchanged, supporting the robustness of the primary finding.

Two RCTs ($n=104$) [29, 36] assessed the effect of acupuncture on total hospital stay, with no significant heterogeneity detected ($\chi^2=0.08$, $df=1$, $P=0.77$, $I^2=0\%$); thus, a fixed-effect model was applied. The pooled MD was -1.60 (95% CI: -2.17 to -1.02, $Z=5.43$, $P<0.00001$), favoring the intervention (**Figure 7**).

28-day mortality: Six RCTs ($n=416$) [32-37] assessed the effect of acupuncture/electroacupuncture plus routine care on 28-day mortality in sepsis-associated gastrointestinal dysfunction. No significant heterogeneity was detected ($\chi^2=1.67$, $df=5$, $P=0.89$, $I^2=0\%$); thus, a fixed-effect model was applied. The pooled RR was 0.76 (95% CI: 0.55 to 1.05, $Z=1.66$, $P=0.10$), showing no significant difference between groups (**Figure 7**).

Clinical efficacy and safety

To explore the clinical effects of acupuncture in patients with sepsis-associated gastrointes-

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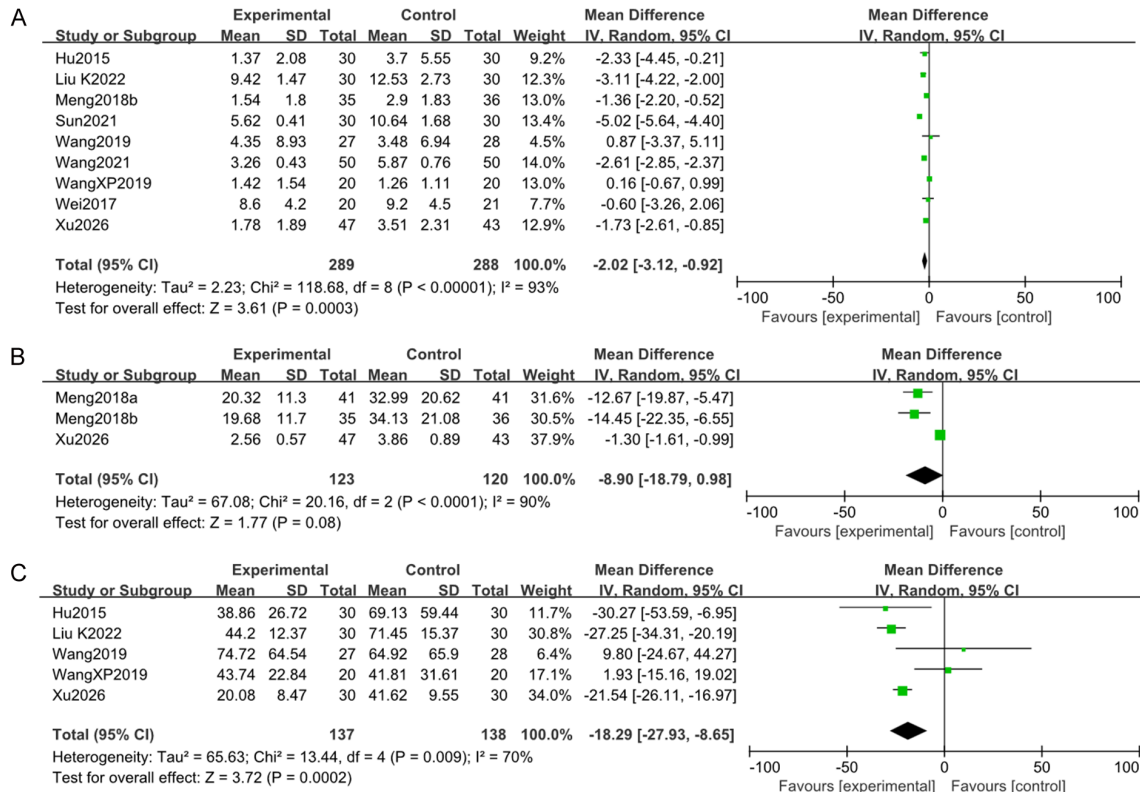


Figure 6. Forest plots of the effects of acupuncture on inflammatory biomarkers in patients with sepsis. A. Procalcitonin (PCT). B. Tumor necrosis factor- α (TNF- α). C. High-sensitivity C-reactive protein (hs-CRP).

tinal dysfunction, pooled analyses were performed on the overall clinical response rate and the incidence of adverse reactions.

