Journal of Pain Research

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Effect of Liposomal Bupivacaine in Peripheral Nerve Block Following Thoracoscopic Lung Surgery: A Systematic Review and Meta-Analysis

Jianhong Hu, Kaiguang Zhang, Zhijun Ma, Dongqing Ren, Wenjun Yan

Department of Anesthesiology, Gansu Provincial Hospital, Lanzhou, Gansu, 730000, People's Republic of China

Correspondence: Wenjun Yan, Email ywjgs2008@qq.com

Background: This systematic review and meta-analysis aims to compare liposomal bupivacaine (LB) with conventional local anesthetics (LAs) in peripheral nerve block following thoracoscopic lung surgery.

Methods: Randomized controlled trials (RCTs) evaluating LB and other LAs for postoperative analgesia were retrieved from databases, including PubMed, Embase, Cochrane Library, and Web of Sciencefrom inception to December 2025. The primary outcome was resting Visual Analogue Scale (VAS) at 24 hours.

Results: We included 9 RCTs with 930 patients. The LB had a lower resting VAS at 24 hours (mean difference [MD] = −0.65, 95% confidence interval [CI]: −0.83 to −0.47). Similar results were shown in the resting VAS at 48 hours (MD = −0.45, 95% CI: −0.61 to −0.29), resting VAS at 72 hours (MD = −0.33, 95% CI: −0.56 to −0.10), movement VAS at 24 hours (MD = −0.60, 95% CI: −0.75 to −0.45), movement VAS at 48 hours (MD = −0.46, 95% CI: −0.71 to −0.21; I2 = 96%), and movement VAS at 72 hours (MD = −0.60, 95% CI: −0.98 to −0.23). Additionally, LB reduced morphine consumption within 24 hours (MD = −2.68, 95% CI: −3.84 to −1.52) and morphine consumption within 72 hours (MD = −8.76, 95% CI: −16.13 to −1.38). However, there were no significant differences between LB and other LAs in morphine consumption within 48 hours and postoperative nausea and vomiting (PONV).

Conclusion: Although LB produced statistically significant reductions in resting and movement pain scores at 24, 48, and 72 hours, as well as lower morphine consumption at 24 and 72 hours, the magnitude of these differences is unlikely to be clinically meaningful. Furthermore, no significant differences were observed for 48-hour morphine consumption or PONV.

Limitation: The results showed many heterogeneity. There was a lack of data on long-term analgesia and functional outcomes.

Keywords: liposomal bupivacaine, pain, nerve block, thoracoscopic, meta-analysis

Introduction

Regional nerve blocks have become an integral component in the multimodal analgesic approach to thoracic surgery, providing effective pain control while minimizing the systemic side effects associated with opioid use.[1] The application of these techniques in thoracic procedures, such as thoracoscopic lung surgery, is particularly important, as they can significantly enhance patient comfort and facilitate early postoperative recovery.[2,3] However, a notable limitation of traditional single-injection nerve blocks is their relatively short duration of analgesia.[4] In many cases, the pain relief provided by these blocks is insufficient to cover the entire postoperative period, often necessitating the use of additional analgesics. Moreover, the incorporation of adjuncts to local anesthetics (LAs), aimed at prolonging analgesic duration, raises concerns regarding potential alterations to the chemical structure of the local anesthetics themselves, which could lead to unforeseen adverse effects in patients.[5–7] This highlights the need for alternative strategies that can offer both effective pain relief and safety.

Currently, ropivacaine and bupivacaine are considered the basic LAs for regional nerve blocks. Ropivacaine, particularly in low concentrations, is especially favored for its ability to provide sensory-motor separation[8] and its lower cardiac toxicity compared to bupivacaine.[9,10] However, their relatively short duration of action remains a significant drawback, particularly in the context of postoperative pain management. Liposomal bupivacaine (LB), a novel formulation that encapsulates bupivacaine in

https://doi.org/10.2147/JPR.S596114
Received: 15 January 2026
Accepted: 1 April 2026
Published: 7 April 2026

lipid-based carriers, has emerged as a promising alternative.[11] This formulation is designed to provide a sustained release of the anesthetic agent, potentially extending the duration of analgesia beyond that achieved with traditional formulations.[12] The unique delivery mechanism of LB maybe address the limitations associated with single-injection nerve blocks, offering prolonged pain relief.

While preliminary studies indicate its effects in other surgical procedures,[13–16] the current literature regarding thoracoscopic surgery is limited and inconclusive, highlighting the need for a systematic review and meta-analysis to aggregate and synthesize the available data. Our research aims to provide a comprehensive assessment of the analgesic efficacy of liposomal bupivacaine compared to traditional LAs focusing on key outcomes such as pain scores, morphine consumption, and the incidence of postoperative nausea and vomiting (PONV).

Methods

Our study adhered to the PRISMA 2020 guidelines,[17] and the protocol was registered with the International Prospective Register of Systematic Reviews (CRD420251266007). Data collection for this study commenced on December 15, 2025.

Inclusion and Exclusion Criteria

Eligibility criteria were established based on the PICOS framework: participants included adults undergoing thoracoscopic lung surgery who received peripheral nerve blocks for postoperative analgesia (P); the intervention focused on LB (I); comparators included bupivacaine, ropivacaine, or other LAs (C); outcomes were defined as resting and movement pain scores within 72 hours, as well as the incidence of postoperative nausea and vomiting (PONV) (O); studies must be randomized controlled trials (RCTs) (S). Studies were excluded based on the following criteria: (1) those that did not report relevant outcomes or provided data that could not be used for statistical analysis; (2) studies that appeared to duplicate data reporting.

Search Strategy

A comprehensive search was conducted across multiple databases, including PubMed, Embase, Cochrane Library, and Web of Science from inception through December 2025. The search strategy was developed in accordance with the PICOS framework, employing key terms and Medical Subject Headings (MeSH) descriptors such as “liposomal bupivacaine”, “block”, and “thoracoscopic.” The detailed search strategy, using PubMed as a representative example, was provided in Supplementary Table 1S.

Data Extraction

Two independent researchers conducted a sequential review of all titles, abstracts, and full texts to determine eligibility. Any disagreements regarding eligibility were resolved through consensus with a third reviewer. Data extracted from each RCT included the following: authorship, year of publication, country of study, blinding methods, types of nerve blocks utilized, descriptions of interventions, sample size, postoperative analgesic regimens, and outcomes. The primary outcome assessed was the resting pain score at 24 hours, while secondary outcomes included both resting and movement pain scores, morphine consumption within 72 hours, and the incidence of PONV.

