

Peripheral Nerve Blocks Following Open Hepatectomy: A Systematic Review and Network Meta-Analysis

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Background: This network meta-analysis (NMA) was conducted to evaluate the analgesic efficacy of various nerve blocks in patients undergoing open partial hepatectomy.

Methods: We retrieved randomized controlled trials (RCTs) assessing different peripheral nerve blocks in patients undergoing open partial hepatectomy from databases including PubMed, Embase, Web of Science, and the Cochrane Library, spanning from inception until December 2025. The NMA was performed using STATA 17.0 software.

Results: A total of 17 RCTs involving 1056 patients and 8 techniques were included in the analysis. Continuous Transversus Abdominis Plane Block (cTAPB) and continuous Thoracic Paravertebral Block (cTPVB) significantly decreased morphine consumption within 24 hours. The Erector Spinae Plane Block (ESPB) and Thoracoabdominal Nerve Block (TANB) reduced resting Visual Analog Scale (VAS) scores at 6 hours. At 12 hours, resting VAS scores were decreased by ESPB and subcostal Transversus Abdominis Plane Block (sTAPB), while at 24 hours, resting VAS scores were lowered by TANB and cTAPB. For movement VAS scores, reductions were observed at 6 hours with ESPB and cTPVB, at 12 hours with ESPB and sTAPB, and at 24 hours with TANB and External Oblique Intercostal Plane Block (EOIPB). Additionally, ESPB and TANB were associated with a decrease in the incidence of postoperative nausea and vomiting (PONV).

Conclusion: While cTAPB and cTPVB ranked higher in terms of reducing 24-hour morphine consumption, the clinical difference between these techniques and other interventions was small. ESPB was more likely to reduce VAS within the first 12 hours and the PONV incidence. Nevertheless, the certainty of evidence for these findings remains low to moderate, and further high-quality randomized controlled trials are warranted to confirm their clinical utility.

Limitation: The studies included in our review exhibited inconsistencies in study design and analgesia protocols, which may introduce bias into our findings. The results may not be directly applicable to laparoscopic procedures. The absence of these unpublished data or ongoing trials could limit the comprehensiveness of our analysis.

Keywords: pain, nerve block, hepatectomy, systematic review, network meta-analysis

Introduction

Open hepatectomy is a common surgical procedure for various hepatic conditions, including liver tumors, metastases, and cirrhosis.¹ Postoperative pain following open hepatectomy can be significant, adversely affecting patient recovery and prolonging hospital stays.² Studies have shown that poor postoperative pain control can lead to complications such as delayed mobilization, increased levels of anxiety and distress, and a subsequent rise in healthcare costs.² Therefore, effective pain management strategies are crucial for improving patient outcomes and reducing the overall burden on healthcare resources.

Current analgesic strategies following open hepatectomy often combine systemic medications with regional nerve blocks.³ This multimodal approach aims to optimize pain control while minimizing the side effects commonly associated with systemic opioids.⁴ Regional analgesia has been shown to provide superior pain relief, decrease the need for opioids,

and promote earlier mobilization compared to systemic analgesia alone.⁴ The synergistic effect of combining systemic analgesics with regional nerve blocks not only enhances analgesia but also contributes to improved patient satisfaction and faster recovery times.⁴

Despite the recognized benefits of various nerve block techniques,^{5–8} there remains a lack of consensus regarding the most effective type of regional analgesia for patients undergoing open hepatectomy. Numerous regional blocks have been proposed, each with its own advantages and limitations; however, determining which technique best meets the specific analgesic needs of these patients remains uncertain, particularly as new nerve block techniques continue to emerge. Network meta-analysis (NMA) extends beyond traditional pairwise meta-analysis by enabling the simultaneous comparison of multiple interventions. It achieves this by integrating both direct and indirect evidence within a coherent analytical framework, whereas conventional meta-analyses are restricted to direct comparisons between two interventions. Therefore, the necessity of our study lies in conducting a systematic review and NMA to comprehensively evaluate and compare the analgesic efficacy of existing regional nerve blocks following open hepatectomy. This research aims to establish evidence-based recommendations that could enhance postoperative pain management for patients undergoing this complex surgical procedure.

Methods

The protocol for this review was preregistered and published in the International Prospective Register of Systematic Reviews (CRD420251239156). This NMA adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.⁹

Eligibility Criteria

Eligibility criteria were designed based on the PICOS framework: patients undergoing open partial hepatectomy (P); regional analgesic techniques, including erector spinae plane block (ESPB), thoracic paravertebral block (TPVB), transversus abdominis plane block (TAPB), quadratus lumborum block (QLB), thoracoabdominal nerve block (TANB), and external oblique intercostal plane block (EOIPB) (I); comparisons with one of the regional analgesic techniques, placebo, or no intervention (C); outcomes measured as morphine consumption within 24 hours, postoperative pain scores, or postoperative nausea and vomiting (PONV) (O); and inclusion of randomized controlled trials (RCTs) (S). Studies were excluded based on the following criteria: (1) incomplete data that could not be utilized for statistical analysis; (2) unpublished studies or those utilizing parallel and crossover randomized designs; and (3) studies with duplicated data or incomplete information.

Search Strategy

We conducted a comprehensive search across PubMed, Embase, Web of Science, and the Cochrane Library, without language restrictions, from inception until December 2025. Following the PICOS principles, the search utilized the following headings: “hepatectomy,” “liver,” “pain,” and “block.” We employed MeSH terms, free-text keywords, and Boolean operators (OR and AND) to refine our search. The complete search strategy for PubMed, as a representative example, is detailed in [Table S1](#).