Overall clinical response rate: Five RCTs ($n=372$) [18, 21, 22, 31, 35] assessed the effect of acupuncture/electroacupuncture plus routine care on the overall clinical response rate in sepsis-associated gastrointestinal dysfunction. No significant heterogeneity was detected ($\chi^2=3.28$, $df=4$, $P=0.51$, $I^2=0\%$); thus, a fixed-effect model was applied. The pooled OR was 3.15 (95% CI: 1.62 to 6.13, $Z=3.38$, $P=0.0007$), favoring the intervention (**Figure 8**).

Incidence of intervention-related adverse events: A total of 23 RCTs reported the incidence of adverse events associated with acupuncture in patients with sepsis-associated gastrointestinal dysfunction. Of these, 20 trials reported no adverse events in either the intervention or control groups. Among the remaining three trials [29, 36, 38], no significant difference in the incidence of adverse events was observed between groups, with

event rates ranging from 0% to 6.7% across studies. Collectively, these findings suggest that acupuncture/electroacupuncture combined with routine care exhibits a favorable safety profile in this patient population.

Publication bias

Publication bias was assessed for the primary outcome (gastrointestinal dysfunction score) using funnel plots. The distribution of study points was roughly symmetric, suggesting a low risk of publication bias (**Figure 9**).

Sensitivity analysis

Sensitivity analyses were performed for all outcomes with detectable heterogeneity by sequentially excluding individual studies and recalculating pooled effect sizes. The direction of pooled effect sizes remained unchanged for all outcomes, and heterogeneity was reduced for most indicators. These findings support the robustness of the overall meta-analytic results.