Certainty of Evidence

The certainty of the evidence was independently evaluated by two investigators using the Cochrane Collaboration’s tool.[18] This assessment included evaluation of sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, completeness of outcome data, selective reporting of outcomes, and other potential sources of bias. The results of this evaluation were presented using the risk of bias and GRADE framework.[19]

Statistical Analysis

Statistical analyses were performed using RevMan 5.4.1 software, with data synthesis conducted using a random-effects model which was selected a priori to account for anticipated heterogeneity. Pain scores were converted to a 0–10 visual analog scale (VAS), and opioid consumption was converted to intravenous morphine equivalent doses.[20] Additionally, we

employed Luo's and Wan's formulas to convert data expressed as medians and interquartile ranges into means and standard deviations.[21,22] The effect estimates for PONV were reported as relative risk (RR) with 95% confidence intervals (CIs), while mean differences (MD) with 95% CIs were reported for VAS scores and morphine consumption. Overall effect sizes were illustrated using forest plots, and subgroup analyses were conducted based on the types of nerve blocks and LAs used. Heterogeneity was considered significant if $I^2 \geq 50\%$, prompting sensitivity analyses and additional subgroup analyses to identify potential sources of heterogeneity.[23] A p-value of < 0.05 was deemed statistically significant for all analyses. Publication bias was assessed through funnel plot.

Results

A total of 9 RCTs with 930 participants were involved.[24–32] Figure 1 showed the process of literature selection. Table 1 showed the basic characteristics of the included studies. Five RCTs used standard bupivacaine as the control drug,[24,25,27,30,31] whereas 4 RCTs used ropivacaine.[26,28,29,32] The most common types of nerve blocks included ICNB (3 RCTs)[25,31,32] and TPVB (3 RCTs).[27–29] The resting pain score at 24 h was reported in 9 RCTs. Additionally, all RCTs reported the method of randomization, but one RCT[24] did not indicate the method of blinding.

Resting VAS at 24 h

The pooled data of nine studies showed significant difference between LB and other LAs (MD = −0.65, 95% CI: −0.83 to −0.47; $I^2 = 97\%$; Figure 2). The sensitivity analysis demonstrated a similar result (MD = −0.59, 95% CI: −0.75 to −0.42; $I^2 = 0\%$; Figure 3). The subgroup analysis showed that LB had a lower VAS than bupivacaine (MD = −0.97, 95% CI: −1.48 to −0.47; Figure 4) and ropivacaine (MD = −0.47, 95% CI: −0.85 to −0.10; Figure 5). Additionally, LB reduced VAS for TPVB (MD = −0.32, 95% CI: −0.49 to −0.15; Figure 6), ICNB (MD = −0.85, 95% CI: −1.64 to −0.06; Figure 7), and SAPB (MD = −1.1, 95% CI: −1.68 to −0.52; Figure 8). However, Figure 9 showed a slight risk of bias for included studies, and the funnel plot showed significant publication bias (Figure 10).

Resting VAS at 48 h

The pooled data of nine studies showed significant difference between LB and other LAs (MD = −0.45, 95% CI: −0.61 to −0.29; I^2= 90%; Supplementary Figure S2A). The sensitivity analysis demonstrated a similar result (MD = −0.63, 95% CI: −0.93 to −0.34; I^2= 46%; Supplementary Figure S2B). The subgroup analysis showed LB had a lower VAS than bupivacaine (MD = −0.30, 95% CI: −0.48 to −0.12; Supplementary Figure S2C) and ropivacaine (MD = −0.65, 95% CI: −1.08 to −0.22; Supplementary Figure S2D). Additionally, LB did not reduce VAS for SAPB (MD = −1.06, 95% CI: −2.14 to 0.03; Supplementary Figure S2E). However, LB was superior to other LAs for ICNB (MD = −0.4, 95% CI: −0.74 to −0.05; Supplementary Figure S2F) and TPVB (MD = −0.31, 95% CI: −0.55 to −0.08; Supplementary Figure S2G).

Resting VAS at 72 h

The pooled data of eight studies showed significant difference between LB and other LAs (MD = −0.33, 95% CI: −0.56 to −0.10; I^2 = 96%; Supplementary Figure S3A). The sensitivity analysis demonstrated a similar result (MD = −0.05, 95% CI: −0.05 to −0.05; I^2 = 0%; Supplementary Figure S3B). The subgroup analysis showed there was no significant difference between LB and bupivacaine (MD = −0.20, 95% CI: −0.59 to 0.20; Supplementary Figure S3C), but LB had a lower VAS than ropivacaine (MD = −0.47, 95% CI: −0.80 to −0.13; Supplementary Figure S3D). Additionally, LB did not reduce VAS for ICNB (MD = −0.4, 95% CI: −1.09 to 0.29; Supplementary Figure S3E) and TPVB (MD = −0.07, 95% CI: −0.13 to 0.00; Supplementary Figure S3F).

Movement VAS at 24 h

The pooled data of eight studies showed significant difference between LB and other LAs (MD = −0.60, 95% CI: −0.75 to −0.45; I^2 = 92%; Supplementary Figure S4A). The sensitivity analysis demonstrated a similar result (MD = −0.34, 95% CI: −0.48 to −0.2; I^2 = 49%; Supplementary Figure S4B). The subgroup analysis showed LB had a lower VAS than bupivacaine (MD = −0.81, 95% CI: −1.24 to −0.38; Supplementary Figure S4C) and ropivacaine (MD = −0.68, 95% CI:

