The Impact of Ultrasound-Guided Regional Anesthesia on Postoperative Pain Control and Opioid Reduction in Adult Surgical Patients: A Systematic Review

Moamen Abdelfadil Ismail[1], Zakiyah Saud Almutairi[2], Mozafar G. M. Hamad[3], Dr. Atif Eid Alrashidi[4], Abdullah Mohammed Ali Alghamdi[5], Anas Hamoud Almutair[6], Aliea Khalid Alrayah Babikir[7], Fatima Ahmed Ali Omer[8], Rawan Turki Naji Alali[9], Ahmed Tarek Elbarkoky[10], Muhannad Saleh Mohammed Alshamrani[11], Omar Abdulqader Alqahtani[12], Dr. Murad Mamdouh Aleidiney[13]

[1]Internal Medicine Consultant, King Abdulaziz Specialist Hospital, Sakaka, Aljouf

[2]Anesthesia Resident, Prince Sultan Millitary Medical City, Riyadh, Zakiyah.Almutairi@gmail.com

[3]Anesthesia & Intensive Care Resident, Saudi German Hospital, Jeddah, mozafar.hamad@gmail.com

[4]GP, ER, KKH IN TABUK, atifeid98@gmail.com
[5]General Practitioner, Bin.Zw7@Yahoo.Com

[6]Intern, Anas_almutair@hotmail.com

[7]Resident Doctor, Anesthesia, ICU and Emergency Department Experience, Buraidah Central Hospital, Saudi Arabia, aliamedicine@hotmail.com

[8]Anesthesia Resident, fatmakona99@gmail.com

[9]Intern, alalirawan134@gmail.com

[10]Lecturer Ansethesia & ICU in ain Shams University, a.elbarkoky@gmail.com

[11]Anesthesia Technology, mohaanad.saleh99@gmail.com

[12]Anesthesia Technology, omaralqhtani18047@gmail.com

[13]Intern, Ibn Sina National College for Medical Studies, Maleidiney@gmail.com

HOW TO CITE:
Moamen Abdelfadil Ismail, Zakiyah Saud Almutairi, Mozafar G. M. Hamad, Atif Eid Alrashidi, Abdullah Mohammed Ali Alghamdi, Anas Hamoud Almutair, Aliea Khalid Alrayah Babikir, Fatima Ahmed Ali Omer, Rawan Turki Naji Alali, Ahmed Tarek Elbarkoky, Muhannad Saleh Mohammed Alshamrani, Omar Abdulqader Alqahtani, Murad Mamdouh

ABSTRACT

Background

Postoperative pain remains a major challenge in surgical care, often leading to delayed recovery and increased opioid-related adverse effects. Although systemic opioids have traditionally been central to pain management, concerns about dependence and side effects have driven interest in opioid-sparing strategies. Ultrasound-guided regional anesthesia (UGRA) offers targeted analgesia with improved precision, yet variability in reported effectiveness across procedures warrants a systematic evaluation.

Methods

This systematic review followed PRISMA guidelines to evaluate the impact of UGRA on postoperative pain control and opioid reduction in adult surgical patients. A comprehensive literature

Aleidiney (2026). The Impact of Ultrasound-Guided Regional Anesthesia on Postoperative Pain Control and Opioid Reduction in Adult Surgical Patients: A Systematic Review International Journal of Special Education, 41(21s), 226 - 240

search was conducted in PubMed/MEDLINE, Embase, Cochrane CENTRAL, and Web of Science. Eligible studies included randomized controlled trials, cohort studies, and controlled clinical studies comparing UGRA with conventional analgesia, systemic opioids, or no block. Primary outcomes were postoperative pain intensity (validated scales) and opioid consumption. Risk of bias was assessed using the Cochrane Risk of Bias tool and Newcastle–Ottawa Scale. A narrative synthesis was performed.

Results

Six primary studies (five RCTs and one network meta-analysis; total N = 1,581 patients) across cardiac, thoracic, orthopedic, and maxillofacial surgeries met inclusion criteria. UGRA consistently reduced postoperative opioid consumption compared to controls: intravenous fentanyl decreased by 47.4% ($p < 0.0001$), rescue morphine by 68.2% ($p < 0.001$), and oral morphine equivalents by 44.2% ($p = 0.023$). Pain scores at rest and during coughing were significantly lower in block groups during the first 12–18 hours ($p < 0.05$ to $p < 0.0001$), with dynamic pain reduced by 3.3 units on VAS ($p < 0.0001$). UGRA also reduced postoperative nausea by up to 50%, shortened extubation time (108.5 vs. 206.3 minutes; $p < 0.0001$), and decreased ICU length of stay by 1.1 days. No major complications (LAST, nerve injury, pneumothorax) were reported.

Conclusion

Ultrasound-guided regional anesthesia significantly improves postoperative pain control, reduces opioid consumption and opioid-related adverse effects, and enhances early respiratory recovery across multiple adult surgical populations. These findings support integrating UGRA into multimodal perioperative analgesic protocols as an effective and safe opioid-sparing strategy. Further large-scale, standardized trials are warranted to optimize technique selection and prolong analgesic duration.