Study Selection

Two independent investigators sequentially reviewed all titles and abstracts, followed by full-text assessments. Any disagreements regarding study eligibility between the two reviewers were resolved by a third reviewer. We extracted relevant data from the eligible literature, ensuring accuracy through confirmation by both investigators. The following characteristics were systematically extracted from each included study: author, year of publication, country of origin, blinding methods, treatment descriptions, sample size, rescue analgesic regimens, and reported outcomes.

Data Extraction and Data Retrieval

The primary outcome assessed was cumulative morphine consumption, quantified in intravenous morphine equivalent doses (mg) within the first 24 hours postoperatively.¹⁰ Secondary outcomes included the incidence of postoperative

nausea and vomiting (PONV) within 24 hours, as well as resting and movement pain scores recorded at 6, 12, and 24 hours. Pain scores were standardized on a 0 to 10 Visual Analog Scale (VAS), with the VAS score at 6 hours defined as the maximum pain score recorded from 2 to 6 hours after surgery, and similar endpoints applied for scores at 8 to 12 hours and 20 to 24 hours.

Quality of Evidence

Two independent reviewers evaluated the risk of bias using the Cochrane Collaboration's Risk of Bias Tool, which assesses the following domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other potential sources of bias.¹¹ To evaluate the confidence in the findings from the network meta-analysis, we employed the Confidence in Network Meta-analysis (CINeMA 2.0.0) framework, which considers six domains: within-study bias, reporting bias, indirectness, imprecision, heterogeneity, and incoherence.^{12,13} The GRADE methodology was utilized to assess the quality of evidence for each outcome.¹⁴

Statistical Analysis

Statistical analysis was conducted using STATA 17.0 software, employing a random-effects model to synthesize the data. Effect estimates were reported as relative risk (RR) with 95% confidence intervals (CIs) for dichotomous variables, and mean differences (MD) with 95% CIs for continuous variables. Data expressed as medians with interquartile ranges were converted into means and standard deviations using the validated formulas from Luo and Wan.^{15,16} Network geometry maps provided visual representations of the relationships between pairs of interventions, while forest plots illustrated study outcomes and global heterogeneity results. Network league tables displayed the relative effectiveness of each intervention. The Surface Under the Cumulative Ranking Curve (SUCRA) was used to estimate ranking probabilities for all interventions, with lower values indicating superior effects. Publication bias was assessed using a funnel plot, and node-splitting inconsistency testing was employed to identify local inconsistencies. A P-value of <0.05 was considered statistically significant for all analyses. Sensitivity and subgroup analyses were planned to explore potential sources of heterogeneity as necessary.

Results

We identified a total of 561 potentially relevant records, ultimately including 17 RCTs that examined 8 distinct regional analgesia techniques in this NMA.^{17–33} The study selection process is illustrated in [Figure 1](#), and [Table 1](#) details the characteristics of the included studies. The primary outcome was reported in 11 of the RCTs, with the ESPB and TAPB being the most frequently utilized interventions.

Primary Outcome

Cumulative Morphine Consumption Within 24 h

Eleven studies with 743 patients were included. The network geometry of eligible comparisons displayed complete, as all nodes could be connected ([Figure 2](#)). The network forest plot did not show any global heterogeneity between trials and the results supported the consistency model ([Figure 3](#)). The result of inconsistency testing did not show any significant local inconsistency ([Table 2](#)). [Figure 4](#) showed that cTAPB attained the lowest SUCRA value (28.1), followed closely by cTPVB (30.8), and subcostal TAPB (sTAPB, 46.4), while EOIPB (77.0) occupied the higher positions in the ranking. Small study bias or any publication bias was not observed in funnel plot ([Figure 5](#)). The risk of bias might increase due to an undisclosed blinding method in a study²⁸ ([Figure 6](#)). Additionally, [Table 3](#) showed the difference in effect size between all treatments.