https://doi.org/10.2147/JPR.S596114

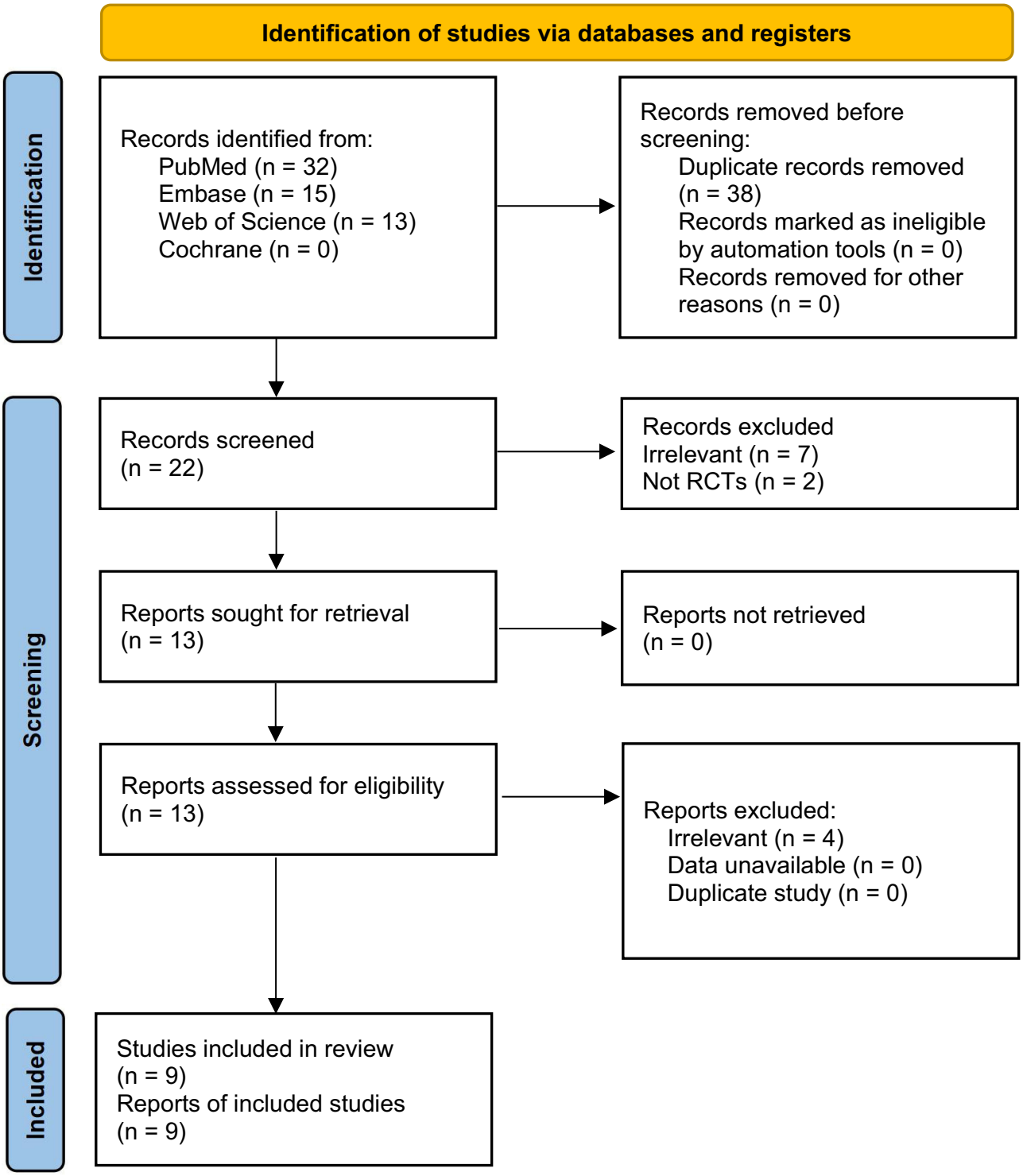

Figure 1 PRISMA flow diagram of study selection.

−1.20 to −0.16; Supplementary Figure S4D). Additionally, LB was superior to other LAs for SAPB (MD = −1.17, 95% CI: −1.46 to −0.89; Supplementary Figure S4E), ICNB (MD = −1.1, 95% CI: −1.99 to −0.2; Supplementary Figure S4F), and TPVB (MD = −0.3, 95% CI: −0.33 to −0.26; Supplementary Figure S4G).

Table 1 Study Characteristics of Included Studies

Study	Country	Blinding	Nerve block	Comparison (n)	Rescue analgesic regimen	Outcomes
Zhang M 2025[24]	China	NR	SAPB	LB (35): 10 mL of 1.33% LB Contorl (35): 0.25% bupivacaine 5 mL/h	A sufentanil PCIA, and IM pethidine 10 mg if necessary	1,2,4,5,8,10
Lu D 2025[25]	China	3	ICNB	LB (25): 20 mL of 1.33% LB Contorl (25): 0.75% bupivacaine	A sufentanil + pentazocine PCIA	1,2,3,4,5,6,10
Zhang Y 2025[26]	China	2	SAPB	LB (32): 40 mL of 0.665% LB Contorl (32): 40 mL of 0.375% ropivacaine	A sufentanil PCIA, and IV flurbiprofen axeti 50 mg every 6 hours if NRS ≥ 4	1,2,3,4,5,6
Yang Z 2025[27]	China	2	TPVB	LB (56): 20 mL of 1.33% LB Contorl (57):20 mL of 0.375% bupivacaine	A sufentanil PCIA	1,2,3,4,5,6,7,8,9
Wang LL 2025[28]	China	2	TPVB	LB (51): 30 mL of 0.33% LB Contorl (50): 30 mL of 0.67% ropivacaine	A sufentanil PCIA, and IM pethidine 50 mg	1,2,3,9,10
Wei Y 2025[29]	China	2	TPVB	LB (30): 20 mL of 0.665% LB Contorl (29): 20 mL of 0.5% ropivacaine	A sufentanil PCIA, and IV flurbiprofen axeti 50 mg if VAS ≥ 4	1,2,3,4,5,6,10
Shan XS 2025[30]	China	2	ESPB	LB (134): 30 mL of 0.887% LB Contorl (133): 30 mL of 0.333% bupivacaine	A sufentanil PCIA, and oral celecoxib 200 mg every 12 hours	1,2,3,4,5,6,7,9,10
Chi Y 2025[31]	China	1	ICNB	LB (47): 20 mL of 1.33% LB Contorl (46): 15 mL of 0.25% bupivacaine	A sufentanil+flurbiprofen axetil PCIA, and IV morphine 5 mg if VAS ≥ 4	1,2,3,4,5,6,10
Dong L 2025[32]	China	2	ICNB	LB (56): 20 mL of 1.33% LB Contorl (57): 20 mL of 0.375% ropivacaine	A sufentanil PCIA, and oral celecoxib 200 mg every 12 hours	1,2,3,4,5,6,7,8,9,10

Notes: 1, resting VAS at 24 hours. 2, resting VAS at 48 hours. 3, resting VAS at 72 h. 4, movement VAS at 24 hours. 5, movement VAS at 48 hours. 6, movement VAS at 72 hours. 7, morphine consumption within 24 hours (intravenous morphine equivalent, mg). 8, morphine consumption within 48 hours. 9, morphine consumption within 72 hours. 10, postoperative nausea and vomiting.

Abbreviations: NR, not reported; LB, liposomal bupivacaine; ESPB, erector spinae plane block; TPVB, thoracic paravertebral block; ICNB, intercostal nerve block; SAPB, serratus anterior plane block; PCIA, patient-controlled intravenous analgesia; IM, intramuscular injection; IV, intravenous injection; NRS, numeric rating scale; VAS, visual analogue scale.

Movement VAS at 48 h

The pooled data of eight studies showed significant difference between LB and other LAs (MD = −0.46, 95% CI: −0.71 to −0.21; I^2 = 96%; Supplementary Figure S5A). The sensitivity analysis demonstrated a similar result (MD = −0.32,

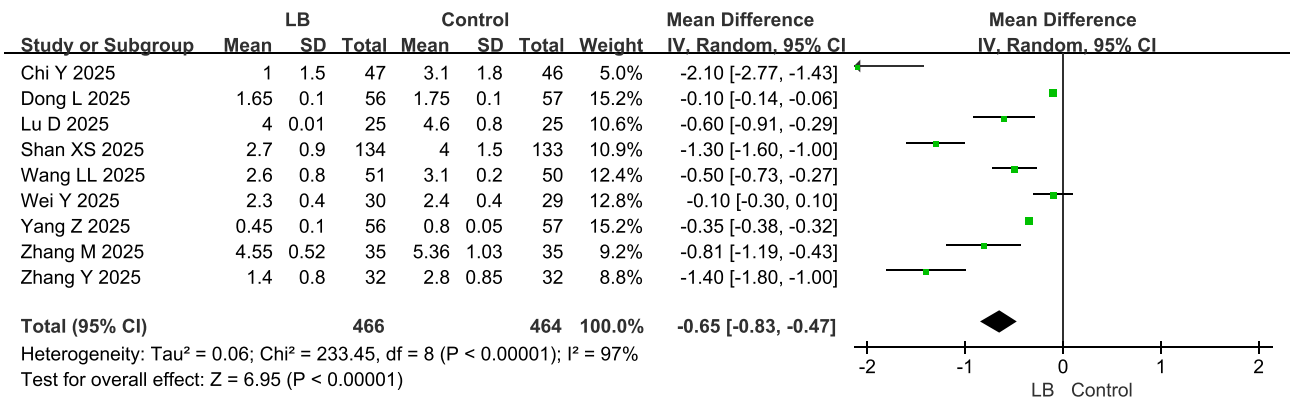

Figure 2 Forest plot.

