

Perioperative Anaesthesia Management and Enhanced Recovery after Cesarean Delivery: A Systematic Review

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Abstract

Background: Cesarean delivery is associated with significant postoperative pain, which may interfere with maternal mobilization, breastfeeding, satisfaction, and overall recovery. Intrathecal morphine provides effective analgesia but may cause opioid-related adverse effects. Regional techniques such as transversus abdominis plane (TAP), quadratus lumborum (QL), and erector spinae plane (ESP) blocks, together with multimodal analgesia and enhanced recovery after cesarean (ERAC/ERAS) pathways, have therefore gained increasing attention. The objective is to systematically evaluate the evidence regarding perioperative anesthesia and analgesic strategies for cesarean delivery, with particular emphasis on intrathecal morphine, TAP, QL and ESP blocks, multimodal analgesia, and ERAC/ERAS pathways, and to assess their effects on postoperative pain, opioid consumption, adverse effects, and maternal recovery. **Material and Methods:** A systematic review was conducted in accordance with PRISMA 2020 guidelines. PubMed/MEDLINE, Scopus, Web of Science, Embase, and the Cochrane Central Register of Controlled Trials were searched for studies published between 2012 and 2026. Original comparative clinical studies involving women undergoing cesarean delivery were eligible. Randomized controlled trials and prospective or retrospective comparative studies evaluating neuraxial opioids, regional/fascial-plane blocks, multimodal analgesia, or ERAC/ERAS pathways were included. The primary outcomes were postoperative pain intensity and opioid/rescue analgesic consumption. Secondary outcomes included time to rescue analgesia, duration of analgesia, postoperative nausea and vomiting, pruritus, mobilization, breastfeeding, maternal satisfaction, quality of recovery, and length of hospital stay. **Results:** Twenty-four original comparative studies were included, predominantly randomized controlled trials. Intrathecal morphine generally provided reliable and prolonged postoperative analgesia, although higher doses were associated with greater opioid-related adverse effects in some studies. TAP, QL, and ESP blocks provided effective postoperative analgesia and reduced rescue opioid requirements in selected settings, particularly when intrathecal morphine was not used. However, adding a QL block to intrathecal morphine did not consistently reduce 24-hour opioid consumption. Multimodal analgesia, including scheduled non-opioid medications, reduced opioid requirements and supported the use of lower intrathecal morphine doses in some protocols. ERAC/ERAS pathways consistently improved broader recovery outcomes, including length of hospital stay, early functional recovery, breastfeeding, pain, and quality of recovery, although opioid reduction was not uniform across studies. **Conclusion:** Current evidence supports a multimodal and individualized approach to perioperative anesthesia management for cesarean delivery. Intrathecal morphine remains an effective analgesic option, while TAP, QL, and ESP blocks provide useful opioid-sparing alternatives or adjuncts in selected patients. ERAC/ERAS pathways appear to provide the broadest recovery benefits by integrating analgesia with early mobilization, breastfeeding, and other components of maternal recovery.

Keywords: Cesarean Delivery, Perioperative Anaesthesia, Enhanced Recovery After Cesarean, Obstetric Anaesthesia, Multimodal Analgesia, Postoperative Recovery, Maternal Outcomes, ERAC.

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INTRODUCTION

Cesarean delivery is one of the most commonly performed surgical procedures in obstetric practice. Although cesarean delivery is generally safe, women may experience considerable postoperative pain during the early recovery period.^[1] Effective pain management is important not only for maternal comfort but also for early mobilization, breastfeeding, maternal satisfaction, and recovery after surgery.^[2,3]

Neuraxial anesthesia, particularly spinal anesthesia with intrathecal morphine, is widely used for cesarean delivery and provides effective and relatively prolonged postoperative analgesia.^[4] However, intrathecal opioids may

cause adverse effects such as pruritus, nausea, vomiting, sedation, and urinary retention. These concerns have increased interest in opioid-sparing analgesic strategies that can provide

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adequate pain relief while minimizing opioid-related side effects.^[5]

Regional and fascial-plane blocks, including the transversus abdominis plane (TAP) block, quadratus lumborum (QL) block, and erector spinae plane (ESP) block, have increasingly been studied as alternatives or additions to intrathecal opioids.^[6] Several clinical trials have reported that these techniques can reduce postoperative pain and rescue opioid requirements, although their effectiveness appears to vary depending on the type of block, anesthetic regimen, use of intrathecal morphine, and timing of administration.^[4,7,8]

At the same time, postoperative analgesia after cesarean delivery has moved from a single-drug approach toward multimodal analgesia. The use of scheduled non-opioid medications, regional anesthesia, and appropriately selected neuraxial opioids aims to provide effective pain control while reducing opioid exposure.^[9,10] In addition to analgesia, enhanced recovery after cesarean (ERAC) or enhanced recovery after surgery (ERAS) pathways address the broader recovery process, including early mobilization, breastfeeding, gastrointestinal recovery, maternal satisfaction, quality of recovery, and reduction in hospital stay.^[11,12]

Recent evidence suggests that ERAC/ERAS pathways can improve several maternal recovery outcomes, although their effect on opioid consumption has not been consistent across studies.^[13, 14] Similarly, regional techniques such as TAP, QL, and ESP blocks appear promising, but differences in study populations, anesthesia techniques, intrathecal morphine doses, multimodal analgesic regimens, and outcome measures make direct comparison difficult.^[15, 16] The studies included in the present review reflect this evolving evidence, ranging from early comparisons of intrathecal morphine and TAP block to more recent studies evaluating QL and ESP blocks, low-dose intrathecal morphine, multimodal analgesia, and ERAS pathways.

Therefore, there is a need to examine these approaches together rather than considering each analgesic technique in isolation. The present systematic review was undertaken to evaluate the evidence on perioperative anesthesia management and enhanced recovery following cesarean delivery, with particular emphasis on intrathecal opioids, TAP, QL and ESP blocks, multimodal analgesia, and ERAC/ERAS pathways. The review focuses on postoperative pain, opioid and rescue analgesic consumption, duration of analgesia, opioid-related adverse effects, mobilization, breastfeeding, maternal satisfaction, quality of recovery, length of hospital stay, and other relevant maternal outcomes.