Background

Postoperative pain remains one of the most common and challenging issues in surgical care, significantly influencing patient recovery, satisfaction, and overall clinical outcomes. Despite advances in surgical techniques and perioperative management, inadequate pain control continues to be reported across a wide range of surgical procedures. Poorly managed postoperative pain is associated with delayed mobilization, prolonged hospital stay, increased risk of complications, and the potential development of chronic postsurgical pain (Dost et al., 2022).

Traditionally, systemic opioids have played a central role in postoperative pain management due to their potent analgesic effects. However, opioid-based analgesia is associated with well-documented adverse effects, including nausea, vomiting, constipation, respiratory depression, sedation, and increased risk of dependence. These complications can negatively impact patient safety and recovery, highlighting the need for effective opioid-sparing analgesic strategies in modern perioperative care (Maniker et al., 2024).

The growing global concern regarding opioid overuse and opioid-related morbidity has intensified efforts to identify alternative approaches to pain management. Healthcare systems are increasingly prioritizing multimodal analgesia, which combines different pharmacological and non-pharmacological techniques to optimize pain relief while minimizing opioid consumption. Within this context, regional anesthesia techniques have gained considerable attention as a key component of opioid-sparing strategies (Liu et al., 2023).

Regional anesthesia involves the targeted blockade of peripheral nerves or nerve plexuses to provide site-specific analgesia. When used in the perioperative period, regional anesthesia can reduce nociceptive input, improve pain control, and decrease the need for systemic analgesics. Advances in technology have significantly enhanced the safety and effectiveness of regional anesthesia, particularly with the introduction of ultrasound guidance (Yao et al., 2020).

Ultrasound-guided regional anesthesia allows real-time visualization of anatomical structures, including nerves, blood vessels, and surrounding tissues. This visualization improves the accuracy of needle placement and local anesthetic deposition, thereby increasing block success rates and reducing the risk of complications. As a result, ultrasound guidance has become an integral part of contemporary regional anesthesia practice (Balan et al., 2021).

The application of ultrasound-guided regional anesthesia spans a wide range of surgical specialties, including orthopedic, abdominal, thoracic, and general surgery. These techniques can be used as sole anesthetic modalities or as adjuncts to general anesthesia, offering flexibility in perioperative pain management. Their use has been associated with improved analgesic quality and enhanced patient comfort in the immediate postoperative period (Zhang et al., 2025).

In addition to pain control, ultrasound-guided regional anesthesia has been suggested to play a role in reducing postoperative opioid requirements. By providing effective localized analgesia, these techniques may limit the need for systemic opioids and thereby reduce opioid-related adverse effects. This potential benefit aligns with current efforts to promote safer and more sustainable pain management practices (Häusler et al., 2022).

Despite the increasing adoption of ultrasound-guided regional anesthesia, variability exists in its reported effectiveness across different surgical procedures and patient populations. Differences in block type, timing, technique, and outcome assessment contribute to inconsistent findings in the literature. This variability underscores the importance of systematically evaluating existing evidence to draw robust conclusions (Wang et al., 2025).

Furthermore, while individual studies have examined postoperative pain outcomes and opioid consumption associated with ultrasound-guided regional anesthesia, the overall strength and consistency of evidence remain unclear. Some studies report significant benefits, while others demonstrate modest or procedure-specific effects. A comprehensive synthesis of available data is necessary to clarify these discrepancies (Zelenty et al., 2023).

Understanding the impact of ultrasound-guided regional anesthesia on postoperative pain and opioid reduction is critical for informing clinical guidelines and anesthetic practice. Evidence-based recommendations can support clinicians in selecting appropriate analgesic strategies tailored to patient and surgical factors, ultimately improving perioperative outcomes (Lee & Kim, 2019).

A systematic review focusing on adult surgical patients provides an opportunity to critically appraise and synthesize existing research on this topic. By evaluating the effects of ultrasound-guided regional anesthesia on postoperative pain control and opioid consumption, such a review can contribute valuable insights to anesthesiology and perioperative medicine.

The aim of this systematic review is to evaluate the impact of ultrasound-guided regional

anesthesia on postoperative pain control and opioid reduction in adult surgical patients.

Methodology

Study Design

This study adopted a systematic review design to comprehensively identify, appraise, and synthesize available evidence on the impact of ultrasound-guided regional anesthesia on postoperative pain control and opioid reduction in adult surgical patients. A systematic review methodology was selected to ensure transparency, methodological rigor, and reproducibility while minimizing bias in the identification and interpretation of existing research evidence. The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure standardized reporting and methodological quality.

Review Protocol and Registration

A detailed review protocol was developed prior to the commencement of the study to predefine objectives, eligibility criteria, search strategy, and methods for data extraction and synthesis. This protocol enhanced methodological transparency and reduced the risk of selective reporting. Where feasible, the protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) to ensure public accessibility and to prevent unnecessary duplication of research efforts.

Eligibility Criteria

Eligibility criteria were defined using the Population, Intervention, Comparison, and Outcomes (PICO) framework to ensure a focused and structured selection of studies.

The population included adult patients aged 18 years or older undergoing any type of surgical procedure. The intervention of interest was ultrasound-guided regional anesthesia administered for perioperative or postoperative pain management. Studies employing nerve blocks, fascial plane blocks, or neuraxial techniques under ultrasound guidance were considered.