Abbreviations: LB, liposomal bupivacaine; CI, confidence interval.

https://doi.org/10.2147/JPR.S596114

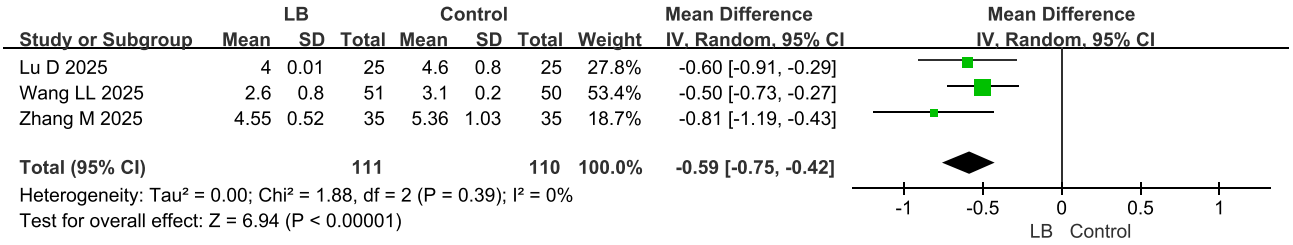

Figure 3 Forest plot of sensitivity analysis.
Abbreviations: LB, liposomal bupivacaine; CI, confidence interval.

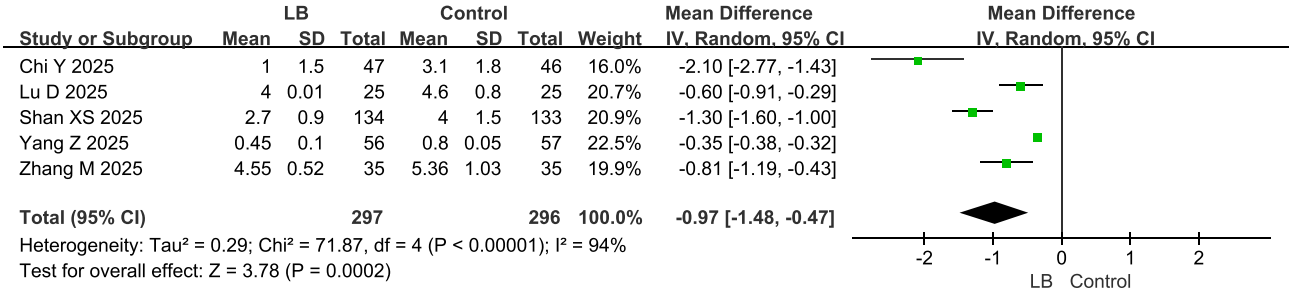

Figure 4 Subgroup analysis for LB versus bupivacaine.
Abbreviations: LB, liposomal bupivacaine; CI, confidence interval.

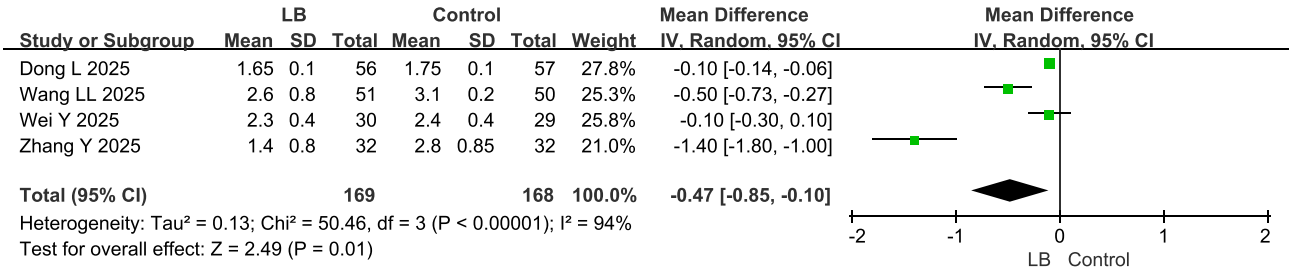

Figure 5 Subgroup analysis for LB versus ropivacaine.
Abbreviations: LB, liposomal bupivacaine; CI, confidence interval.

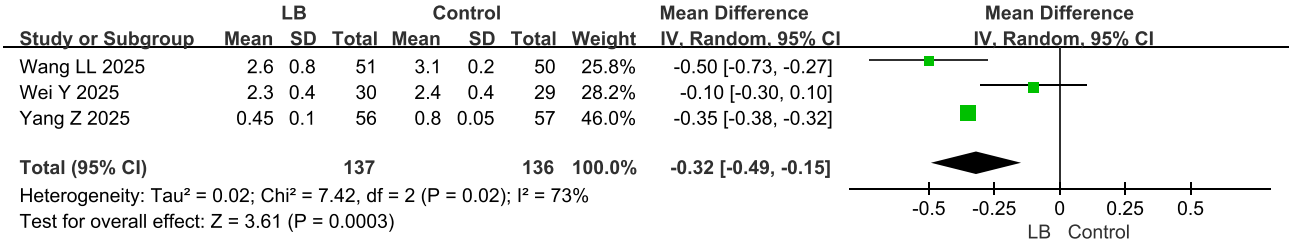

Figure 6 Subgroup analysis for TPVB.

95% CI: −0.39 to −0.26; I^2 = 0%; Supplementary Figure S5B). The subgroup analysis showed that there was no significant difference between LB and bupivacaine (MD = −0.45, 95% CI: −0.94 to 0.04; Supplementary Figure S5C), but LB had a lower VAS than ropivacaine (MD = −0.53, 95% CI: −0.83 to −0.24; Supplementary Figure S5D). Additionally, LB did not reduce VAS for SAPB (MD = −0.37, 95% CI: −1.64 to 0.90; Supplementary Figure S5E) and TPVB (MD = −0.19, 95% CI: −0.58 to 0.20; Supplementary Figure S5F). LB was superior to other LAs for ICNB (MD = −0.56, 95% CI: −0.99 to −0.12; Supplementary Figure S5G).

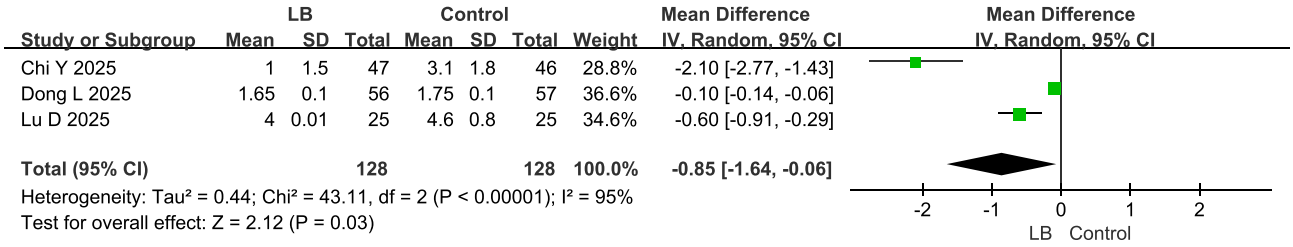

Figure 7 Subgroup analysis for ICNB.
Abbreviations: LB, liposomal bupivacaine; CI, confidence interval.