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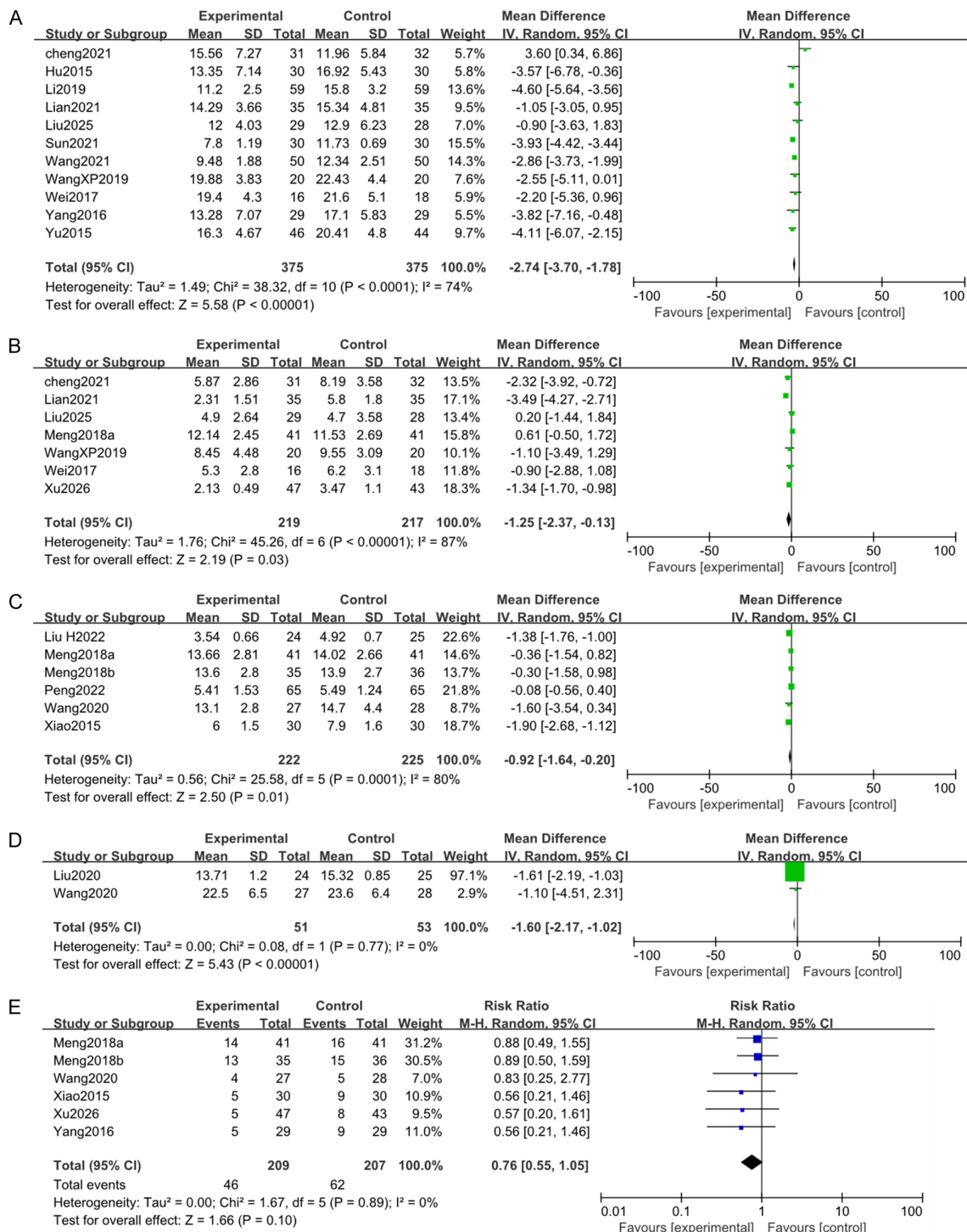


Figure 7. Forest plots of the effects of acupuncture on severity and prognostic outcomes in patients with sepsis. A. APACHE II score. B. SOFA score. C. ICU length of stay. D. Hospital length of stay. E. 28-day mortality.

Discussion

In addition to drawing the core conclusions that acupuncture can improve gastrointestinal

function, protect intestinal barrier and regulate inflammatory response, the present meta-analysis provided novel insight into the translational potential of acupuncture for sepsis-induced

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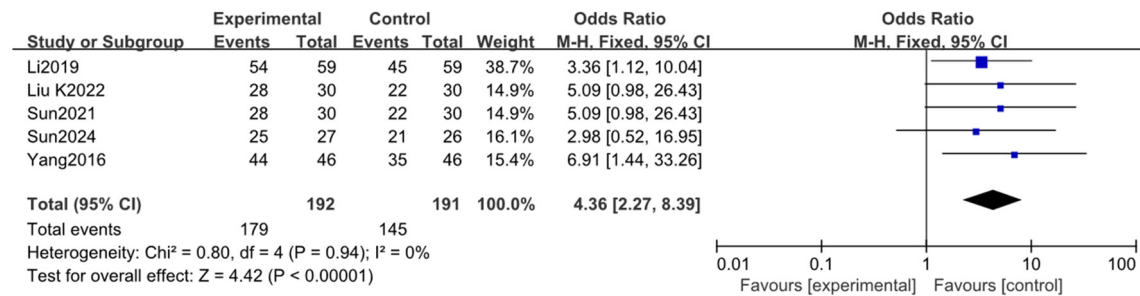


Figure 8. Forest plots of clinical total effective rate in patients with sepsis.