Comparators included conventional analgesic approaches, non-ultrasound-guided regional anesthesia, systemic analgesia, or standard care without regional anesthesia. Primary outcomes included postoperative pain intensity measured using validated pain scales and postoperative opioid consumption. Secondary outcomes included opioid-related adverse effects and duration of analgesia.

Randomized controlled trials, cohort studies, and controlled clinical studies were included. Case reports, editorials, narrative reviews, conference abstracts, and studies involving pediatric populations were excluded.

Information Sources

A comprehensive literature search was conducted using multiple electronic databases to ensure broad coverage of relevant studies. The databases included PubMed/MEDLINE, Embase, the Cochrane Central Register of Controlled Trials, and Web of Science.

In addition to database searches, the reference lists of included studies and relevant review articles were manually screened to identify any additional eligible studies that may not have been captured through electronic searching.

Search Strategy

A structured search strategy was developed in accordance with established systematic review methodologies. The search incorporated a combination of controlled vocabulary terms and free-text keywords related to ultrasound-guided regional anesthesia, postoperative pain, opioid consumption, and adult surgical patients.

Search terms were adapted for each database to account for differences in indexing systems. Boolean operators were used to combine search terms, and filters were applied to restrict results to studies involving human adults and publications in the English language. The full search strategy was documented to ensure

reproducibility in accordance with PRISMA recommendations.

Study Selection Process

All records retrieved from the literature search were imported into reference management software, and duplicate records were removed. Study selection was conducted in two stages. In the first stage, titles and abstracts were screened for relevance based on the predefined eligibility criteria. In the second stage, full-text articles of potentially eligible studies were assessed for inclusion.

The study selection process was performed independently by at least two reviewers to minimize selection bias. Any disagreements were resolved through discussion or consultation with a third reviewer. The selection process was documented using a PRISMA flow diagram.

Data Extraction

A standardized data extraction form was developed to systematically collect relevant information from included studies. Extracted data included study characteristics, patient demographics, surgical type, details of the regional anesthesia technique, comparator interventions, pain assessment methods, opioid consumption outcomes, and key findings.

Data extraction was conducted independently by two reviewers to ensure accuracy and completeness. Any discrepancies were resolved through consensus. This structured approach enhanced the reliability and validity of the extracted data.

Risk of Bias Assessment

The methodological quality and risk of bias of included studies were assessed using validated assessment tools appropriate to the study design. Randomized controlled trials were evaluated using the Cochrane Risk of Bias tool, while observational studies were assessed using the Newcastle–Ottawa Scale.

These tools allowed for systematic evaluation of potential sources of bias, including selection bias, performance bias, detection bias, and reporting bias. The results of the risk of bias assessment were considered during data synthesis and interpretation of findings.

Data Synthesis

A narrative synthesis was conducted to summarize and compare findings across included studies. Results were organized according to surgical type, regional anesthesia technique, and outcome measures. Where sufficient homogeneity existed in study design and outcome reporting, a quantitative synthesis was considered.

Postoperative pain outcomes and opioid consumption were analyzed descriptively, highlighting trends, consistencies, and variations across studies. The synthesis emphasized clinical relevance and applicability to perioperative pain management practice.

Assessment of Evidence Quality

The overall quality and strength of the body of evidence were evaluated using established principles of evidence synthesis. Consideration was given to study design, consistency of findings, risk of bias, and precision of outcome measures. This assessment supported balanced interpretation of results and identification of evidence gaps.

Ethical Considerations

As this study was a systematic review based exclusively on previously published data, it did not involve direct contact with human participants. Therefore, ethical approval was not required. However, the review adhered to ethical standards of research integrity, transparency, and accurate reporting.

Dissemination of Findings

The findings of this systematic review were disseminated through inclusion in an academic research report and submission to a peer-reviewed journal in the field of anesthesiology or perioperative medicine. The results were also suitable for presentation at scientific conferences to support evidence-based clinical practice and inform future research.

Results

A total of six primary clinical studies met the rigorous eligibility criteria and were included in the systematic review. This section presents the structured flow of literature selection following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, followed by detailed extractions of study designs, sample characteristics, primary opioid consumption metrics, postoperative pain trajectories, and secondary clinical recovery markers.

PRISMA Flow Assessment

The selection of literature for this systematic review proceeded through four main sequential phases in strict accordance with the PRISMA statement guidelines:

- **Identification:** Electronic database searches across PubMed, EMBASE, Scopus, Cochrane Central Register of Controlled Trials (CENTRAL), and Web of Science yielded a total of n = 606 potentially relevant records. An additional manual search of reference lists (citation snowballing) identified n = 5 further records, establishing an initial pool of n = 611 citations. After removing duplicates (n = 38), a total of n = 573 records remained for screening.
- **Screening:** Title and abstract screening was performed independently on the remaining n = 573 records against the prespecified inclusion and exclusion criteria. This stage resulted in the exclusion of n = 546 records due to irrelevance, non-surgical focus, or lack of regional anesthesia application. A total of n = 27 articles were deemed eligible for full-text retrieval.
- **Eligibility:** Full-text evaluation was conducted for the n = 27 retrieved articles. Of these, 12 articles were excluded with specific clinical justifications: n = 4 lacked recoverable or distinct baseline data, n = 3 reported incompatible or unvalidated primary outcomes, and n = 5 utilized landmark-guided or continuous infusion methodologies rather than single-shot, ultrasound-guided regional techniques.
- **Inclusion:** Consequently, a total of 6 highly relevant, primary clinical data sources (including five randomized controlled trials and one comprehensive network meta-analysis pooling individual clinical trial data) were selected for final qualitative and quantitative data synthesis.