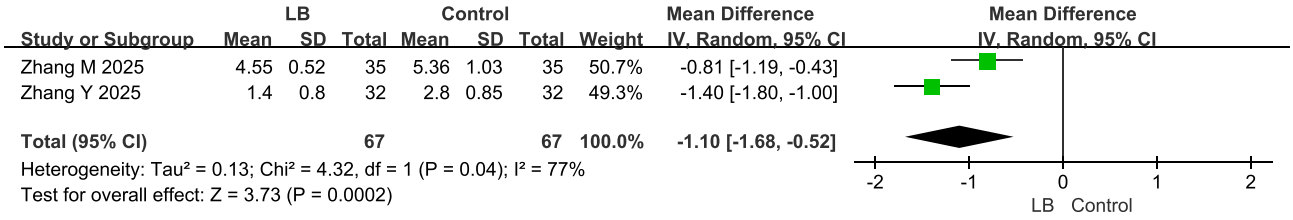

Figure 8 Subgroup analysis for SAPB.
Abbreviations: LB, liposomal bupivacaine; CI, confidence interval.

Movement VAS at 72 h

The pooled data of seven studies showed significant difference between LB and other LAs (MD = −0.60, 95% CI: −0.98 to −0.23; I^2 = 98%; Supplementary Figure S6A). The sensitivity analysis demonstrated that there was no significant difference between LB and LAs (MD = −0.00, 95% CI: −0.03 to −0.03; I^2 = 0%; Supplementary Figure S6B). The subgroup analysis showed that LB had a lower VAS than bupivacaine (MD = −0.36, 95% CI: −0.71 to −0.02; Supplementary Figure S6C), but there was no significant difference between LB and ropivacaine (MD = −0.81, 95% CI: −2.04 to 0.42; Supplementary Figure S6D). Additionally, LB did not reduce VAS for ICNB (MD = −0.65, 95% CI: −1.44 to 0.14; Supplementary Figure S6E) and TPVB (MD = −0.34, 95% CI: −1.06 to 0.37; Supplementary Figure S6F).

Morphine Consumption within 24 h (Mg)

The pooled data of three studies showed significant difference between LB and other LAs (MD = −2.68, 95% CI: −3.84 to −1.52; I^2 = 0%; Supplementary Figure S7A).

Morphine Consumption within 48 h (Mg)

The pooled data of three studies showed that there was no significant difference between LB and other LAs (MD = −2.78, 95% CI: −5.56 to 0.01; I^2 = 77%; Supplementary Figure S8A). The sensitivity analysis demonstrated a similar result (MD = −1.73, 95% CI: −5.57 to 2.11; I^2 = 24%; Supplementary Figure S8B).

Morphine Consumption within 72 h (Mg)

The pooled data of four studies showed significant difference between LB and other LAs (MD = −8.76, 95% CI: −16.13 to −1.38; I^2 = 89%; Supplementary Figure S9A). The sensitivity analysis demonstrated a similar result (MD = −4.34, 95% CI: −5.78 to −2.89; I^2 = 0%; Supplementary Figure S9B). The subgroup analysis showed that LB had a lower morphine consumption than bupivacaine (MD = −6.06, 95% CI: −11.39 to −0.73; Supplementary Figure S9C), but there was no significant difference between LB and ropivacaine (MD = −10.93, 95% CI: −24.54 to 2.69; Supplementary Figure S9D). Additionally, LB was superior to other LAs for TPVB (MD = −13.53, 95% CI: −24.79 to −2.26; Supplementary Figure S9E).

https://doi.org/10.2147/JPR.S596114

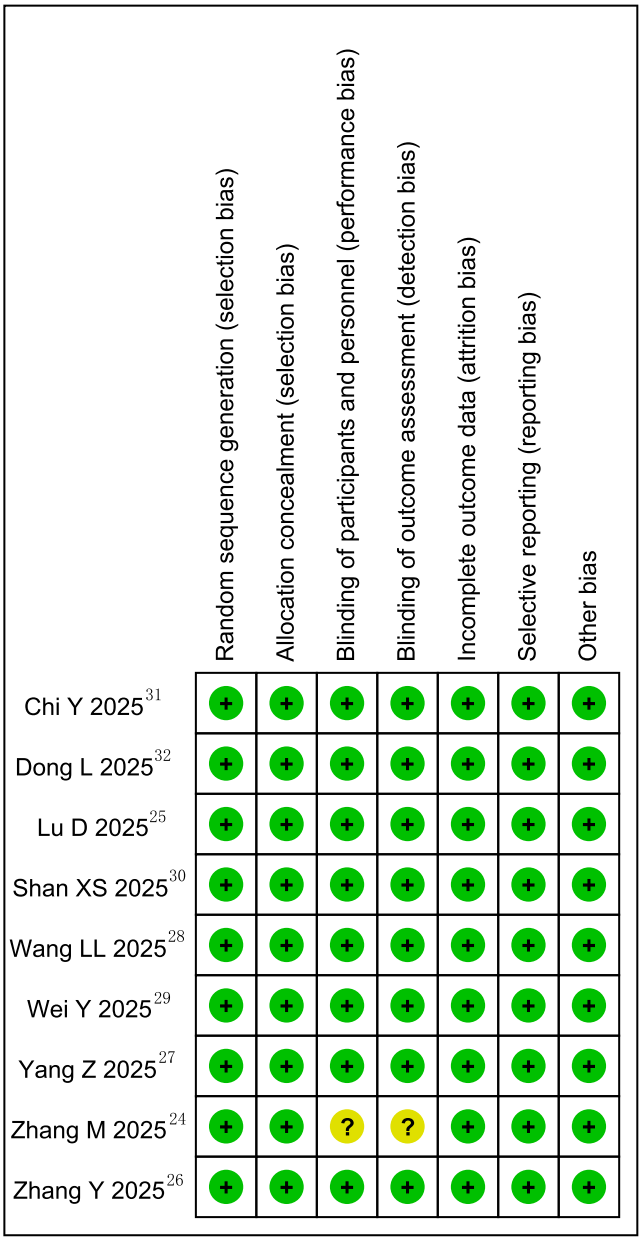

Figure 9 Risk of bias.

Ponv

The pooled data of seven studies showed that there was no significant difference between LB and other LAs (RR = 0.78, 95% CI: 0.43 to 1.42; I^2 = 58%; Supplementary Figure S10A). The sensitivity analysis demonstrated a similar result (RR = 0.70, 95% CI: 0.43 to 1.14; I^2 = 43%; Supplementary Figure S10B). The subgroup analysis showed that LB was not superior to bupivacaine (RR = 0.76, 95% CI: 0.38 to 1.52; Supplementary Figure S10C) and ropivacaine (RR = 1.1, 95% CI: 0.2 to 6.24; Supplementary Figure S10D). Additionally, LB had a lower incidence of PONV for ICNB (RR = 0.46, 95% CI: 0.29 to 0.75; Supplementary Figure S10E), but not for TPVB (RR = 2.39, 95% CI: 0.06 to 99.28; Supplementary Figure S10F).