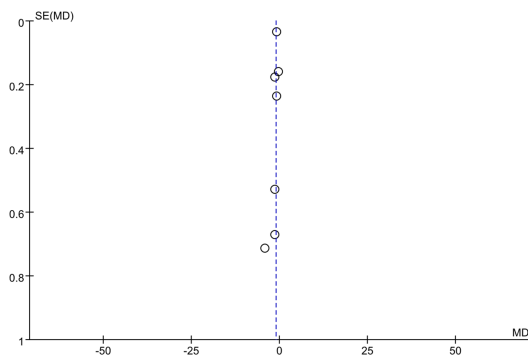


Figure 9. Funnel plot for publication bias of gastrointestinal function score in patients with sepsis treated with acupuncture. The horizontal axis represents the mean difference (MD), and the vertical axis represents the standard error of MD (SE(MD)). The roughly symmetric distribution of the included studies indicates a low risk of publication bias.

gastrointestinal dysfunction. Emerging preclinical and clinical research evidence further supports its underlying mechanisms of action.

First, this meta-analysis observed significant reductions in gastrointestinal dysfunction scores and marked improvements in the gastric antral motility index, which align with findings from preclinical studies: acupuncture modulates the brain-gut axis, a bidirectional signaling pathway critical for sustaining gastrointestinal homeostasis during sepsis [39, 40]. Animal experiments have demonstrated that acupuncture at Zusanli (ST36) activates the vagus nerve, suppresses excessive sympathetic excitation, alleviates intestinal hypoperfusion, and thereby reverses sepsis-induced gastrointestinal dysmotility [10, 41]. A systematic review published by Shi et al. (2025) incorporating 23 randomized controlled trials with 1,603 patients reported that acupuncture significantly increases bowel sounds, lowers intra-abdom-

inal pressure, and reduces gastric residual volume in patients with sepsis-associated gastrointestinal dysfunction [12]. This mechanistic pathway may explain the shortened time to reach target enteral nutrition calories observed in our analysis, as vagal nerve activation directly boosts gastrointestinal peristalsis and improves enteral feeding tolerance.

Second, acupuncture exerts prominent anti-inflammatory regulatory effects by downregulating the levels of peripheral inflammatory biomarkers and ameliorating the excessively activated inflammatory state after surgery. Postoperative gastrointestinal injury is frequently accompanied by a systemic inflammatory response with massive release of pro-inflammatory cytokines. Persistent inflammatory disturbance further aggravates gastrointestinal mucosal damage, delays the recovery of gastrointestinal function, and is closely correlated with an elevated risk of postoperative complications. In this meta-analysis, three classic inflammatory biomarkers including PCT, TNF- α and hs-CRP were included for quantitative pooled analysis two inflammatory biomarkers (PCT and hs-CRP) were assessed to evaluate the regulatory effect of acupuncture on systemic inflammation. The results verified that acupuncture combined with routine care could effectively reduce the above inflammatory indicators and relieve excessive systemic inflammatory response. Zhang et al. (2024) systematically illustrated that acupuncture regulates systemic inflammatory and immune homeostasis by modulating autonomic nerve pathways such as the sympathetic-adrenal axis and vagal-cholinergic pathway [9]. Another meta-analysis by Xu et al. (2026) also confirmed that adjuvant acupuncture intervention alleviates clinical manifestations in

patients with postoperative gastrointestinal dysfunction while simultaneously decreasing peripheral inflammatory biomarker levels [13]. Basic experimental studies have validated that acupuncture at Zusanli (ST36) elicits gastrointestinal protective effects through multiple pathways: inhibiting overactivation of the TLR4/NF- κ B signaling cascade, regulating intestinal flora homeostasis, attenuating systemic inflammatory response, and preserving the integrity of the intestinal mucosal barrier [42]. As a core regulatory target of the inflammatory cascade, the NF- κ B pathway can be blocked from excessive activation by acupuncture to suppress abundant secretion of inflammatory cytokines. Multiple synergistic mechanisms collectively mitigate postoperative excessive inflammation, supporting acupuncture as a reliable adjuvant intervention for alleviating postoperative inflammatory gastrointestinal injury.