Table 1: Baseline Characteristics of Included Primary Studies

Study Identifier (Author, Year)	Country of Origin	Surgical Procedure	Total Sample (N)	Group Distribution (n)	Specific Regional Block Type	Local Anesthetic Regimen (Dose, Volume, Adjuvants)	Control Group Modality
Hamed et al., 2022	Egypt	Valve replacement or adult congenital repair via median sternotomy	N = 70	Block: n = 35 Control: n = 35	Bilateral Transversus Thoracic Muscle Plane (TTMP) block	0.25% Bupivacaine (20 mL per side)	Sham block with 0.9% Normal Saline (20 mL per side)
Chen et al., 2021	China	Mediastinal mass resection via median sternotomy	N = 41	PSI: n = 20	Bilateral Parasternal Intercostal Nerve	0.5% Ropivacaine (10 mL per space at the 3rd and 5th	Sham injection with 0.9% Normal Saline (10

				Control: n = 21	block (PSI)	intercostal spaces)	mL per point)
Esquerré et al., 2024	France	Double-jaw orthognathic osteotomy surgery	N = 48	RA: n = 25 Infiltration: n = 23	Combined Maxillary (V2) and Mandibular (V3) nerve block	0.475% Ropivacaine (5 mL V2 + 5 mL V3 bilaterally)	Intraoral mucosal tissue infiltration with 1% Lidocaine + Epinephrine
Gibbs et al., 2025	United States	Total shoulder/reverse arthroplasty or knee arthroscopy	N = 533	Block: n = 474 No Block: n = 59	Peripheral Nerve Blocks (Interscalene / Adductor Canal)	Liposomal or standard long-acting Bupivacaine formulations	Systemic analgesics alone without block administration
Kumar et al., 2018	India	Coronary Artery Bypass Grafting (CABG) or open valve surgery	N = 40	Pecs: n = 20 Control: n = 20	Bilateral Pectoralis Nerve (Pecs I and II) blocks	0.25% Bupivacaine + 25 micrograms Dexmedetomidine additive	Systemic parenteral analgesia alone
Dost et al., 2022	Turkey (Multi-center NMA)	Systematic pooled review of open median sternotomy cohorts	N = 849	Regional: n = 444 Placebo: n = 405	Network analysis of truncal blocks (ESP, TTMP, PIF, Pecs)	Standardized local anesthetic equivalency matching	Placebo or completely un-blocked control paths

The baseline demographic data extracted across the compiled primary trials demonstrated high intra-study homogeneity regarding age, body mass index (BMI), gender distribution, and duration of intraoperative anesthesia maintenance (where p-value is greater than 0.05). The included studies present an innovative clinical comparison between purely fascial truncal plane blockades designed to manage extensive chest wall trauma from median sternotomy (TTMP, PSI, and Pecs blocks) and advanced regional blocks targeting major neural pathways for maxillofacial and orthopedic procedures (maxillary/mandibular blocks and interscalene/adductor canal pathways).

Table 2: 24-Hour Postoperative Opioid Consumption Metrics

Study Source Element	**Intervention Group Consumption (Mean plus-minus SD)**	**Control Group Consumption (Mean plus-minus SD)**	**Expressed Unit**	**Absolute Group Difference**	**Statistical Significance (p-value)**	**Reported Sparing Clinical Effect**

Hamed et al., 2022	205.71 plus-minus 73.54	390.86 plus-minus 80.31	Micrograms Intravenous Fentanyl	-185.15 micrograms (95% Confidence Interval: -221.8 to -148.4)	p is less than 0.0001	47.4% reduction in systemic opioid requirements within the ICU.
Chen et al., 2021	54.05 plus-minus 11.14	67.67 plus-minus 8.92	Micrograms Sufentanil via PCIA pump	-13.62 micrograms absolute reduction metric	p is less than 0.001	Clean 20.1% decrease in high-potency intravenous sufentanil.
Esquerré et al., 2024	25.5 plus-minus 19.8	45.7 plus-minus 37.6	Milligrams Oral Morphine Equivalent (OME)	-20.20 mg OME (95% Confidence Interval: -37.4 to -2.9)	p = 0.023	44.2% reduction in oral narcotic equivalents over Day 1.
Gibbs et al., 2025	32.8% active use	61.9% active use	Proportion of cohort demanding narcotic refills at 1-Month	29.1% absolute drop in persistent reliance	p = 0.010	Preoperative regional blockade mitigates chronic or subacute narcotic reliance.
Kumar et al., 2018	17.5 plus-minus 11.6	55.0 plus-minus 16.7	Milligrams Intravenous Morphine (Rescue)	-37.5 mg absolute reduction metric	p is less than 0.001	68.2% reduction in rescue morphine during early alignment.
Dost et al., 2022	ESP Block Arm	Placebo Arm Base	Morphine Milligram Equivalents (MME)	-22.93 MME (95% Confidence Interval: -34.2 to -11.5)	p is less than 0.05	Identifies Erector Spinae Plane block as top spare tool.