Secondary Outcomes

Resting VAS at 6 h

Ten studies with 583 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that

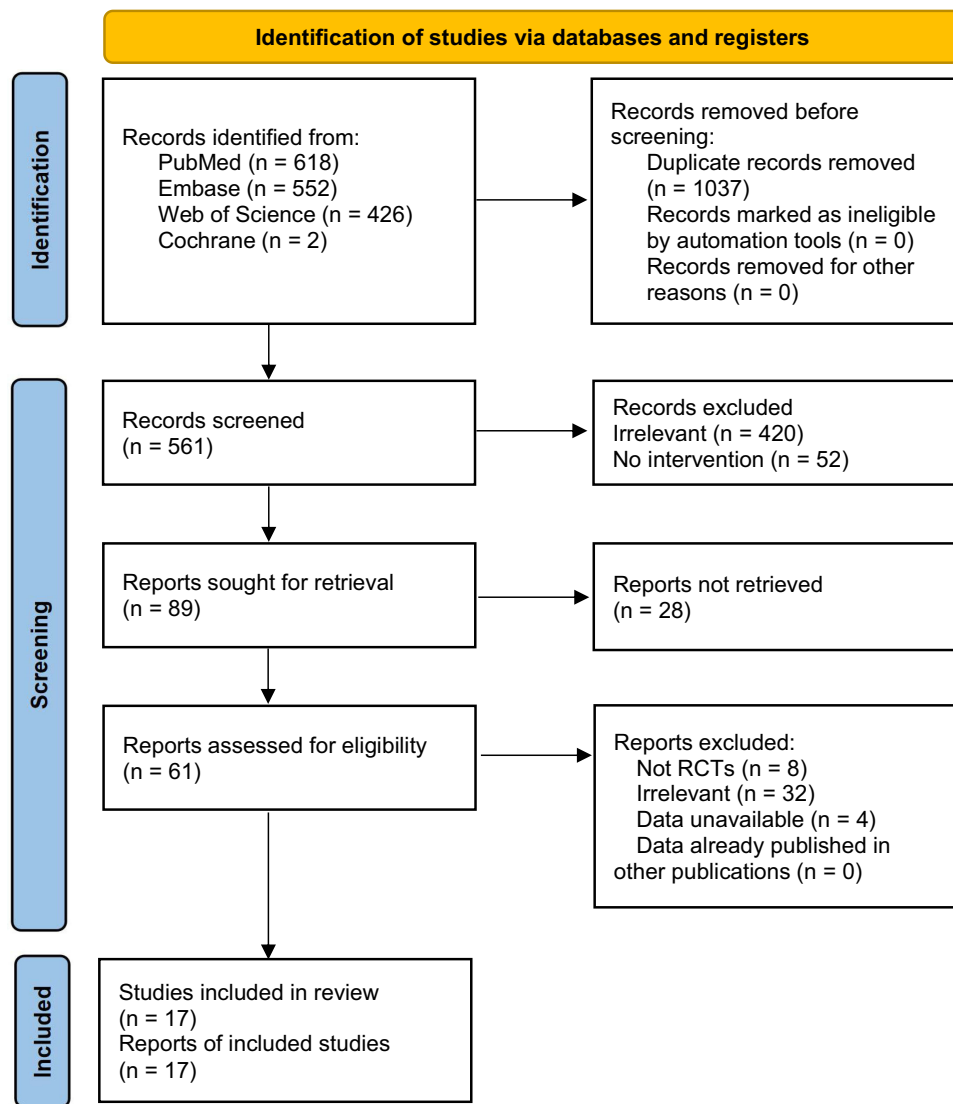


Figure 1 PRISMA flow diagram of study selection.

ESPB attained the lowest value (17.1), followed closely by TANB (41.7), and sTAPB (52.1), while EOIPB (55.9) and cTAPB (66.6) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S2A–C](#), [Table S2A](#) and [B](#).

Table 1 Study Characteristics of Included studies^{17–33}

Study	Country	Blinding	Comparison (n)	Rescue Analgesic Regimen	Outcomes
Guo 2018 ¹⁷	China	I	TAPB(35): 40mL of 0.375% ropivacaine Contorl(35): saline at the same scheme of administration	A sufentanil PCIA and iv 40 mg parecoxib every 12 h	(3)(4)(6)(7)(8)
Mao 2023 ¹⁸	China	I	QLB(29): 40 mL of 0.5% ropivacaine TAPB(30): 40 mL of 0.5% ropivacaine.	A sufentanil PCIA and iv 5 mg dezocine if necessary	(1)(8)
Mostafa 2023 ¹⁹	Egypt	I	ESPB(30): 40 mL of 0.25% bupivacaine sTAPB(30): 40 mL of 0.25% bupivacaine	IV paracetamol 1 g/6 h and ketorolac 30 mg/8 h, and iv 2 mg morphine if NRS > 3	(1)(2)(3)(4)(5)(6)(7)(8)

(Continued)

Table 1 (Continued).

Study	Country	Blinding	Comparison (n)	Rescue Analgesic Regimen	Outcomes
Wang 2025 ²⁰	China	1	Control(37): no block sTAPB(37): 60 mL of 0.3% ropivacaine	IV hydromorphone and flurbiprofen	(1)(2)(4)(5)(7)
Hacıbeyoğlu 2022 ²¹	Turkey	1	Control(25): no block ESPB(25): 40 mL of 0.375% bupivacaine + 4 mg of dexamethasone	A morphine PCIA and iv 0.5 mg/kg meperidine if NRS > 4	(1)(2)(3)(4)(5)(6)(7)(8)
Huang 2020 ²²	China	1	TAPB(42): 40 mL of ropivacaine 3 mg/kg plus dexamethasone 0.1 mg/kg Control(41): no block	A sufentanil PCIA and iv parecoxib 40 mg every 12 h	(2)(4)(8)
Chen 2014 ²³	China	1	cTPVB(22): 10 mL bolus of 0.2% ropivacaine, followed by a continuous infusion at 6 mL/h Control(22): saline at the same scheme of administration	A sufentanil PCIA and iv tramadol	(1)(5)(6)(7)(8)
Gungor 2025 ²⁴	Turkey	1	TANB(25): 60 mL of 0.25% bupivacaine Control(25): no block	A fentanyl PCIA and iv 1g acetaminophen every 8 h, then iv 0.5 mg/kg meperidine if NRS > 3	(2)(3)(4)(5)(6)(7)(8)
Fu 2020 ²⁵	China	1	ESPB(30): 40mL of 0.5% ropivacaine Control(30): no block	IV morphine and fentanyl	(2)(3)(4)(5)(6)(7)(8)
Tong 2025 ²⁶	China	2	EOIPB(35): 30mL of 0.375% ropivacaine Control(35): saline at the same scheme of administration	A hydromorphone PCIA	(1)(8)
Cui 2022 ²⁷	China	2	cTPVB(36): 0.2% ropivacaine at 0.125 mL/kg/h Control(37): saline at the same scheme of administration	A morphine PCIA	(1)(3)(4)(6)(7)(8)
Serag 2014 ²⁸	Egypt	NR	cTAPB(25): 0.375% bupivacaine every 8 h Control(25): no block	A fentanyl PCIA	(1)(2)(3)(4)(8)
Erdogan 2017 ²⁹	Turkey	2	TAPB(22): 40 mL of 0.5% bupivacaine Control(22): no block	A morphine PCIA and iv acetaminophen 1000 mg every 6 h	(1)
Kitlik 2017 ³⁰	Turkey	2	TAPB(25): 40 mL of 1.5 mg/kg bupivacaine Control(25): no block	A morphine PCIA iv acetaminophen 1000 mg every 6 h	(2)(3)(4)(5)(6)(7)(8)
Bang 2025 ³¹	Korea	2	ESPB(38): 40 mL of 0.5% ropivacaine QLB(38): 40 mL of 0.5% ropivacaine Control(37): no block	A fentanyl PCIA and iv ibuprofen 800 mg every 8 h	(1)(4)(7)
Sahin 2025 ³²	Turkey	2	EOIPB(32): 40 mL of 0.25% bupivacaine sTAPB(33): 40 mL of 0.25% bupivacaine	A morphine PCIA and iv ibuprofen 400 mg every 6 h, then IV 1 mg/kg tramadol if necessary	(1)(2)(3)(4)(5)(6)(7)(8)
Uludag 2024 ³³	Turkey	1	ESPB(20): 40 mL of 0.25% bupivacaine Control(21): no block	A fentanyl PCIA and iv 1000 mg acetaminophen every 8 h, then iv 0.5 mg/kg meperidine if NRS ≥ 4	(1)(2)(3)(4)(5)(6)(7)(8)