MATERIALS AND METHODS

Study Design and Reporting Guidelines: This systematic review was conducted to evaluate the evidence regarding perioperative anesthesia management and enhanced recovery after cesarean delivery, with particular emphasis on neuraxial anesthesia, intrathecal opioids, regional/fascial-plane blocks, multimodal analgesia and

enhanced recovery pathways. The review was planned and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines.^[17]

Review Question: Among women undergoing cesarean delivery, do optimized perioperative anesthesia and enhanced recovery strategies, compared with conventional anesthesia/analgesic care or alternative regional techniques, improve postoperative pain control, reduce opioid consumption and facilitate maternal recovery?

PICO Framework:

- **Population:** Women undergoing cesarean delivery under spinal, combined spinal-epidural or general anesthesia.
- **Intervention:** Perioperative anesthesia and analgesic strategies including intrathecal morphine, intrathecal adjuvants, TAP block, quadratus lumborum (QL) block, erector spinae plane (ESP) block, other fascial-plane blocks, intravenous/non-opioid multimodal analgesia and enhanced recovery after cesarean (ERAC/ERAS) pathways.
- **Comparator:** Conventional analgesia, placebo/sham intervention, no regional block, alternative regional block, different intrathecal opioid dose or conventional perioperative care.
- **Outcomes:** Postoperative pain, opioid/rescue analgesic consumption, time to first rescue analgesia, duration of analgesia, postoperative nausea and vomiting (PONV), mobilization, urinary catheter removal, breastfeeding, maternal satisfaction, quality of recovery, length of hospital stay and adverse events.

Search Strategy: A comprehensive literature search was performed using PubMed/MEDLINE, Scopus, Web of Science, Embase and the Cochrane Central Register of Controlled Trials (CENTRAL).

Studies published from 2012 to 2026 were considered, allowing evaluation of the evolution of cesarean anesthesia and enhanced recovery strategies from early regional analgesic techniques to contemporary ERAC pathways. The search strategy combined controlled vocabulary and free-text terms related to cesarean delivery, anesthesia, regional blocks, intrathecal opioids, multimodal analgesia and enhanced recovery.

The principal search terms included: ("cesarean section" OR "caesarean section" OR "cesarean delivery" OR "caesarean delivery") AND ("spinal anesthesia" OR "spinal anaesthesia" OR "neuraxial anesthesia" OR "intrathecal morphine" OR "intrathecal opioid") AND ("TAP block" OR "transversus abdominis plane block" OR "quadratus lumborum block" OR "QL block" OR "erector spinae plane block" OR "ESP block" OR "fascial plane block" OR "regional anesthesia") AND ("postoperative analgesia" OR "postoperative pain" OR opioid OR morphine OR "multimodal analgesia" OR "enhanced recovery" OR ERAS OR ERAC).

Reference lists of relevant articles and previously published systematic reviews were also screened to identify additional eligible original studies.

Eligibility Criteria

Inclusion Criteria

Studies were included if they fulfilled the following criteria:

1. Original clinical studies involving women undergoing cesarean delivery.
2. Studies evaluating perioperative anesthesia, postoperative analgesia or enhanced recovery interventions.
3. Studies evaluating intrathecal morphine or other intrathecal analgesic regimens, TAP block, QL block, ESP block or other relevant regional/fascial-plane techniques.
4. Studies evaluating multimodal analgesia or enhanced recovery after cesarean delivery pathways.
5. Randomized controlled trials and prospective or retrospective comparative clinical studies.
6. Studies with an appropriate comparator group receiving conventional care, placebo/sham intervention, an alternative analgesic technique, different dose/regimen or standard perioperative management.
7. Studies reporting at least one relevant postoperative outcome, including pain scores, opioid consumption, rescue analgesic requirement, duration of analgesia, PONV, mobilization, breastfeeding, quality of recovery, maternal satisfaction or hospital stay.
8. Full-text articles published in English.

Exclusion Criteria:

The following studies were excluded:

1. Studies involving non-cesarean surgical populations.
2. Pediatric or non-obstetric populations.
3. Case reports, case series, editorials, letters and narrative reviews.
4. Systematic reviews, meta-analyses and clinical guidelines.
5. Animal, cadaveric, anatomical or laboratory studies.
6. Studies without a comparator group where comparative evaluation was not possible.
7. Duplicate publications or studies reporting the same patient population without additional relevant information.
8. Studies without sufficient outcome data.
9. Articles for which the full text was unavailable.
10. Studies published in languages other than English.

Study Selection: All identified records were screened after removal of duplicate publications. Titles and abstracts were assessed according to the predefined eligibility criteria. Potentially relevant studies were retrieved for full-text evaluation.

Full-text articles were independently assessed for eligibility, and reasons for exclusion were recorded. Reference lists of relevant studies and systematic reviews were additionally screened for potentially eligible original studies. Any disagreement between reviewers was resolved through discussion and consensus.

Data Extraction: Data were extracted using a standardized data-extraction form.

The extracted variables included first author, year of publication, country, study design, sample size, type of cesarean delivery, type of anesthesia, intervention, comparator, intrathecal opioid dose, regional block technique, local anesthetic regimen, timing of intervention, multimodal analgesic regimen, ERAC/ERAS components

and reported outcomes.

Postoperative outcomes extracted included pain scores, opioid/rescue analgesic consumption, time to first rescue analgesia, duration of analgesia, PONV, pruritus, sedation, urinary retention, time to mobilization, urinary catheter removal, breastfeeding, maternal satisfaction, quality-of-recovery scores, length of hospital stay and other reported adverse events.