Moderate-to-substantial heterogeneity was observed in the pooled analyses of multiple inflammatory and gastrointestinal function indicators in the present meta-analysis. Based on available evidence, potential sources of heterogeneity were analyzed as follows: inconsistent acupoint selection and intervention durations across included studies, as well as varying timing of follow-up measurements for intestinal barrier and inflammatory factor detection. In addition, substantial heterogeneity in the gastrointestinal dysfunction score analysis was partly attributable to the use of different scoring systems across the included studies (e.g., AGI grading, the 1995 MODS criteria, and various composite scales), which necessitated the use of SMD rather than MD for statistical pooling. In addition, discrepancies in the severity of surgical trauma and baseline gastrointestinal injury among patients amplified between-study differences in effect sizes. Furthermore, one included study [26] utilized a different control intervention from the others, which may have contributed to heterogeneity; however, sensitivity analysis confirmed that excluding this study did not reverse the direction or significance of the pooled effect, suggesting that the overall conclusions were not substantially affected by this variation. Although sensitivity analysis identified outlier studies and confirmed the stability of

the overall conclusions, this meta-analysis was restricted by limited outcome reporting in the original trials. Therefore, additional intestinal barrier biomarkers such as I-FABP, D-lactate and ZO-1 could not be incorporated into quantitative synthesis. Intestinal barrier damage was only indirectly assessed by peripheral inflammatory markers, which creates limitations in the mechanistic evidence base [43].

Compared to previous systematic reviews, this meta-analysis offered several distinct contributions: (1) comprehensive evaluation of multiple clinically relevant outcomes specifically in sepsis-associated gastrointestinal dysfunction; (2) inclusion of recently published RCTs not covered in earlier reviews; (3) refinement of methods using SMD with Hedges' adjusted g to harmonize heterogeneous scoring instruments; and (4) systematic safety assessment across all 23 included trials. These features position this study as the most comprehensive and methodologically rigorous synthesis to date on this topic.

Several limitations of this meta-analysis should be acknowledged. First, all included studies were conducted in China and the majority were published in Chinese-language journals, which may limit the generalizability of our findings to other populations and healthcare settings. Second, the quality of the original studies varied, with many lacking adequate reporting of randomization concealment and blinding, potentially introducing selection and detection bias. The predominance of single-center studies with relatively small sample sizes further constrains the robustness of the pooled estimates for certain outcomes. These factors should be taken into consideration when interpreting the results.

Lastly, acupuncture demonstrates favorable safety profiles, with no significant increase in the incidence of adverse events compared with routine treatment. A systematic review on acupuncture safety conducted by Huang et al. (2024) reported that severe acupuncture-related adverse events are extremely rare, and most common reactions are mild, including subcutaneous ecchymosis, hematoma, dizziness, and fatigue [15]. This finding is particularly critical for sepsis management. Septic patients usually receive multiple concurrent

medications and suffer from organ dysfunction, which elevates their risk of drug-related adverse reactions. As a non-pharmacologic intervention, acupuncture therefore represents a highly promising adjuvant therapeutic option.

Conclusions

This systematic review and meta-analysis demonstrated that acupuncture combined with routine treatment significantly improved gastrointestinal function, suppressed inflammatory responses, and ameliorated clinical prognosis (reduced APACHE II scores, shortened ICU length of stay, and a trend toward lower 28-day mortality) in patients with sepsis-associated gastrointestinal dysfunction, with satisfactory safety profiles. Although the quality of current evidence is limited by drawbacks in the method, acupuncture exhibits promising application prospects as an adjuvant therapy for sepsis-induced gastrointestinal dysfunction. Further high-quality, multicenter randomized controlled trials are required to validate these findings and thoroughly explore the underlying mechanisms of acupuncture in future research.

Disclosure of conflict of interest

None.

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