Notes: (1) morphine consumption within 24 h. (2) resting pain scores at 6 h. (3) resting pain scores at 12 h. (4) resting pain scores at 24h. (5) movement pain scores at 6 h. (6) movement pain scores at 12 h. (7) movement pain scores at 24 h. (8) postoperative nausea and vomiting (PONV).

Abbreviations: NR, not reported; ESPB, erector spinae plane block; TPVB, thoracic paravertebral block; TAPB, transversus abdominis plane block; QLB, quadratus lumborum block; TANB, thoracoabdominal nerve block; EOIPB, external oblique intercostal plane block; sTAPB, subcostal TAPB; cTAPB, continuous TAPB; cTPVB, continuous TPVB; IV, intravenous injection; PCIA, patient-controlled intravenous analgesia; NRS, numeric rating scale.

Resting VAS at 12 h

Ten studies with 569 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that ESPB attained the lowest value (27.1), followed closely by sTAPB (37.0), and EOIPB (40.2), while cTPVB (59.1) and TAPB (60.2) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S3A–C](#), [Table S3A](#) and [B](#).

Resting VAS at 24 h

Thirteen studies with 839 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that TANB attained the lowest value (38.5), followed closely by cTAPB (44.5), and EOIPB (50.1), while TAPB (52.6) and

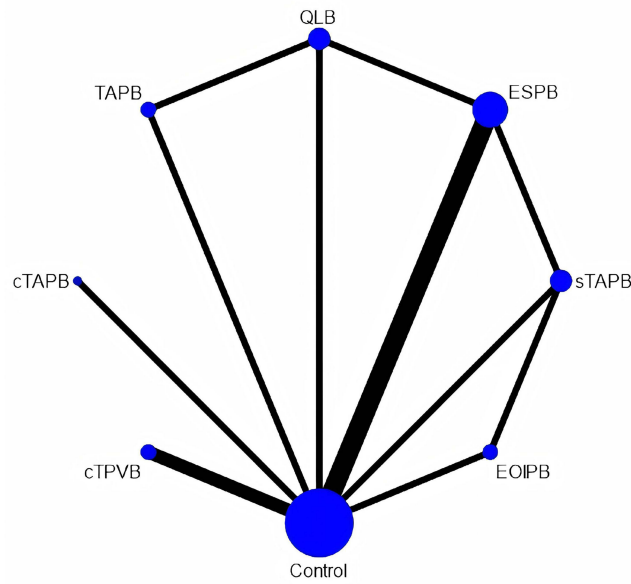


Figure 2 Network map.

Abbreviations: ESPB, erector spinae plane block; QLB, quadratus lumborum block; TAPB, transversus abdominis plane block; sTAPB, subcostal TAPB; EOIPB, external oblique intercostal plane block; cTAPB, continuous TAPB; cTPVB, continuous thoracic paravertebral block.