Outcome Measures:

The primary outcomes were:

1. Postoperative pain intensity assessed using VAS or NRS.
2. Postoperative opioid or rescue analgesic consumption.

Secondary outcomes included:

- Time to first rescue analgesia
- Duration of postoperative analgesia
- PONV
- Pruritus and other opioid-related adverse effects
- Time to mobilization
- Urinary catheter removal
- Return of gastrointestinal function
- Breastfeeding
- Maternal satisfaction
- Quality of recovery
- Length of hospital stay
- Readmission or postoperative complications
- Block-related complications

Quality and Risk-of-Bias Assessment: The methodological quality of randomized controlled trials was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool, considering randomization, deviations from intended interventions, missing outcome data, outcome measurement and selective reporting (18). Comparative non-randomized studies, when included, were assessed using the ROBINS-I tool (19). Risk of bias was categorized according to the respective assessment framework.

Data Synthesis: The findings were initially synthesized descriptively according to the major intervention categories: intrathecal morphine and neuraxial anesthesia, TAP block, QL block, ESP block, other regional techniques, multimodal analgesia and ERAC/ERAS pathways.

Because substantial clinical and methodological heterogeneity was anticipated with respect to anesthetic techniques, intrathecal opioid doses, regional block techniques, analgesic regimens and outcome measurements, the primary synthesis was performed narratively.

Where studies were sufficiently homogeneous, quantitative synthesis could be considered. Continuous outcomes were summarized using mean difference (MD) when identical measurement scales were used and standardized mean difference (SMD) when different scales were used. Dichotomous outcomes were summarized using risk ratios (RR) or odds ratios (OR), with 95% confidence intervals.

Subgroup Analysis

Where adequate evidence was available, subgroup analyses were considered according to:

- Intrathecal morphine versus fascial-plane block
- TAP versus QL block
- QL versus ESP block
- Different intrathecal morphine doses

- Regional block versus no regional block
- Multimodal analgesia versus conventional analgesia
- ERAC/ERAS versus conventional perioperative care
- Elective versus emergency cesarean delivery
- Spinal/neuraxial versus general anesthesia
- Presence or absence of intrathecal morphine

RESULTS

Study Selection: The systematic literature search identified studies evaluating perioperative anesthesia, postoperative analgesia, regional anesthesia and enhanced recovery strategies following cesarean delivery. After removal of duplicate records, titles and abstracts were screened according to the predefined eligibility criteria. Potentially relevant articles were retrieved for full-text assessment. Studies were excluded when they involved non-cesarean surgical populations, did not include an appropriate comparator, were non-comparative publications, or did not report relevant postoperative outcomes. Reference-list screening of eligible articles and relevant systematic reviews was additionally performed to identify potentially missed original studies.

The final qualitative synthesis included 24 original comparative clinical studies, predominantly randomized controlled trials, evaluating intrathecal morphine, TAP block, QL block, ESP block, multimodal analgesia and enhanced recovery pathways.

The included studies were published between 2012 and 2026 and included elective as well as emergency cesarean deliveries. The studies demonstrated a progressive transition from comparison of individual analgesic techniques toward multimodal, opioid-sparing and enhanced recovery approaches.

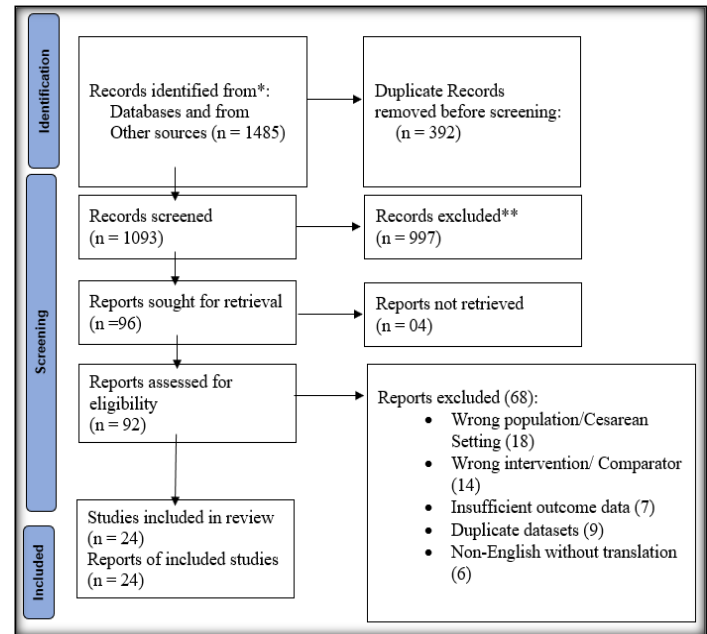


Table 1: Characteristics Of Included Original Studies

No.	Study	Design	Sample	Intervention / comparison	Main findings relevant to review
1	Loane et al., 2012, ^[20]	Double-blind RCT	69 enrolled; 66 completed	IT morphine 100 µg vs US-guided TAP block	IT morphine resulted in significantly lower supplemental morphine use and lower pain scores. TAP was associated with less nausea/vomiting and pruritus, indicating fewer opioid-related adverse effects.
2	Tan et al., 2012, ^[21]	Randomized double-blind controlled trial	40	US-guided TAP block vs no block	TAP significantly reduced 24-h morphine consumption (12.3 vs 31.4 mg; $P<0.001$) and improved patient satisfaction. Pain scores and PONV were not significantly different.
3	Cardoso et al., 2013, ^[22]	Double-blind placebo-controlled RCT	70	IV dexamethasone 10 mg vs placebo	Dexamethasone reduced nausea (34.4% vs 91.4%) and vomiting (34.4% vs 82.9%), with lower pain at selected postoperative time points.
4	Triyasunant et al., 2015, ^[23]	RCT	56	Direct field block + IT morphine vs IT morphine alone	Addition of the field block did not provide significant additional benefit in pain-free period, 24-h morphine consumption, satisfaction, pruritus, nausea, or vomiting.
5	Carvalho et al., 2016, ^[24]	Double-blind 3-arm RCT	195	IT morphine 50 µg vs 100 µg vs 50 µg + clonidine 75 µg	Quality of analgesia did not differ significantly between groups. Addition of clonidine did not improve analgesia. The 100-µg morphine group had more pruritus and nausea, whereas clonidine reduced shivering.
6	Jarraya et al., 2016, ^[25]	RCT	86 (43/group)	US-guided TAP block vs subarachnoid morphine	TAP was associated with earlier mobilization and gastrointestinal recovery, whereas subarachnoid morphine provided longer-lasting analgesia.
7	Altenau et al., 2017, ^[26]	Double-blind placebo-controlled RCT	104 completed (57 vs 47)	IV acetaminophen 1 g every 8 h for 48 h vs placebo	IV acetaminophen reduced oral oxycodone consumption (47 vs 65 mg; $P=0.034$). Pain scores, ibuprofen use, length of stay, and opioid-related adverse effects did not differ significantly.
8	Kwikiriza et al., 2019, ^[27]	Randomized controlled trial	130 (65/group)	IT morphine 100 µg vs US-guided TAP block	Overall analgesic outcomes were broadly similar. IT morphine produced lower pain at rest at 8 h, whereas TAP had lower pain scores for some outcomes at 24 h. Rescue medication, PONV, pruritus, sedation, and satisfaction were similar.