Discussion

Our meta-analysis indicated that LB was associated with lower resting VAS at 24, 48, and 72 hours post-surgery, as well as reduced movement VAS scores across the same timeframes. However, it was important to note that the differences

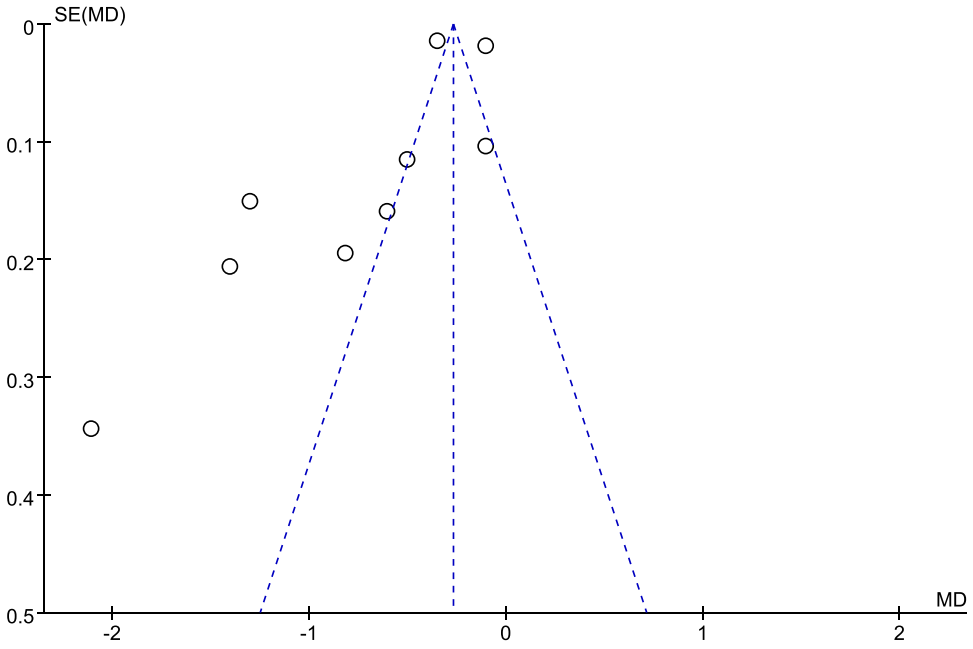

Figure 10 Funnel plot.
Abbreviation: MD, mean difference.

observed were relatively small, with mean differences predominantly falling within one point on the VAS. Clinically, such differences may not translate into significant improvements in patient experience or pain management. Additionally, although LB demonstrated some reduction in morphine consumption within the first 24 and 72 hours, the advantage was not sustained at the 48-hour mark, where no significant difference was found compared to other LAs. Furthermore, the incidence of PONV did not show a significant benefit associated with LB. Overall, while LB presents some favorable outcomes, its clinical relevance might be limited by the small effect sizes observed. Finally, due to the fact that some included studies did not explicitly state adherence to randomization and double-blinding, and there was considerable heterogeneity in the results, the evidence levels for most outcome indicators were downgraded (Table 2).

Currently, there are few meta-analysis evaluating the use of LB for regional nerve block in patients undergoing thoracoscopic surgery, primarily due to the limited availability of relevant clinical trials. Chen et al found that the LB did not reduce pain scores and morphine consumption over standard bupivacaine for ICB[33] We believe that the small beneficial effects of LB on pain scores and opioid consumption, despite statistical significance, can be attributed to several factors. Firstly, the intensity of incision pain significantly decreases 24 hours after thoracoscopic surgery, which may obscure the

Table 2 Quality of Evidences

Outcome	Patients (trails)	Effect Size	95% CI	I^2	*p* value	Certainty (GRADE)
Resting VAS at 24 hours	930(9)	MD −0.65	−0.83 to −0.47	97%	<0.01	Low
Resting VAS at 48 hours	930(9)	MD −0.45	−0.61 to −0.2	90%	<0.01	Low
Resting VAS at 72 hours	860(8)	MD −0.33	−0.56 to −0.1	96%	<0.01	Moderate
Movement VAS at 24 hours	829(8)	MD −0.60	−0.75 to −0.45	92%	<0.01	Low
Movement VAS at 48 hours	829(8)	MD −0.46	−0.71 to −0.21	96%	<0.01	Low
Movement VAS at 72 hours	759(7)	MD −0.60	−0.98 to −0.23	98%	<0.01	Moderate
Morphine consumption within 24 hours	493(3)	MD −2.68	−3.84 to −1.52	0%	<0.01	High
Morphine consumption within 48 hours	296(3)	MD −2.78	−5.56 to 0.01	77%	0.05	Low
Morphine consumption within 72 hours	594(4)	MD −8.76	−16.13 to −1.38	89%	0.02	Moderate
PONV	753(7)	RR 0.78	0.43 to 1.42	58%	0.41	Low

Abbreviations: PONV, postoperative nausea and vomiting; MD, mean difference; RR, relative risk; CI, confidence interval.

https://doi.org/10.2147/JPR.S596114

analgesic advantages of LB during the 24 to 72-hour postoperative period. Secondly, nerve blocks may be ineffective in alleviating persistent inflammatory pain during the 72-hour postoperative period. The complex, self-perpetuating nature of this inflammation is highlighted by studies in related pulmonary disease models.[34,35] Finally, the use of additional analgesics may substantially lower baseline pain levels for all patients.

Although we conducted sensitivity and subgroup analysis on the results exhibiting high heterogeneity, the subgroup analysis still revealed a considerable degree of heterogeneity. We believe that the differences in the effects of the same nerve block across various studies may be attributed to variations in operator experience, patient populations, surgical techniques, LAs concentrations or volumes. Therefore, to validate the true efficacy of LB in each nerve block modality, future randomized controlled trials with large sample sizes and strictly standardized baseline characteristics (eg., uniform patient demographics, surgical protocols, and anesthetic regimens) are warranted. The effectiveness of the TPVB can be significantly influenced by the operator's experience, as its mechanism of action is notably more complex compared to that of the SAPB, ICNB, TPVB, and ESPB. TPVB involves the injection of LAs into the paravertebral space adjacent to the thoracic vertebrae, providing extensive analgesia across multiple dermatomes; however, it can be technically challenging and requires substantial operator expertise to achieve optimal results.[36] In contrast, SAPB is performed by injecting LAs in the plane between the serratus anterior muscle and the chest wall, which is generally considered easier to execute and carries a lower risk of complications, thereby making it more accessible for less experienced practitioners.[37] ICNB involves direct injection at the intercostal spaces, offering localized analgesia to specific dermatomes, and is relatively straightforward for operators; however, its efficacy is limited to the targeted dermatomes.[38] Conversely, ESPB involves injecting LAs deep to the erector spinae muscles, resulting in analgesia that covers multiple dermatomes, similar to TPVB.[39] This technique is typically regarded as easier to perform due to its less technical requirements, making it more achievable for operators with varying levels of experience.[39] Additionally, we must acknowledge the discrepancies in the volume of the same LA across different studies; however, due to the limited number of studies available, we are unable to conduct a further analysis on this aspect.