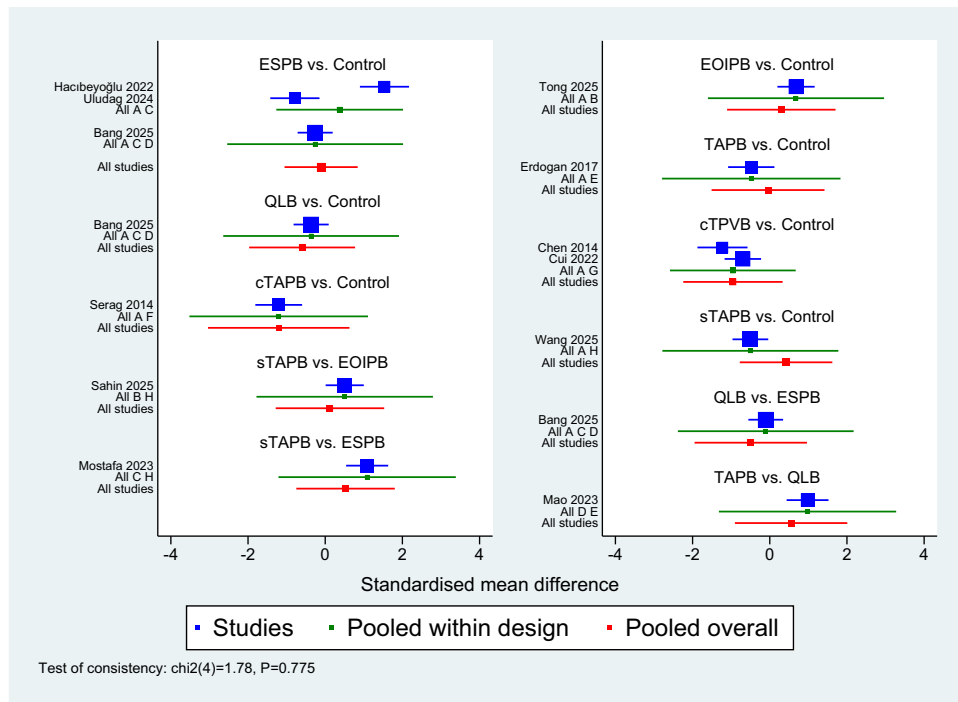


Figure 3 Forest plot.

cTPVB (54.2) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S4A–C](#), [Table S4A](#), and [B](#).

Movement VAS at 6 h

Nine studies with 494 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that

Table 2 Node-Splitting of Morphine Consumption

Side	Direct		Indirect		Difference		P> z
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	
Control vs EOIPB	0.6807341	0.9681632	-0.3012475	1.215038	0.9819816	1.553595	0.527
Control vs. ESPB	0.1542743	0.5252639	-1.214569	1.082674	1.368844	1.203406	0.255
Control vs. QLB	-0.3646586	0.9913152	-0.9317053	1.182805	0.5670467	1.543482	0.713
Control vs. TAPB	-0.4795713	0.9720663	0.7211959	1.292194	-1.200767	1.616997	0.458
Control vs. sTAPB	-0.503157	0.8252273	1.171512	0.745299	-1.674669	1.111967	0.132
EOIPB vs. sTAPB	0.5058522	0.9697706	-0.4760835	1.21424	0.9819356	1.553973	0.527
ESPB vs. QLB	-0.1043078	0.9572931	-1.258118	1.3421	1.15381	1.648472	0.484
ESPB vs. sTAPB	1.087206	0.9525359	-0.0202799	0.9425935	1.107486	1.340077	0.409
QLB vs. TAPB	0.9786223	0.9632747	-0.2223995	1.299436	1.201022	1.617539	0.458

Abbreviations: ESPB, erector spinae plane block; TAPB, transversus abdominis plane block; QLB, quadratus lumborum block; EOIPB, external oblique intercostal plane block; sTAPB, subcostal TAPB.

ESPB attained the lowest value (27.4), followed closely by cTPVB (47.8), and EOIPB (52.0), while TANB (54.4) and TAPB (55.0) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S5A–C](#), [Table S5A](#) and [B](#).

Movement VAS at 12 h

Ten studies with 563 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that ESPB attained the lowest value (25.4), followed closely by sTAPB (37.1), and EOIPB (40.8), while TAPB (59.8) and cTPVB (61.8) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S6A–C](#), [Table S6A](#) and [S6B](#).

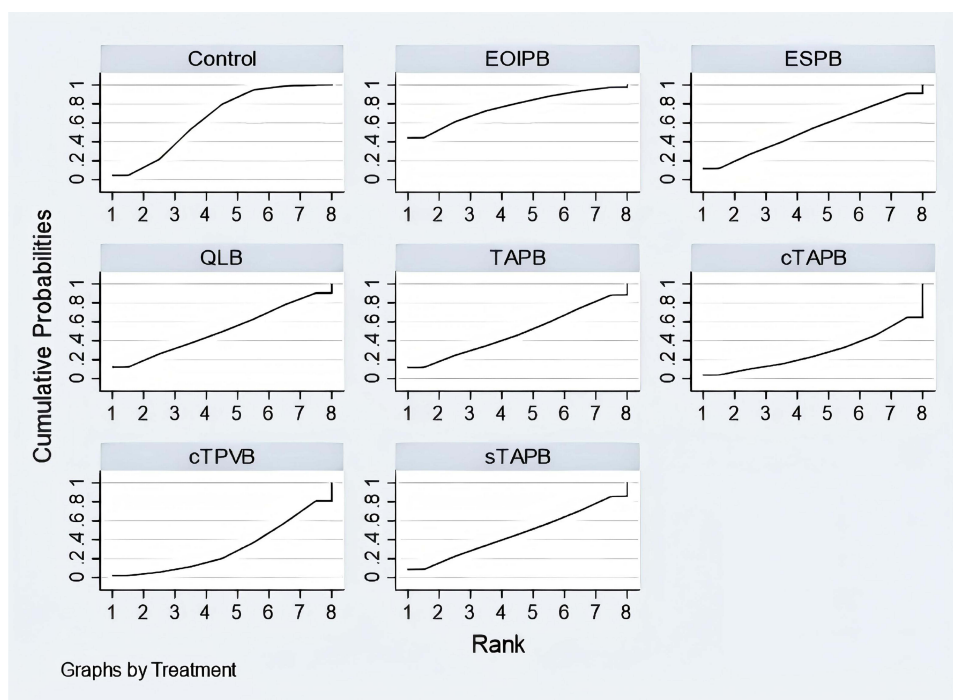


Figure 4 SUCRA. Control (64.8), EOIPB (77.0), ESPB (53.1), QLB (51.0), TAPB (48.6), cTAPB (28.1), cTPVB (30.8), sTAPB (46.4).