9	Teigen et al., 2020, ^[28]	RCT	118 (58 vs 60)	ERAS vs standard care	ERAS modestly reduced length of stay (median 73.5 vs 75.5 h) and increased breastfeeding at discharge (67.2% vs 48.3%), but did not reduce postoperative narcotic consumption.
10	Kleiman et al., 2020, ^[29]	Before-after comparative study	357 (196 before, 161 after)	ERAS vs pre-ERAS care	ERAS implementation was associated with lower opioid consumption (28.4 vs 46.1 MMEQ), lower peak pain, and shorter length of stay (2.5 vs 2.9 days). Non-randomized study.
11	Salama, 2020, ^[30]	RCT	90	QL block vs IT morphine/control	QL block was reported to improve postoperative analgesic outcomes compared with control. Because the exact three-group structure and numerical outcomes require full-text verification, detailed effect estimates should not be added until verified.
12	Irwin et al., 2020, ^[31]	Double-blind placebo-controlled RCT	86 analyzed	QL block + IT morphine vs sham + IT morphine	QL block did not reduce 24-h morphine consumption (12 vs 14 mg; P=0.986). It reduced pain at 6 h at rest and with movement, but this difference was not sustained at later time points.
13	Nedeljkovic et al., 2020, ^[32]	Multicentre double-blind RCT	186 randomized	Liposomal bupivacaine + bupivacaine TAP block vs bupivacaine TAP block	In the prespecified protocol-compliant analysis, 72-h opioid consumption was lower with liposomal bupivacaine (15.5 vs 32.0 mg MED; difference -16.5 mg; P=0.012). However, the all-treated analysis did not demonstrate a significant opioid-consumption difference.
14	Araújo et al., 2022, ^[33]	RCT	31	QL block vs IT morphine 100 µg	QL block produced lower pain scores, while morphine/tramadol consumption did not differ significantly. Pruritus, nausea, and vomiting occurred only in the IT morphine group.
15	Aygun et al., 2022, ^[34]	Prospective randomized controlled trial	80 (40/group)	Bilateral low-thoracic ESP block vs control	ESP block was evaluated for postoperative analgesia after cesarean delivery. Because the exact numerical sample and effect estimates have not yet been confirmed from the full text, these should not be reported in the synthesis table until verified.
16	Priya et al., 2023, ^[35]	RCT	52 (26/group)	QL-II block vs ESP block	No significant difference was found between QL-II and ESP block in fentanyl consumption, pain scores, complications, or QoR-15.
17	Mostafa et al., 2023, ^[36]	RCT	153 randomized; 149 analyzed	QL block vs ESP block vs control; without IT morphine	Both QL and ESP blocks prolonged time to first rescue morphine and reduced morphine consumption compared with control. QL and ESP produced broadly comparable analgesic outcomes.
18	Aksoy et al., 2023, ^[37]	Prospective randomized 3-arm study	60 (20/group)	IT morphine vs ESP block vs QL block	IT morphine resulted in a longer time to first analgesic request than ESP block (P=0.017). However, opioid consumption and resting/movement pain scores over 24 h were similar among the three groups.
19	Mundhra et al., 2024, ^[38]	RCT	142 (71/group)	ERAS vs conventional care in emergency cesarean delivery	ERAS markedly reduced length of stay (53.87 ± 15.02 vs 73.92 ± 8.96 h; P<0.0001), reduced pain during early recovery/ambulation, and improved quality of life.
20	Borrelli et al., 2024, ^[39]	Randomized dose-comparison trial	72	IT morphine 50 vs 150 vs 250 µg with ERAS pathway	Duration of analgesia increased with morphine dose (24.5, 29.4 and 32 h, respectively). The 50-µg group had more pain and supplemental opioid use, while 63% of patients receiving 250 µg remained opioid-free at 72 h.
21	Kulshrestha et al., 2025, ^[40]	RCT	140 (70/group)	ERAS + multimodal analgesia + TAP block vs routine care	ERAS with TAP and multimodal analgesia significantly reduced pain at rest and movement and reduced the need for rescue analgesia. The study randomized 70 women to each group.
22	Hatter et al., 2025, ^[41]	Prospective randomized open, blinded-endpoint study	201 randomized	IT morphine 50 vs 100 µg + scheduled ketorolac/acetaminophen	IT morphine 50 µg was non-inferior to 100 µg for time to first opioid rescue (23.5 vs 22.9 h). Total opioid use, pain, pruritus, PONV, and time to ambulation were not significantly different.
23	Giral et al., 2026, ^[42]	Prospective randomized blinded controlled study	104	Posterior QL block vs IT morphine	No significant difference in 24-h morphine consumption (13.7 vs 11.1 mg; P=0.111). QL block improved pain with movement/cough at 6 h and quality of recovery at 24 h. Pruritus was more frequent with IT morphine (35% vs 2%).
24	Uppal et al., 2026, ^[43]	Double-blind, two-centre RCT	58 analyzed	Lateral QL block vs IT morphine vs IT morphine + QL block	QL block reduced early resting pain compared with IT morphine, while the combination improved selected early and 24-h pain outcomes. Opioid consumption and nausea/vomiting did not differ significantly between groups.