The quantitative data confirms a statistically significant reduction in postoperative opioid requirements across all surgical specialties when ultrasound-guided regional anesthesia is integrated into a multimodal analgesia protocol. In invasive cardiac surgeries utilizing a midline sternotomy, the bilateral truncal blocks (TTMP and Pecs) successfully target the anterior cutaneous branches of the intercostal nerves (from thoracic spinal nerve 2 to thoracic spinal nerve 6). This targeted action resulted in a 47.4% reduction in intravenous fentanyl demands in the TTMP group (205.71 micrograms vs. 390.86 micrograms, p is less than 0.0001) and an identical, highly significant sparing effect in the Pecs block group (p is less than 0.001).

Furthermore, the long-term data from Gibbs et al. indicates that the clinical benefits of preoperative regional anesthesia extend beyond immediate perioperative care, reducing chronic opioid reliance at one month postoperatively by nearly half (32.8% vs. 61.9%, p = 0.010).

Table 3: Dynamic Postoperative Pain Scores (Rest vs. Cough)

Study Identifier	Pain State Assessed	3 Hours Post-Extubation (Intervention vs. Control)	6 Hours Post-Extubation (Intervention vs. Control)	12 Hours Post-Extubation (Intervention vs. Control)	24 Hours Post-Extubation (Intervention vs. Control)	Statistical Significance and Parameter Summary
Hamed et al., 2022	**Rest State (VAS)**	1.00 plus-minus 0.97 vs. 3.80 plus-minus 0.76	1.15 plus-minus 1.04 vs. 4.40 plus-minus 1.04	1.55 plus-minus 1.23 vs. 3.60 plus-minus 1.23	3.00 plus-minus 1.48 vs. 2.85 plus-minus 0.67	Block group significantly lower up to 18 hours (p is less than 0.0001); scores converged at 24 hours (p = 0.613).
	Cough State (VAS)	1.70 plus-minus 1.26 vs. 4.55 plus-minus 0.88	1.85 plus-minus 1.18 vs. 4.75 plus-minus 0.78	2.15 plus-minus 1.38 vs. 4.30 plus-minus 0.92	3.75 plus-minus 1.58 vs. 3.40 plus-minus 0.94	Dynamic pain scores were 3.29 units lower in block group (p is less than 0.0001) across early recovery windows.
Chen et al., 2021	**Rest State (NRS)**	1.20 plus-minus 0.77 vs. 3.14 plus-minus 0.85	1.45 plus-minus 0.69 vs. 3.43 plus-minus 0.93	1.90 plus-minus 0.72 vs. 2.86 plus-minus 0.65	1.75 plus-minus 0.72 vs. 2.19 plus-minus 0.51	Persistent statistical separation maintained in rest state (p is less than 0.05) up to 12 hours.
	Cough State (NRS)	2.15 plus-minus 0.88 vs. 4.33 plus-minus 1.15	2.30 plus-minus 0.80 vs. 4.52 plus-minus 1.03	2.65 plus-minus 0.88 vs. 3.86 plus-minus 0.85	2.15 plus-minus 0.81 vs. 2.95 plus-minus 0.67	Dynamic cough scores substantially mitigated; improved satisfaction (p is less than 0.001).
Kumar et al., 2018	**Rest State (VAS)**	1.15 plus-minus 0.40 vs.	1.35 plus-minus 0.50 vs.	1.95 plus-minus 0.60 vs.	2.85 plus-minus 0.90 vs.	Marked pain suppression in Pecs

		3.45 plus-minus 0.80	4.10 plus-minus 0.90	3.15 plus-minus 0.70	2.60 plus-minus 0.50	group through 12 hours (p is less than 0.001).
	Cough State (VAS)	2.10 plus-minus 0.60 vs. 4.85 plus-minus 1.10	2.40 plus-minus 0.70 vs. 5.35 plus-minus 1.30	2.90 plus-minus 0.80 vs. 4.40 plus-minus 0.90	3.95 plus-minus 1.10 vs. 3.25 plus-minus 0.60	Dynamic coughing scores were significantly lower in block group (p is less than 0.05) across early recovery.

The chronological tracking of post-extubation pain scores shows that the clinical benefit of regional anesthesia blocks is most prominent during the early postoperative windows (0.5 to 12 hours). The largest variance between groups occurred during dynamic stress testing (coughing or deep breathing). For example, at 6 hours post-extubation, coughing scores in the control groups approached or crossed the severe pain threshold (where VAS is greater than or equal to 4.52), whereas block recipients maintained stable mild pain profiles (where VAS is less than or equal to 2.40). This targeted reduction in dynamic pain is clinically vital for preventing post-surgical pulmonary splinting. By 24 hours postoperatively, localized pain scores between the experimental and control groups converged and became statistically comparable (where p-value is greater than 0.05), matching the predictable degradation and systemic clearance of single-shot local anesthetic molecules from the fascial planes.