Abbreviations: ESPB, erector spinae plane block; QLB, quadratus lumborum block; TAPB, transversus abdominis plane block; sTAPB, subcostal TAPB; EOIPB, external oblique intercostal plane block; cTAPB, continuous TAPB; cTPVB, continuous thoracic paravertebral block.

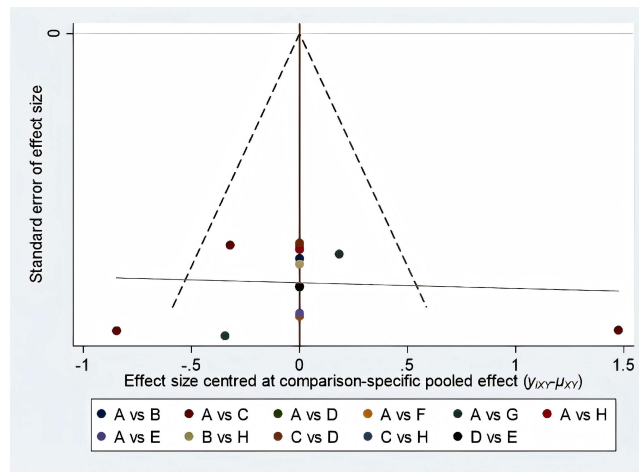


Figure 5 Funnel plot.

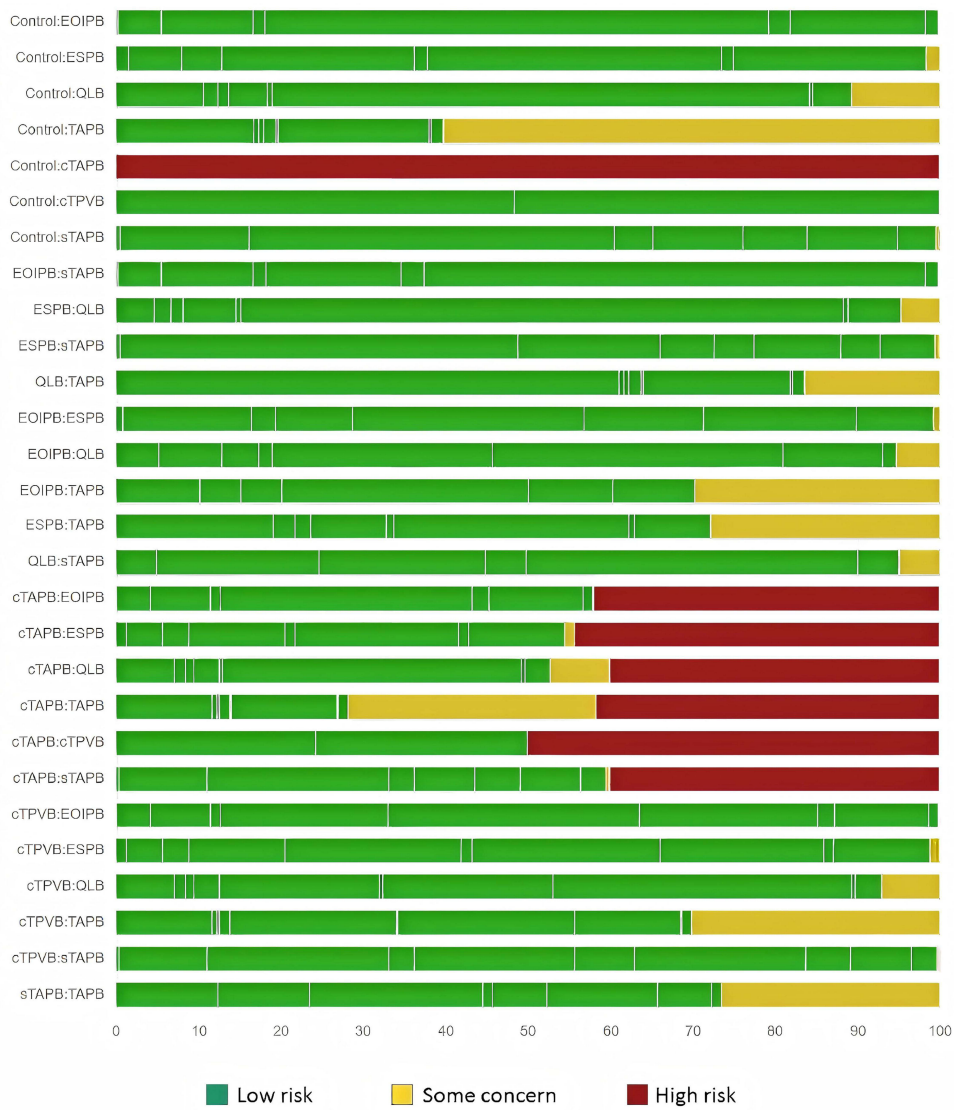


Figure 6 Risk of bias.