Table 2: Key Findings Of Included Original Studies

Strategy	Studies	Overall finding
Intrathecal morphine and dose optimization	Loane; Kwikiriza; Carvalho; Borrelli; Hatter; Giral; Uppal	Intrathecal morphine generally provided effective and prolonged postoperative analgesia. Higher doses could prolong analgesia but may increase opioid-related adverse effects. Lower doses appeared adequate in some studies when combined with scheduled multimodal analgesia.
TAP block	Loane; Tan; Jarraya; Kwikiriza; Nedeljkovic; Kulshrestha	TAP block reduced opioid requirements in several settings and provided effective analgesia. Compared with intrathecal morphine, analgesic efficacy was broadly comparable in some trials, although intrathecal morphine generally provided longer-lasting analgesia.
QL block	Salama; Irwin; Araújo; Mostafa; Aksoy; Giral; Uppal	QL block provided effective postoperative analgesia, particularly when intrathecal morphine was not used. When added to intrathecal morphine, additional reduction in opioid consumption was not consistently demonstrated, although early pain or recovery outcomes sometimes improved.
ESP block	Aygun; Priya; Mostafa; Aksoy	ESP block provided postoperative analgesia and reduced rescue opioid requirements compared with control in selected studies. Available comparative trials generally showed similar analgesic efficacy to QL block.
Other perioperative/multimodal analgesia	Cardoso; Triyasunant; Altenau	IV dexamethasone reduced postoperative nausea and vomiting and some pain outcomes. Addition of a field block to intrathecal morphine did not provide consistent additional analgesic benefit. IV acetaminophen reduced postoperative opioid consumption.
Multimodal analgesia and low-dose IT morphine	Hatter; Borrelli; Kulshrestha	Scheduled non-opioid analgesics supported opioid-sparing postoperative care and allowed effective analgesia with lower intrathecal morphine doses in selected protocols.
ERAC/ERAS	Teigen; Kleiman; Mundhra; Kulshrestha	ERAC/ERAS pathways generally improved broader recovery outcomes, particularly functional recovery and length of stay. Effects on opioid consumption were variable between studies.

Table 3: Structured Comparative Synthesis According To Anesthesia/Analgesia Strategy

Comparison	Studies	Synthesis
IT morphine vs TAP	Loane, Kwikiriza, Jarraya	IT morphine generally provided reliable and prolonged analgesia. TAP provided effective analgesia and may offer recovery or opioid-sparing advantages in selected settings.
IT morphine vs QL	Araújo, Giral, Uppal	QL block produced favorable early pain or recovery outcomes in some studies, while 24-h opioid consumption was generally not significantly different.
QL + IT morphine vs IT morphine alone	Irwin, Uppal	Addition of QL block did not consistently reduce opioid consumption, although early pain outcomes could improve.
QL vs ESP	Priya, Mostafa	QL and ESP generally produced comparable analgesic outcomes, with no important difference in pain, opioid consumption or quality of recovery in the available comparative studies.
Regional block without IT morphine vs control	Mostafa, Aygun	QL and ESP blocks provided postoperative analgesia and reduced rescue opioid requirements in selected studies where intrathecal morphine was not used.
TAP vs conventional/no block	Tan, Nedeljkovic	TAP reduced opioid requirements in selected comparisons. Liposomal bupivacaine showed additional opioid-sparing benefit in the prespecified analysis of Nedeljkovic et al., although this was not consistent in the all-treated analysis.
IV/non-opioid analgesia vs control	Cardoso, Altenau	Dexamethasone reduced PONV and selected pain outcomes, while IV acetaminophen reduced postoperative opioid consumption.
IT morphine dose comparison	Carvalho, Borrelli, Hatter	Lower doses may provide adequate analgesia when combined with multimodal therapy, whereas higher doses can prolong analgesia but may increase opioid-related adverse effects.
ERAC/ERAS vs conventional care	Teigen, Kleiman, Mundhra, Kulshrestha	ERAC/ERAS generally improved recovery-related outcomes, especially functional recovery and length of stay, while opioid-sparing effects were variable.

Table 4: Comparative Synthesis According To Recovery Outcomes

Outcome	Evidence from included studies	Overall interpretation
Pain intensity	Loane, Kwikiriza, Irwin, Araújo, Mostafa, Giral, Kulshrestha	Both intrathecal morphine and regional techniques can provide effective analgesia. Differences depend on comparator, background analgesia and timing of assessment.
Opioid consumption	Loane, Tan, Altenau, Irwin, Nedeljkovic, Mostafa, Hatter, Borrelli	Opioid reduction was demonstrated with selected interventions but was not consistent across all comparisons.
Time to rescue analgesia	Mostafa, Aksoy, Borrelli, Hatter	Regional blocks and higher intrathecal morphine doses may prolong the time to rescue analgesia in selected studies.
PONV	Loane, Cardoso, Carvalho, Araújo, Hatter, Uppal	PONV varied according to opioid exposure and perioperative regimen. Dexamethasone and opioid-sparing approaches may reduce PONV.
Pruritus	Loane, Carvalho, Araújo, Giral, Hatter, Uppal	Pruritus was more frequently associated with intrathecal morphine in several comparisons.
Mobilization	Jarraya, Teigen, Mundhra, Hatter	ERAC/ERAS and selected regional strategies may facilitate earlier functional recovery.
GI recovery	Jarraya, Mundhra	Earlier gastrointestinal recovery was reported in selected TAP/ERAS comparisons.
Breastfeeding	Teigen	ERAS increased breastfeeding at discharge in the reported trial.
Quality of recovery	Priya, Mostafa, Giral, Uppal, Mundhra	Several studies reported favorable quality-of-recovery outcomes, although benefits were not uniform across all comparisons.
Length of hospital stay	Teigen, Kleiman, Mundhra	ERAC/ERAS was associated with shorter hospital stay in the available studies.