LB is a formulation of bupivacaine encapsulated in liposomes, designed to provide prolonged analgesia through controlled release.[40] While it shares a similar onset of action and mechanism of sodium channel blockade with both traditional bupivacaine and ropivacaine, its unique formulation reduces peak plasma concentrations, potentially lowering the risk of systemic toxicity associated with bupivacaine and enhancing safety compared to both bupivacaine and ropivacaine.[40] However, previous meta-analysis have not demonstrated a unified conclusion regarding the clinical application of LB, with many studies indicating that it does not offer particularly advantageous in postoperative pain management.[41–44] Therefore, we require more high-quality studies to validate the effectiveness of LB in specific surgical contexts, aiming to provide robust evidence for optimizing healthcare costs.

Limitations

This study has several limitations that warrant consideration. Firstly, the presence of significant heterogeneity among the included studies, which may stem from differences in patient populations and surgical techniques, complicates the generalizability of our findings. Secondly, the short follow-up period, limited to the first 72 hours postoperative, may not capture the long-term benefits of LB on pain management and recovery. Future studies should include follow-up periods of at least one week to better capture its sustained effect. Thirdly, the analysis primarily compared LB to a restricted range of LAs, limiting the applicability of the results to diverse clinical settings. Finally, the potential for publication bias should also be acknowledged, as studies with positive outcomes are more likely to be published, possibly leading to an overestimation of LB's efficacy.

Conclusions

Although liposomal bupivacaine (LB) was associated with statistically significant reductions in resting and movement VAS scores at multiple time points (24–72 hours) as well as in morphine consumption at 24 and 72 hours compared with other LAs, the magnitude of these differences—such as a mean reduction of 0.33–0.65 on the VAS scale and 2.68–8.76 mg in morphine use—is unlikely to translate into clinically meaningful improvements in postoperative pain control or opioid-related outcomes. Moreover, no significant differences were observed in 48-hour morphine consumption or the incidence of PONV. Therefore, while LB demonstrates statistical superiority, its clinical relevance remains limited, and routine use over

conventional LAs should be carefully weighed against cost and practical considerations. Future large-scale RCTs with rigorous standardization (eg., of LA volume, technique, and assessment timing) and extended follow-up are needed to definitively establish the short-, medium-, and long-term efficacy of LB for each specific nerve block indication.

Funding

The study is supported by the Hospital Foundation of Gansu Provincial Hospital (23GSSYB-6), the Gansu Provincial Anesthesia and Brain Function Clinical Medical Research Center project (21JR7RA675), and the Gansu Province Key Talent Project: Talent Cultivation in Anesthesiology of Gansu Province Based on a Diversified Innovative Training System (2023RCXM13).

Disclosure

The authors declare that they have no competing interests.

References

1. Feray S, Lubach J, Joshi GP, et al. PROSPECT guidelines for video-assisted thoracoscopic surgery: a systematic review and procedure-specific postoperative pain management recommendations. *Anaesthesia*. 2022;77(3):311–325. doi:10.1111/anae.15609
2. Neskovic V, Hofmeyr R, Kawagoe I, et al. Pain management in thoracic surgery: bridging evidence and practice. *Curr Opin Anaesthesiol*. 2026;39(1):92–99. doi:10.1097/ACO.0000000000001585
3. Joshi GP, Mariano E, Elkassabany NM, et al. American society of anesthesiologists practice guideline on perioperative pain management using local and regional analgesia for cardiothoracic surgeries, mastectomy, and abdominal surgeries. *Anesthesiology*. 2026;144(1):19–43. doi:10.1097/ALN.0000000000005790
4. Nestor CC, Ng C, Sepulveda P, et al. Pharmacological and clinical implications of local anaesthetic mixtures: a narrative review. *Anaesthesia*. 2022;77(3):339–350. doi:10.1111/anae.15641
5. Wu KW, Deng SY, Zhang XF, et al. Thoracoscopy-guided thoracic paravertebral block using dexmedetomidine in combination with ropivacaine for postoperative analgesia after thoracoscopic radical resection of lung cancer: a randomized controlled trial. *J Cancer Res Clin Oncol*. 2025;151(5):158. doi:10.1007/s00432-025-06218-6
6. Xuan C, Yan W, Wang D, et al. The facilitatory effects of adjuvant pharmaceutics to prolong the duration of local anesthetic for peripheral nerve block: a systematic review and network meta-analysis. *Anesth Analg*. 2021;133(3):620–629. doi:10.1213/ANE.0000000000005640
7. Song ZG, Pang SY, Wang GY, et al. Comparison of postoperative analgesic effects in response to either dexamethasone or dexmedetomidine as local anesthetic adjuvants: a systematic review and meta-analysis of randomized controlled trials. *J Anesth*. 2021;35(2):270–287. doi:10.1007/s00540-021-02895-y
8. Eledjam -J-J, Ripart J, Viel E. Clinical application of ropivacaine for the lower extremity. *Curr Top Med Chem*. 2001;1(3):227–231. doi:10.2174/1568026013395317
9. Finucane BT. La toxicité cardiaque à la ropivacaïne, comparée à la bupivacaïne, ne présente pas autant de complications. *Can J Anaesth*. 2005;52(5):449–453. doi:10.1007/BF03016520
10. Plakhotnik J, Zhang L, Estrada M, et al. Local anesthetic cardiac toxicity is mediated by cardiomyocyte calcium dynamics. *Anesthesiology*. 2022;137(6):687–703. doi:10.1097/ALN.0000000000004389
11. On'Gele MO, Weintraub S, Qi V, et al. Local anesthetics, local anesthetic systemic toxicity (LAST), and liposomal bupivacaine. *Anesthesiol Clin*. 2024;42(2):303–315. doi:10.1016/j.anclin.2023.11.011
12. Ilfeld BM, Sessler DI. Liposomal bupivacaine in peripheral nerve blocks: duration and meaningful differences. *Anesthesiology*. 2024;141(4):638–642. doi:10.1097/ALN.0000000000005133
13. Liu HH, Qiu D, Xu DR, et al. Recovery quality of transversus abdominis plane block with liposomal bupivacaine after cesarean delivery: a randomized trial. *J Clin Anesth*. 2024;99:111608. doi:10.1016/j.jclinane.2024.111608
14. Chan TCW, Wong JSH, Wang F, et al. Addition of liposomal bupivacaine to standard bupivacaine versus standard bupivacaine alone in the supraclavicular brachial plexus block: a randomized controlled trial. *Anesthesiology*. 2024;141(4):732–744. doi:10.1097/ALN.0000000000005035
15. Solis-Pazmino P, Figueroa L, La K, et al. Liposomal bupivacaine versus conventional anesthetic or placebo for hemorrhoidectomy: a systematic review and meta-analysis. *Techniques Coloproctol*. 2024;28(1):29. doi:10.1007/s10151-023-02881-4
16. Hamilton TW, Knight R, Stokes JR, et al. Efficacy of liposomal bupivacaine and bupivacaine hydrochloride vs bupivacaine hydrochloride alone as a periarticular anesthetic for patients undergoing knee replacement: a randomized clinical trial. *JAMA Surg*. 2022;157(6):481–489. doi:10.1001/jamasurg.2022.0713
17. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71
18. Higgins JP, Altman DG, Gøtzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343(oct18 2):d5928. doi:10.1136/bmj.d5928
19. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336(7650):9246. doi:10.1136/bmj.39489.470347.AD
20. Adams MCB, Sward KA, Perkins ML, et al. Standardizing research methods for opioid dose comparison: the NIH HEAL morphine milligram equivalent calculator. *Pain*. 2025;166(8):1729–1737. doi:10.1097/j.pain.0000000000003529
21. Luo D, Wan X, Liu J, et al. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. *Stat Methods Med Res*. 2018;27(6):1785–1805. doi:10.1177/0962280216669183