Table 3 Netleague of Resting VAS at 6 h After Surgery

Control								
1.20 (-1.11,3.52)	sTAPB							
0.48 (-1.83,2.79)	0.45 (-2.35,3.26)	cTPVB						
-1.09 (-5.07,2.88)	0.70 (-2.55,3.95)	0.25 (-2.58,3.08)	cTAPB					
0.37 (-1.91,2.64)	-0.02 (-3.27,3.22)	-0.48 (-3.31,2.35)	-0.73 (-4.00,2.55)	TAPB				
-0.37 (-2.02,1.27)	-0.14 (-3.36,3.08)	-0.59 (-3.39,2.21)	-0.84 (-4.09,2.41)	-0.11 (-3.36,3.13)	QLB			
0.64 (-2.17,3.44)	-0.88 (-3.69,1.93)	-1.33 (-3.64,0.98)	-1.58 (-4.42,1.26)	-0.85 (-3.69,1.98)	-0.74 (-3.55,2.07)	ESPB		
-0.68 (-2.96,1.60)	-1.18 (-4.41,2.04)	-1.64 (-4.44,1.17)	-1.88 (-5.13,1.37)	-1.16 (-4.41,2.09)	-1.04 (-4.27,2.18)	-0.30 (-3.12,2.51)	EOIPB	

Abbreviations: ESPB, erector spinae plane block. TAPB, transversus abdominis plane block. QLB, quadratus lumborum block. EOIPB, external oblique intercostal plane block. sTAPB, subcostal TAPB. cTAPB, continuous TAPB. cTPVB, continuous thoracic paravertebral block.

Movement VAS at 24 h

Twelve studies with 750 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that TANB attained the lowest value (31.9), followed closely by EOIPB (47.1), and TAPB (51.5), while QLB (53.9) and cTPVB (60.9) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S7A–C](#), [Table S7A](#) and [B](#).

Postoperative Nausea and Vomiting (PONV)

Fourteen studies with 825 patients were included. The network geometry of eligible comparisons displayed complete. There were no significant global heterogeneity and local inconsistency could be found. The result of SUCRA showed that ESPB attained the lowest value (25.3), followed closely by TANB (29.6), and QLB (30.3), while sTAPB (66.2) and cTPVB (65.4) occupied the higher positions in the ranking. The netleague showed the difference in effect size between all treatments. All results were shown in [Figure S8A–C](#), [Table S8A](#) and [B](#).

Discussion

The results of our NMA revealed small differences in the efficacy of various regional analgesia techniques for managing postoperative pain following open hepatectomy. Notably, both cTAPB and cTPVB are more likely to reduce morphine consumption within the first 24 hours postoperatively, as suggested by the SUCRA rankings. However, the clinical differences were small when compared with other other interventions. Meanwhile, the analgesic effect of a single injection is not as prolonged as that achieved with continuous infusion of local anesthetics (LAs). The ESPB was shown to be an effective treatment for reducing both resting and movement VAS scores within the first 12 hours. ESPB effectively targets the sensory nerves supplying the thoracic region, thereby blocking both incisional and visceral pain, which results in superior analgesic effects compared to TAPB, sTAPB, cTAPB, TANB, and EOIPB. Furthermore, when compared to TPVB and QLB, ESPB may offer broader analgesic coverage due to the more extensive spread of local anesthetic within the muscle plane, potentially affecting multiple dermatomes and a larger area of pain reception. While TANB appeared to be more effective in reducing resting and movement VAS scores at 24 hours, it is important to note that the effectiveness of current nerve blocks may diminish over time, and the observed low VAS values could be attributed to the use of rescue analgesic medications. Although ESPB and TANB were associated with a reduced incidence of PONV, we do not recommend these techniques specifically for this purpose, as no direct causal relationship was established, and PONV is influenced by multiple factors. Additionally, our study found no evidence of global heterogeneity or local inconsistency; however, the overall levels of evidence were diminished by some studies lacking sufficiently rigorous methodologies ([Table 4](#)).

Currently, there are few studies that discuss the analgesic effects of peripheral nerve blocks in open partial hepatectomy. Abdildin's research indicated that the TAPB decreased resting pain at 24 hours postoperatively; however, it did not reduce total opioid consumption and PONV. These findings are consistent with our own results, suggesting that the incisional pain following open surgery can be quite severe, and TAPB does not effectively enhance the quality of

Table 4 Summary of Evidence

Outcomes	Patients (Trails)	Results	Certainty (Grade)
Morphine consumption within 24 h	743 (11)	cTAPB and cTPVB were superior to others	⊕⊕⊕○ moderate
Resting VAS at 6 h	583 (10)	ESPB and TANB were superior to others	⊕⊕○○ low
Resting VAS at 12 h	569 (10)	ESPB and sTAPB were superior to others	⊕⊕○○ low
Resting VAS at 24 h	839 (13)	TANB and cTAPB were superior to others	⊕⊕○○ low
Movement VAS at 6 h	494 (9)	ESPB and cTPVB were superior to others	⊕⊕⊕○ moderate
Movement VAS at 12 h	563 (10)	ESPB and sTAPB were superior to others	⊕⊕⊕○ moderate
Movement VAS at 24 h	750 (12)	TANB and EOIPB were superior to others	⊕⊕⊕○ moderate
PONV	825 (14)	ESPB and TANB were superior to others	⊕⊕○○ low

Abbreviations: ESPB, erector spinae plane block; TAPB, transversus abdominis plane block; QLB, quadratus lumborum block. TANB, thoracoabdominal nerve block; EOIPB, external oblique intercostal plane block; sTAPB, subcostal TAPB; cTAPB, continuous TAPB; cTPVB, continuous thoracic para-vertebral block; VAS, visual analog scale; PONV, postoperative nausea and vomiting.