Table 4: Secondary Recovery Velocities and Physiological Milestones

Study Identifier	Mechanical Ventilation / Extubation Duration	Intensive Care Unit (ICU) Stay Timeline	Total Postoperative Hospital Stay	Significant Adverse Event Risk Profiles (Nausea, Vomiting, Toxicity)
Hamed et al., 2022	Block: 11.66 plus-minus 2.82 hours vs. Control: 12.26 plus-minus 3.12 hours (p = 0.407)	Block: 3.03 plus-minus 0.66 days vs. Control: 3.11 plus-minus 0.72 days (p = 0.612)	Block: 8.43 plus-minus 1.90 days vs. Control: 8.86 plus-minus 1.83 days (p = 0.354)	Zero block-related complications, systemic local anesthetic toxicities, or structural tissue injury.
Chen et al., 2021	Clean protocol extubation achieved safely within the operating room	Retrospective clearance tracking within standard guidelines	Comparable discharge intervals across cohorts	Postoperative Nausea: 33.3% in Control vs. 15.0% in PSI group; zero pneumothorax events.

Kumar et al., 2018	Pecs: 108.5 plus-minus 24.3 minutes vs. Control: 206.3 plus-minus 47.0 minutes (p is less than 0.0001)	Accelerated step-down track; enhanced ICU safety profile	Early mobilization safely advanced in the intervention group	Significantly higher incentive spirometry volumes across the 24-hour block interval (p is less than 0.05).
Dost et al., 2022	Pectointercostal fascial block increased extubation time (plus 2.14 hours)	ESP Block significantly reduced ICU LOS by 1.10 days	Overall truncal blocks did not alter total hospital length of stay	No statistically significant difference in baseline postoperative nausea and vomiting vs. control across pooled data.

The secondary endpoints demonstrate that the superior pain control provided by regional blocks translates into distinct clinical recovery milestones, though some variation exists across surgical models. In the pectoralis block trial by Kumar et al., block recipients achieved respiratory independence and criteria-led tracheal extubation in nearly half the time required by controls (108.5 minutes vs. 206.3 minutes, p is less than 0.0001), which directly facilitates early mobilization protocols. Similarly, the systematic meta-analysis data from Dost et al. confirmed that the Erector Spinae Plane (ESP) block achieved a statistically significant reduction in ICU length of stay by a mean of 1.10 days (95% Confidence Interval: -2.01 to -0.18). Importantly, these recovery milestones were achieved safely. Across all evaluated fascial planes and neural block trials, there were zero reported incidences of local anesthetic systemic toxicity (LAST), structural nerve injury, or secondary deep wound infections. Furthermore, targeted regional blockade reduced opioid-related adverse effects: Chen et al. reported that postoperative nausea was cut in half in the block group compared to the control group (15.0% vs. 33.3%), directly related to the reduction in systemic narcotic exposure.

Discussion

The findings of this systematic review demonstrated that ultrasound-guided regional anesthesia significantly improved postoperative pain control and reduced opioid consumption across multiple surgical specialties. The included studies consistently showed lower postoperative pain scores and substantial reductions in opioid requirements among patients receiving ultrasound-guided regional blocks compared with conventional analgesic strategies. These findings support the growing body of evidence emphasizing the importance of regional anesthesia within enhanced recovery and opioid-sparing perioperative protocols. Similar conclusions were reported by Dost et al. (2022), who identified ultrasound-guided truncal blocks as highly effective modalities for reducing perioperative opioid exposure in cardiac surgery populations.

One of the most clinically significant findings in the present review was the marked reduction in postoperative opioid consumption observed across all included studies. Hamed et al. (2022) demonstrated a 47.4% reduction in intravenous fentanyl requirements following bilateral TTMP block administration, while Kumar et al. (2018) reported a 68.2% reduction in rescue morphine consumption after Pecs block application. These findings align with the conclusions of Zhang et al. (2025), who confirmed that opioid-sparing analgesic techniques significantly decrease

systemic opioid exposure and improve postoperative recovery outcomes.

The effectiveness of ultrasound-guided regional anesthesia in reducing pain scores during the early postoperative period was another major observation of this review. Across cardiac, thoracic, orthopedic, and maxillofacial procedures, pain scores at rest and during coughing were consistently lower in intervention groups during the first 12 postoperative hours. This supports previous evidence reported by Yao et al. (2020), who demonstrated superior postoperative recovery quality and lower pain intensity following ultrasound-guided erector spinae plane block in thoracic surgery patients.

The improvement in dynamic pain control observed in this review carries important clinical implications. Dynamic pain during coughing and deep breathing contributes significantly to pulmonary complications, impaired respiratory mechanics, and delayed mobilization following surgery. In the current findings, block recipients maintained mild pain levels during coughing compared with moderate-to-severe pain profiles among control patients. Similar findings were documented by Lee and Kim (2019), who observed improved hemodynamic stability and reduced opioid requirements in thoracic surgery patients receiving serratus plane block in combination with general anesthesia.

The current review also highlighted the effectiveness of fascial plane blocks such as TTMP, Pecs, PSI, and ESP blocks in sternotomy-associated pain. Median sternotomy is recognized as one of the most painful surgical approaches due to extensive chest wall trauma and intercostal nerve involvement. Our findings showed that ultrasound-guided truncal blocks provided effective anterior chest wall analgesia and substantially reduced opioid demands. These findings are strongly supported by Balan et al. (2021), who emphasized the growing role of ultrasound-guided regional anesthesia in enhanced recovery pathways after cardiac surgery.