22. Wan X, Wang W, Liu J, et al. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol*. 2014;14:135. doi:10.1186/1471-2288-14-135
23. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21(11):1539–1558. doi:10.1002/sim.1186
24. Zhang M, Zheng Z, Xie X, et al. Comparison of continuous serratus anterior plane block (cSAPB) with bupivacaine versus single liposomal bupivacaine block in postoperative analgesia after video-assisted thoracoscopic surgery (VATS): a randomized controlled trial. *BMC Anesthesiol*. 2025;25(1):399. doi:10.1186/s12871-025-03249-x
25. Lu D, Huang Z, Peng H, et al. Clinical outcomes of liposomal and conventional bupivacaine in postoperative pain management in female patients following thoracoscopic lung surgery. *Sci Rep*. 2025;15(1):40601. doi:10.1038/s41598-025-24214-1
26. Zhang Y, Li W, Wei A, et al. Comparing liposomal bupivacaine and ropivacaine in serratus anterior plane block for thoracoscopic lobectomy: a randomized controlled trial. *Drug Des Devel Ther*. 2025;19:4717–4726. doi:10.2147/DDDT.S513287
27. Yang Z, Liu M, Wang C, et al. Thoracic paravertebral block with liposomal bupivacaine versus plain bupivacaine in patients undergoing thoracoscopic lung resection: a randomized controlled study. *Drug Des Devel Ther*. 2025;19:6955–6964. doi:10.2147/DDDT.S532122
28. Wang -L-L, Zhu Y, Hui L-Y, et al. Liposomal bupivacaine in ultrasound-guided paravertebral block reduces opioid consumption and accelerates recovery after thoracic surgery: a randomized controlled trial. *Drug Des Devel Ther*. 2025;19:9137–9149. doi:10.2147/DDDT.S550595
29. Wei Y, Wei X, He F, et al. Effect of liposomal bupivacaine for preoperative thoracic paravertebral blockade on postoperative pain following video-assisted thoracoscopic lung surgery: a prospective, double-blind, randomized controlled trial. *J Cardiothorac Vasc Anesth*. 2025;S1053-0770(25):00812. doi:10.1053/j.jvca.2025.09.040
30. Shan XS, Liao DW, Guo J, et al. Effect of liposomal bupivacaine for preoperative erector spinae plane block on postoperative pain following video-assisted thoracoscopic lung resection: a multicenter, randomized, double-blind, clinical trial. *Int J Surg*. 2025. doi:10.1097/JS9.0000000000003956
31. Chi Y, Su X, Liu S, et al. Liposomal bupivacaine intercostal nerve block for pain control in thoracoscopic surgery: a randomized controlled trial. *Front Med Lausanne*. 2025;12:1647324. doi:10.3389/fmed.2025.1647324
32. Dong L, Wang X, Fu L, et al. Efficacy and safety of bupivacaine liposomal in intercostal nerve block for postoperative pain management following uniportal thoracoscopy: a randomized trial. *Pain Res Manag*. 2025;2025(1):8816879. doi:10.1155/prm/8816879
33. Chen R, Wang Z. Efficacy of liposomal as compared to standard bupivacaine for intercostal nerve blocks in patients undergoing minimally invasive thoracic surgery: a systematic review and meta-analysis. *Minimally Invasive Therapy Allied Technol*. 2025;34(3):219–229. doi:10.1080/13645706.2024.2440910
34. Wang L, Yu Q, Xiao J, et al. Cigarette smoke extract-treated mouse airway epithelial cells-derived exosomal LncRNA MEG3 promotes M1 macrophage polarization and pyroptosis in chronic obstructive pulmonary disease by upregulating TREM-1 via m 6 A methylation. *Immune Netw*. 2024;24(2):e3. doi:10.4110/in.2024.24.e3
35. White WL. Erratum to: why i hate the index finger. *Hand*. 2011;6(2):233. doi:10.1007/s11552-011-9321-0
36. Jones A, Le-Wendling L, Ihnatsenka B, et al. Empirical guide to a safe thoracic paravertebral block based on dimensions of paravertebral space when ultrasound visualization is challenging. *Reg Anesth Pain Med*. 2024;49(2):133–138. doi:10.1136/rapm-2022-104181
37. Oostvogels L, Weibel S, Meißner M, et al. Erector spinae plane block for postoperative pain. *Cochrane Database Syst Rev*. 2024;2(2):CD013763. doi:10.1002/14651858.CD013763.pub3
38. Guerra-Londono CE, Privorotskiy A, Cozowicz C, et al. Assessment of intercostal nerve block analgesia for thoracic surgery: a systematic review and meta-analysis. *JAMA Network Open*. 2021;4(11):e2133394. doi:10.1001/jamanetworkopen.2021.33394
39. Capuano P, Hileman BA, Martucci G, et al. Erector spinae plane block versus paravertebral block for postoperative pain management in thoracic surgery: a systematic review and meta-analysis. *Minerva Anestesiologica*. 2023;89(11):1042–1050. doi:10.23736/S0375-9393.23.17510-9
40. Rathmell JP. Liposomal bupivacaine, scientific evidence, and the clinician's conundrum. *Anesthesiology*. 2024;140(5):865–867. doi:10.1097/ALN.0000000000004935
41. Chen JJ, Wu YC, Wang JS, et al. Liposomal bupivacaine administration is not superior to traditional periarticular injection for postoperative pain management following total knee arthroplasty: a meta-analysis of randomized controlled trials. *J Orthop Surg Res*. 2023;18(1):206. doi:10.1186/s13018-023-03699-4
42. Hussain N, Speer J, Abdallah FW. Analgesic effectiveness of liposomal bupivacaine versus plain local anesthetics for abdominal fascial plane blocks: a systematic review and meta-analysis of randomized trials. *Anesthesiology*. 2024;140(5):906–919. doi:10.1097/ALN.0000000000004932
43. Nguyen A, Grape S, Gobbetti M, et al. The postoperative analgesic efficacy of liposomal bupivacaine versus long-acting local anaesthetics for peripheral nerve and field blocks: a systematic review and meta-analysis, with trial sequential analysis. *Eur J Anaesthesiol*. 2023;40(9):624–635. doi:10.1097/EJA.0000000000001833
44. Hussain N, Brull R, Sheehy BT, et al. The mornings after-periarticular liposomal bupivacaine infiltration does not improve analgesic outcomes beyond 24 hours following total knee arthroplasty: a systematic review and meta-analysis. *Reg Anesth Pain Med*. 2021;46(1):61–72. doi:10.1136/rapm-2020-101995