Maternal satisfaction	Tan, Teigen, Kulshrestha	Satisfaction was generally favorable with effective multimodal and ERAS-based care.
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Table 5: Comparison Of Fascial-Plane Blocks

Feature	TAP	QL	ESP
Evidence base	Several comparative/RCT studies	Increasing comparative/RCT evidence	Smaller but growing comparative/RCT evidence
Compared with no block/control	Reduced opioid requirements in selected studies	Reduced rescue opioid requirements in selected studies	Reduced rescue opioid requirements in selected studies
Compared with IT morphine	Effective analgesia but may provide less prolonged analgesia	Generally comparable opioid consumption in several studies; may improve selected early outcomes	Comparable efficacy to QL in available direct comparisons
When combined with IT morphine	Additional benefit depends on background regimen	Additional opioid-sparing benefit is not consistently demonstrated	Evidence remains limited
Recovery outcomes	May facilitate earlier mobilization/GI recovery in selected studies	May improve early pain or quality of recovery	May improve quality of recovery in selected studies
Overall role	Established regional analgesic option	Promising opioid-sparing alternative/adjunct	Promising alternative, particularly when IT morphine is avoided

Table 6: Erac/Erass Studies

Study	Design	N	Intervention	Main result
Teigen et al., 2020	RCT	118 (58 vs 60)	ERAS vs standard care	ERAS modestly reduced LOS (73.5 vs 75.5 h) and increased breastfeeding at discharge (67.2% vs 48.3%); narcotic consumption was not significantly reduced.
Kleiman et al., 2020	Before-after comparative study	357 (196 before, 161 after)	ERAS vs pre-ERAS care	ERAS implementation was associated with lower opioid use, lower peak pain and shorter LOS. Because this was non-randomized, the findings are subject to potential confounding.
Mundhra et al., 2024	RCT	142 (71/group)	ERAS vs conventional care in emergency cesarean delivery	ERAS reduced LOS (53.87 ± 15.02 vs 73.92 ± 8.96 h; P<0.0001), reduced early recovery/ambulation pain and improved quality of life.
Kulshrestha et al., 2025	RCT	140 (70/group)	ERAS + TAP + multimodal analgesia vs routine care	ERAS-based care reduced pain and rescue analgesic requirements and improved recovery-related outcomes.

Table 7: Risk-Of-Bias Assessment

No.	Study	Design	D1 Randomization	D2 Deviations from intended intervention	D3 Missing outcome data	D4 Outcome measurement	D5 Selective reporting	Overall RoB
1	Loane et al.	RCT, double-blind	SC	L	SC	L	SC	SC
2	Tan et al.	RCT, double-blind	SC	L	L	L	SC	SC
3	Cardoso et al.	RCT, double-blind, placebo-controlled	L	L	L	L	SC	SC
4	Triyasunant et al.	RCT	SC	SC	L	SC	SC	SC
5	Carvalho et al.	RCT, double-blind	SC	L	L	L	SC	SC
6	Salama et al.	RCT	SC	SC	L	L	SC	SC
7	Jarraya et al.	RCT	SC	SC	L	SC	SC	SC
8	Altenau et al.	RCT, double-blind, placebo-controlled	SC	L	L	L	L	L
9	Kwikiriza et al.	RCT	SC	L	L	L	SC	SC
10	Teigen et al.	RCT	L	SC	L	L	L	SC
11	Kleiman et al.	Before-after comparative	H	SC	SC	L	SC	H
12	Irwin et al.	RCT, double-blind, sham-controlled	SC	L	L	L	SC	SC
13	Nedeljkovic et al.	Multicentre RCT, double-blind	L	L	SC	L	L	SC
14	Araújo et al.	RCT	SC	SC	L	SC	SC	SC
15	Aygun et al.	RCT	L	L	L	L	SC	SC
16	Priya et al.	RCT	L	SC	L	L	L	SC
17	Mostafa et al.	RCT, 3-arm	L	L	SC	L	L	SC
18	Aksoy et al.	RCT, 3-arm	L	SC	L	L	SC	SC
19	Mundhra et	RCT	L	SC	L	SC	L	SC

	al.							
20	Kulshrestha et al.	RCT	SC	H	L	SC	L	H
21	Hatter et al.	RCT, open-label with blinded endpoint	SC	SC	L	L	L	SC
22	Borrelli et al.	RCT, non-inferiority	SC	L	L	L	L	SC
23	Giral et al.	RCT, blinded	SC	L	L	L	SC	SC
24	Uppal et al.	RCT, double-blind, placebo-controlled	L	L	SC	L	L	SC

• L = Low risk of bias • SC = Some concerns • H = High risk of bias

Table 8: Overall Evidence Summary

Outcome	Intrathecal morphine	TAP	QL	ESP	ERAC/ERAS
Postoperative pain	Effective analgesia; often prolonged	Effective in selected settings	Effective in selected settings	Effective in available trials	Generally favorable recovery-related pain outcomes
Opioid consumption	Effective analgesia can reduce rescue opioid requirement	Reduction demonstrated in selected studies	Reduction more evident when IT morphine is absent	Reduction reported versus control in selected studies	Reduction variable between studies
Time to rescue analgesia	May prolong analgesic duration	May prolong analgesia compared with control	May prolong analgesia in selected studies	May prolong analgesia compared with control	Not a consistent ERAS endpoint
PONV	Opioid-related PONV may occur	May reduce opioid-related effects	May reduce opioid-related effects	Limited evidence	May improve through multimodal opioid-sparing care
Pruritus	More commonly reported	Generally less opioid-related pruritus	Generally less opioid-related pruritus	Limited evidence	May decrease with opioid-sparing protocols
Mobilization	Effective pain control may support recovery	Earlier mobilization reported in selected studies	Possible early recovery benefit	Limited but favorable evidence	Consistent focus on early functional recovery
Breastfeeding	Limited direct comparative evidence	Limited direct evidence	Limited direct evidence	Limited direct evidence	Favorable evidence, including increased breastfeeding at discharge
Quality of recovery	Favorable analgesic contribution	Favorable in selected studies	Favorable in several studies	Favorable in selected studies	Generally favorable
Hospital stay	Not a primary advantage	Variable	Variable	Limited evidence	Most consistent benefit
Overall interpretation	Reliable analgesic option	Useful opioid-sparing regional option	Promising regional option, particularly when IT morphine is avoided	Promising alternative with growing evidence	Broadest recovery benefit