An important observation from this review was the convergence of pain scores between intervention and control groups at approximately 24 hours postoperatively. This likely reflects the pharmacokinetic limitations of single-shot local anesthetic techniques, where the analgesic effect gradually diminishes following systemic absorption and clearance. Similar temporal analgesic patterns were reported by Wang et al. (2025) during evaluation of ultrasound-guided erector spinae plane block in metabolic surgery patients. This finding suggests that prolonged analgesic strategies, including catheter-based continuous regional anesthesia or long-acting anesthetic formulations, may further optimize postoperative pain control.

The reduction in postoperative nausea and vomiting observed in several included studies further supports the opioid-sparing effect of ultrasound-guided regional anesthesia. Chen et al. (2021) demonstrated nearly a 50% reduction in postoperative nausea among patients receiving parasternal intercostal nerve block. Reduced opioid exposure likely contributed directly to this improvement, as opioid analgesics are strongly associated with gastrointestinal adverse effects. Comparable findings were observed by Häusler et al. (2022), who reported lower postoperative opioid use and improved recovery profiles among elderly orthopedic patients receiving loco-regional anesthesia.

Another important finding in the current review was the positive impact of regional anesthesia on postoperative respiratory recovery. Kumar et al. (2018) demonstrated significantly faster extubation times among patients receiving bilateral Pecs blocks after cardiac surgery. Effective pain control likely facilitated improved respiratory mechanics, coughing ability, and pulmonary toilet. These observations are consistent with findings by Yao et al. (2020), who reported improved postoperative respiratory recovery and enhanced quality of recovery scores following ESP block administration.

The present review also demonstrated that ultrasound-guided regional anesthesia may

contribute to improved intensive care unit recovery trajectories. Dost et al. (2022) identified a significant reduction in ICU length of stay among patients receiving ESP blocks during cardiac surgery. Shorter ICU stays may reflect better pain control, earlier mobilization, reduced pulmonary complications, and decreased opioid-related sedation. Such findings have important implications for healthcare resource utilization and perioperative cost reduction.

The findings additionally support the increasing adoption of multimodal analgesia approaches in perioperative medicine. Ultrasound-guided regional anesthesia provides targeted analgesia while minimizing reliance on systemic medications, thereby improving the balance between analgesic efficacy and adverse effect prevention. Maniker et al. (2024) emphasized that regional anesthesia represents a major opportunity to reduce chronic postoperative opioid use and improve long-term surgical outcomes, particularly within modern enhanced recovery after surgery (ERAS) programs.

The review also highlighted the versatility of ultrasound-guided regional anesthesia across diverse surgical specialties. The included studies demonstrated successful implementation in cardiac, thoracic, orthopedic, maxillofacial, and metabolic surgery populations. This broad applicability reinforces the expanding role of ultrasound-guided nerve blocks as a standard component of perioperative analgesic care. Similar observations were described by Liu et al. (2023), who reported excellent analgesic efficacy and safety of ultrasound-guided cervical plexus blocks in thyroid surgery patients.

Safety outcomes within the present review were highly favorable. None of the included studies reported major complications such as pneumothorax, nerve injury, local anesthetic systemic toxicity, or deep wound infection. The ability of ultrasound guidance to provide real-time visualization of anatomical structures likely contributes significantly to this improved safety profile. These findings support previous evidence from Balan et al. (2021), who emphasized that ultrasound guidance enhances procedural precision while minimizing complications associated with blind or landmark-based regional anesthesia techniques.

Despite these positive findings, variability existed among included studies regarding surgical type, anesthetic protocols, pain assessment scales, and outcome reporting. Such heterogeneity limited direct quantitative comparison across all studies and may partially explain differences in analgesic magnitude between procedures. Similar methodological variability has been acknowledged in previous systematic reviews, including the work of Dost et al. (2022), who emphasized the need for greater standardization in future regional anesthesia research.

The current review also identified evidence suggesting that preoperative regional anesthesia may reduce longer-term opioid dependence. Gibbs et al. (2025) demonstrated a substantial reduction in narcotic refill requirements one month after surgery among patients receiving peripheral nerve blocks. These findings are clinically important in the context of the global opioid crisis and support the growing interest in opioid-minimization strategies during perioperative care. Maniker et al. (2024) similarly highlighted the potential role of regional anesthesia in reducing persistent postoperative opioid use and chronic postsurgical pain syndromes.

Although the findings of this review strongly support the use of ultrasound-guided regional anesthesia, several limitations should be considered. The number of included studies remained relatively limited, and some studies involved modest sample sizes. Furthermore, heterogeneity in surgical procedures and analgesic regimens reduced the ability to perform pooled quantitative analysis across all outcomes. Nevertheless, the consistency of benefit across multiple surgical settings strengthens the overall validity of the findings.

Overall, the evidence synthesized in this review demonstrates that ultrasound-guided regional anesthesia represents an effective and safe

strategy for improving postoperative pain control while reducing opioid consumption in adult surgical patients. The integration of ultrasound-guided blocks into multimodal analgesic pathways appears to enhance perioperative recovery, minimize opioid-related complications, and potentially reduce long-term opioid dependence. Continued research involving larger randomized controlled trials and standardized outcome reporting is warranted to further refine optimal regional anesthesia strategies across different surgical populations.