analgesia.³⁴ Postoperative pain following open liver resection primarily arises from several sources. First, incisional pain occurs due to the tissue damage associated with abdominal incision, affecting the skin, muscles, and abdominal wall nerves, leading to localized discomfort.³⁵ Second, visceral pain may result from irritation or injury to the intra-abdominal organs, particularly the liver and surrounding structures, which can elicit deep, dull pain in the abdominal cavity.³⁶ Additionally, the postoperative inflammatory response contributes to pain by releasing inflammatory mediators that sensitize nociceptive pathways.³⁷ Currently, there is considerable variation in the analgesic coverage provided by different regional anesthesia techniques, and not all methods are capable of fully addressing incisional pain. Additionally, some techniques may not be effective for managing visceral pain.

The ESPB involves the injection of LA into the plane superficial to the erector spinae muscles. This technique effectively targets the dorsal rami of the spinal nerves, providing analgesia for both somatic and visceral pain in the thoracic and abdominal regions.³⁸ ESPB is associated with a wide analgesic coverage, making it particularly effective for managing postoperative pain.³⁸ Its advantages include a low risk of complications and a straightforward technique, although potential risks such as infection, hematoma, and rare instances of pneumothorax should be considered.³⁸ The TPVB involves the injection of LA into the paravertebral space, which is the area lateral to the vertebral column and contains the ventral and dorsal rami of the spinal nerves, as well as the sympathetic chain.³⁹ By targeting this space, TPVB blocks the transmission of nociceptive signals from multiple spinal segments, effectively providing analgesia for somatic pain from the thoracic and abdominal walls.³⁹ While TPVB is effective at providing segmental analgesia, it carries risks such as inadvertent vascular or pleural puncture, and complications can include unilateral block failure, hematoma, and neural injury.³⁹

The TAPB involves injecting LA into the fascial plane between the transversus abdominis muscle and the internal oblique muscle, effectively blocking the lower intercostal, subcostal, and iliohypogastric nerves.⁴⁰ The TAPB provides effective analgesia for the anterior abdominal wall, helping manage somatic pain associated with abdominal surgeries.⁴⁰ The sTAPB is a variation of the TAPB, where LA is injected subcostally to block the nerves innervating the abdominal wall.¹⁹ This block is designed to provide targeted analgesia for the upper abdominal region and incisional pain following surgery.¹⁹ Nevertheless, like TAPB, its limitations lie in its primary focus on somatic pain, potentially insufficiently addressing visceral discomfort.¹⁹ The QLB involves the injection of LA in the proximity of the quadratus lumborum muscle, targeting the thoracic and lumbar nerves.⁴¹ This technique has the potential to provide analgesia for both the abdominal and flank regions, and providing analgesia for visceral pain.⁴¹

The TANB involves the injection of LA near the thoracoabdominal nerves. This technique is effective for providing analgesia primarily for incisional pain and is valuable for patients undergoing upper abdominal surgeries.⁴² The EOIPB entails injecting LA in the plane between the external oblique muscle and the underlying intercostal muscles.⁴³ This technique targets the intercostal nerves, providing effective analgesia for the lateral and anterior thoracic wall and is particularly beneficial in managing postoperative pain following thoracic and abdominal surgery.⁴³ Additionally, cTAPB and cTPVB allows for continuous infusion of LA, providing sustained analgesia for abdominal surgery patients.

However, potential complications include catheter-related issues leading to infection or catheter misplacement, which must be monitored closely for optimal patient outcomes and careful tuning of local anesthetic dosages to avoid systemic toxicity.

Based on the above review, it is evident that the ESPB may be a suitable regional analgesia technique for patients undergoing open liver resections, as it offers a relatively broad coverage of incisional pain while also alleviating visceral pain. The TPVB may have better overall efficacy than ESPB, the comparison of VAS scores within the first 12 hours does not support its use as the preferred option for this specific surgical population. Moreover, the other analgesic techniques evaluated did not show significant advantages over ESPB. Additionally, the continuous infusion techniques appear to provide a more effective strategy for reducing morphine consumption. Therefore, future research should focus on exploring the efficacy of continuous infusion protocols within the context of ESPB to further enhance postoperative pain management in liver surgery patients.

Limitations

Despite the comprehensive nature of this systematic review and network meta-analysis, there are several limitations to consider. Firstly, the difference of the included studies may affect the consistency of the findings, as variations in study design, patient populations, and analgesia protocols can introduce bias. Secondly, our findings are specifically applicable to open hepatectomy and may not be directly extrapolated to laparoscopic procedures, necessitating further research in that area. Thirdly, while efforts were made to include all relevant studies, there may still be unpublished data or ongoing trials that could contribute to the findings, limiting the comprehensiveness of our analysis. Finally, the emergence of new regional blocks and analgesic strategies may rapidly change the landscape of pain management in open hepatectomy, meaning that our findings could become outdated as new evidence emerges.

Conclusions

Our systematic review and NMA indicated that cTAPB and cTPVB ranked higher in terms of reducing morphine consumption within 24 hours, but there was no significant clinical difference between these techniques and other interventions. Additionally, the ESPB was more likely to reduce pain scores within the first 12 hours postoperatively and decrease the incidence of PONV within 24 hours. Nevertheless, the certainty of evidence for these findings remains low to moderate, and further high-quality randomized controlled trials are warranted to confirm their clinical utility.

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Disclosure

The authors declare that they have no competing interests.

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