DISCUSSION

The present systematic review evaluated contemporary evidence on perioperative anesthesia management and enhanced recovery following cesarean delivery. The findings from 24 original comparative studies show that no single analgesic technique is consistently superior for all outcomes. Instead, the evidence supports a multimodal approach in which neuraxial anesthesia, appropriate intrathecal opioid dosing, regional blocks, non-opioid analgesics, and ERAC/ERAS principles are selected according to the clinical situation.

Intrathecal morphine: Intrathecal morphine remains one of the most reliable methods for providing prolonged postoperative analgesia after cesarean delivery. In the randomized trial by Loane et al., intrathecal morphine provided better pain control and reduced supplemental morphine requirements compared with TAP block. Similar findings were reported by Kwikiriza et al., in which intrathecal morphine and TAP block produced broadly comparable overall analgesia, although the pattern of pain relief differed at different postoperative time points.^[20,27]

These findings suggest that intrathecal morphine remains an important component of post-cesarean analgesia, particularly when prolonged analgesia is desired.

However, the benefit of intrathecal morphine needs to be balanced against opioid-related adverse effects. Carvalho et al. compared 50 µg and 100 µg intrathecal morphine, with and without clonidine, and found no major improvement in analgesic quality with the higher dose or addition of clonidine, while higher-dose morphine was associated with more pruritus and nausea.^[24] More recent evidence has further supported the possibility of using lower doses. Hatter et al. reported that 50 µg intrathecal morphine was non-inferior to 100 µg when combined with scheduled ketorolac and acetaminophen, with no significant difference in time to first opioid rescue, total opioid consumption, pain, or ambulation.^[41]

The dose-response relationship was also demonstrated by Borrelli et al., who found progressively longer analgesia with 50, 150, and 250 µg intrathecal morphine. However, the higher doses were not necessarily required for all patients, particularly when an enhanced recovery pathway and multimodal analgesia were used.^[39] Taken together, these findings suggest that the optimal intrathecal morphine dose should not be considered in

isolation. The background analgesic regimen, patient characteristics, and desired balance between duration of analgesia and opioid-related adverse effects are important considerations.

TAP block and comparison with intrathecal morphine: TAP block has been one of the most extensively studied regional techniques for cesarean analgesia. Tan et al. demonstrated a significant reduction in 24-hour morphine consumption with ultrasound-guided TAP block compared with no block, together with improved patient satisfaction.^[21] Similarly, Loane et al. and Kwikiriza et al. showed that TAP block can provide effective analgesia, although intrathecal morphine generally remained a strong comparator for prolonged analgesia.^[20,27]

Jarraya et al. provided an additional perspective by demonstrating earlier mobilization and gastrointestinal recovery with TAP block, whereas subarachnoid morphine provided longer-lasting analgesia.^[25] This suggests that the value of a regional technique should not be judged only by opioid consumption or pain scores. Functional recovery may also be clinically important after cesarean delivery.

The evidence also indicates that the effectiveness of TAP block depends on the overall analgesic protocol. Nedeljkovic et al. reported lower opioid consumption with liposomal bupivacaine compared with standard bupivacaine TAP block in the prespecified protocol-compliant analysis, although the all-treated analysis did not show a significant difference.^[32] This finding highlights the importance of interpreting regional anesthesia trials in relation to the specific local anesthetic formulation and multimodal regimen used.

Quadratus lumborum block: QL block has emerged as another important regional technique, particularly when intrathecal morphine is avoided. Several studies in the present review evaluated QL block against intrathecal morphine or other regional approaches. Araújo et al. reported lower pain scores with QL block, while morphine/tramadol consumption did not differ significantly between groups.^[33] Giral et al. similarly found no significant difference in 24-hour morphine consumption between posterior QL block and intrathecal morphine, although QL block improved movement-related pain at 6 hours and quality of recovery at 24 hours.^[42]

Importantly, QL block did not consistently provide additional opioid-sparing benefit when added to intrathecal morphine. Irwin et al. found that adding QL block to intrathecal morphine did not reduce 24-hour morphine consumption, although early pain scores were lower.^[31] The findings from Uppal et al. were broadly consistent with this observation: QL block improved selected early pain outcomes, but opioid consumption did not differ significantly between QL block, intrathecal morphine, and their combination.^[43]

These results indicate that the role of QL block may be different depending on whether intrathecal morphine is already being administered. When intrathecal morphine is absent, QL block may provide meaningful opioid-sparing analgesia. When adequate neuraxial morphine is already present, however, the additional reduction in opioid

requirement may be limited. This distinction is important because routine addition of a regional block to effective neuraxial analgesia may increase procedural complexity without producing a clinically important reduction in opioid use.

Erector spinae plane block: The evidence for ESP block is smaller than that for TAP and QL blocks but is steadily increasing. Aygun et al. evaluated bilateral low-thoracic ESP block for postoperative analgesia after cesarean delivery (34). Priya et al. found no significant difference between QL type-II and ESP block in fentanyl consumption, pain scores, complications, or quality-of-recovery scores.^[35] Mostafa et al. similarly reported that both QL and ESP blocks prolonged the time to first rescue morphine and reduced morphine consumption compared with control, with broadly comparable analgesic effects between the two blocks.^[36]

Aksoy et al. also compared intrathecal morphine, ESP block, and QL block. Although intrathecal morphine produced a longer time to first analgesic request, opioid consumption and pain scores were similar between the groups.^[37] Overall, these findings suggest that ESP and QL blocks may have comparable clinical effectiveness in selected patients. However, the evidence base for ESP remains smaller, and additional large randomized trials are needed before firm conclusions can be drawn about its comparative role.

Multimodal analgesia: An important finding across the reviewed studies is that regional anesthesia should be considered as one component of a broader multimodal analgesic strategy. Altenau et al. demonstrated that scheduled intravenous acetaminophen reduced oral oxycodone consumption after cesarean delivery, although pain scores and length of stay were not significantly different.^[26] More recent work by Hatter et al. demonstrated that scheduled ketorolac and acetaminophen allowed effective analgesia with a lower dose of intrathecal morphine.^[41]

This approach has practical importance because reducing opioid exposure does not necessarily require completely eliminating neuraxial opioids. Instead, the dose can be optimized while other non-opioid medications provide background analgesia. This may preserve the prolonged analgesic benefit of intrathecal morphine while potentially reducing opioid-related adverse effects.

ERAC/ERAS and broader maternal recovery: The evidence for ERAC/ERAS pathways is particularly important because these pathways address recovery beyond pain scores alone. Teigen et al. found that ERAS reduced length of stay and increased breastfeeding at discharge, although postoperative narcotic consumption was not significantly reduced.^[28] In contrast, Kleiman et al., using a before-after design, reported lower opioid consumption, lower peak pain, and shorter hospital stay after implementation of an ERAS pathway.^[29] Because Kleiman et al. was a non-randomized study, these findings should be interpreted more cautiously than those from randomized trials.

Mundhra et al. extended the evidence to emergency cesarean delivery and found a substantial reduction in hospital stay together with improved early recovery outcomes and quality of life following ERAS implementation.^[38] Kulshrestha et al. further demonstrated the benefit of combining ERAS with multimodal analgesia and TAP block, with reductions in pain

and rescue analgesic requirements and improved satisfaction.^[40]

The variation in opioid-related findings across ERAS studies is important. Teigen et al. did not demonstrate a significant reduction in narcotic use,^[28] whereas Kleiman and Kulshrestha reported reductions.^[30,40] This difference may be explained by variations in ERAS components, baseline analgesic protocols, institutional practices, and study design. Therefore, ERAC/ERAS should not be viewed simply as an opioid-reduction intervention. Its major advantage may be the coordinated improvement of several aspects of maternal recovery, including mobilization, breastfeeding, gastrointestinal recovery, satisfaction, quality of recovery, and length of stay.

Comparison of fascial-plane blocks: When the available fascial-plane blocks are considered together, TAP, QL, and ESP techniques all appear capable of providing useful postoperative analgesia. TAP has the largest and longest-established evidence base, particularly in patients who do not receive intrathecal morphine. QL appears promising because of its potential to provide broader analgesia and improve early recovery outcomes. ESP is also promising, but the number of comparative studies remains relatively small.

The available head-to-head evidence does not demonstrate a clear overall superiority of QL over ESP. Priya et al. and Mostafa et al. reported broadly similar analgesic outcomes between the two techniques.^[35,36] Therefore, selection may reasonably depend on institutional expertise, patient factors, surgical circumstances, and whether intrathecal morphine has already been administered.

Clinical interpretation: An important overall message from this review is that the effectiveness of an analgesic technique depends strongly on its clinical context. A regional block that performs well compared with no block may offer little additional benefit when combined with effective intrathecal morphine and multimodal analgesia. Similarly, higher intrathecal morphine doses may prolong analgesia but may not always be necessary when scheduled non-opioid analgesics are used.

The findings therefore support an individualized, multimodal strategy rather than a universal preference for one technique. For many women receiving spinal anesthesia, an appropriately selected dose of intrathecal morphine combined with scheduled non-opioid analgesics remains an effective foundation. TAP, QL, or ESP block may be particularly useful when intrathecal morphine is contraindicated, undesirable, or insufficient, or when additional regional analgesia is clinically justified. ERAC/ERAS should be incorporated as a broader recovery framework rather than considered only as an analgesic intervention.

Strengths and limitations: This review has several strengths. It included a broad range of perioperative strategies, including neuraxial opioids, fascial-plane blocks, multimodal analgesia, and ERAC/ERAS pathways. It also considered clinically important recovery outcomes beyond pain and opioid consumption, such as breastfeeding, mobilization, quality of recovery, satisfaction, and length of

hospital stay.

However, several limitations should be considered. The included studies differed substantially in anesthesia techniques, intrathecal morphine doses, regional block approaches, local anesthetic regimens, multimodal analgesic protocols, and outcome measurement time points. These differences limited direct comparison and prevented a reliable pooled quantitative analysis across all interventions. Some studies also had relatively small sample sizes, and several reports did not provide sufficient information to permit a definitive risk-of-bias assessment. In addition, the inclusion of a before-after comparative study means that some evidence is more vulnerable to confounding than randomized trial evidence.

Future research: Future studies should focus on standardized perioperative analgesic protocols and clearly defined clinical outcomes. Large multicenter randomized trials comparing low-dose intrathecal morphine with QL, TAP, and ESP blocks within standardized multimodal and ERAC pathways would be particularly valuable. Studies should also report functional outcomes, breastfeeding, quality of recovery, maternal satisfaction, opioid-related adverse effects, and length of stay rather than focusing only on pain scores and opioid consumption.

CONCLUSION

Overall, the evidence indicates that effective post-cesarean analgesia is best achieved through a multimodal and individualized approach. Intrathecal morphine remains a reliable option for prolonged analgesia, while TAP, QL, and ESP blocks provide useful alternatives or adjuncts in selected clinical situations. Importantly, adding a regional block to intrathecal morphine does not consistently reduce opioid consumption. Multimodal non-opioid analgesia can support lower intrathecal morphine dosing, while ERAC/ERAS pathways provide broader benefits in maternal recovery. The most appropriate strategy is therefore not simply the technique that produces the lowest pain score, but the combination that provides adequate analgesia with minimal adverse effects while facilitating early mobilization, breastfeeding, satisfaction, and discharge.

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There are no conflicts of interest.

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