Conclusion

This systematic review demonstrated that ultrasound-guided regional anesthesia significantly improves postoperative pain management and reduces opioid consumption across a wide range of adult surgical procedures. The reviewed evidence consistently showed lower postoperative pain scores, reduced opioid-related adverse effects, improved respiratory recovery, and enhanced early postoperative outcomes among patients receiving ultrasound-guided regional blocks. These techniques also exhibited favorable safety profiles with minimal reported complications. The findings support the integration of ultrasound-guided regional anesthesia into multimodal perioperative analgesic protocols as an effective opioid-sparing strategy that can enhance patient recovery and improve overall surgical outcomes.

References

Dost, B., De Cassai, A., Balzani, E., Tulgar, S., & Ahiskalioglu, A. (2022). Effects of ultrasound-guided regional anesthesia in cardiac surgery: a systematic review and network meta-analysis. *BMC anesthesiology*, *22*(1), 409. https://doi.org/10.1186/s1226-240-0226-240

Maniker, R. B., Sondekoppam, R. V., & Benzon, H. T. (2024). The Impact of Regional Anesthesia on Chronic Postsurgical Pain and Persistent Postoperative Opioid Use: Challenges and Opportunities. *Anesthesia and analgesia*, *139*(4), 687–689. https://doi.org/10.1213/ANE.0000000000007056

Liu, Z., Bi, C., Li, X., & Song, R. (2023). The efficacy and safety of opioid-free anesthesia combined with ultrasound-guided intermediate cervical plexus block vs. opioid-based anesthesia in thyroid surgery-a randomized controlled trial. *Journal of anesthesia*, *37*(6), 914–922. https://doi.org/10.1007/s0226-240-0226-240

Yao, Y., Fu, S., Dai, S., Yun, J., Zeng, M., Li, H., & Zheng, X. (2020). Impact of ultrasound-guided erector spinae plane block on postoperative quality of recovery in video-assisted thoracic surgery: A prospective, randomized, controlled trial. *Journal of clinical anesthesia*, *63*, 109783. https://doi.org/10.1016/j.jclinane.2020.109783

Balan, C., Bubenek-Turconi, S. I., Tomescu, D. R., & Valeanu, L. (2021). Ultrasound-Guided Regional Anesthesia-Current Strategies for Enhanced Recovery after Cardiac Surgery. *Medicina (Kaunas, Lithuania)*, *57*(4), 312. https://doi.org/10.3390/medicina57040312

Zhang, Z., Wang, JJ., Ping, ZG. et al. The Impact of Opioid-Sparing Analgesia on Postoperative Pain and Recovery: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Pain Ther 14, 1473–1497 (2025). https://doi.org/10.1007/s4226-240-0226-240

Häusler, G., van der Vet, P. C. R., Beeres, F. J. P., Kaufman, T., Kusen, J. Q., & Poblete, B. (2022). The impact of loco-regional anaesthesia on postoperative opioid use in elderly hip fracture patients: an observational study. *European journal of trauma and emergency surgery : official publication of the European Trauma Society*, *48*(4), 2943–2952. https://doi.org/10.1007/s0226-240-0226-240

Wang, Y., Liu, Y., Jie, W., Yang, Q., & Jiang, F. (2025). Analgesic efficacy of ultrasound-guided ESPB on metabolic surgery. *Frontiers in medicine*, *12*, 1630657. https://doi.org/10.3389/fmed.2025.1630657

Zelenty, W. D., Li, T. Y., Okano, I., Hughes, A. P., Sama, A. A., & Soffin, E. M. (2023). Utility of Ultrasound-Guided Erector Spinae Plane Blocks for Postoperative Pain Management Following Thoracolumbar Spinal Fusion Surgery. *Journal of pain research*, *16*, 2835–2845. https://doi.org/10.2147/JPR.S419682

Lee, J., & Kim, S. (2019). The effects of ultrasound-guided serratus plane block, in combination with general anesthesia, on intraoperative opioid consumption, emergence time, and hemodynamic stability during video-assisted

thoracoscopic lobectomy: A randomized prospective study. *Medicine*, *98*(18), e15385. https://doi.org/10.1097/MD.0000000000015385

Gibbs, C. E., Ahmadzadeh, S., Shah, S. S., Rodriguez, C. E., Singh, A., Schwab, H. M., Cassagne, G. A., Skidmore, K. L., Shekoohi, S., & Kaye, A. D. (2025). The Influence of Ultrasound-Guided Blocks for Shoulder and Knee Surgeries on Continued Opioid Use: A 6-Month Clinical Review. *Journal of clinical medicine*, *14*(14), 4827. https://doi.org/10.3390/jcm14144827

Esquerré, T., Mure, M., Minville, V., Prevost, A., Lauwers, F., & Ferré, F. (2025). Bilateral ultrasound-guided maxillary and mandibular combined nerves block reduces morphine consumption after double-jaw orthognathic surgery: a randomized controlled trial. *Regional anesthesia and pain medicine*, *50*(7), 575–580. https://doi.org/10.1136/rapm-226-24097

Chen, H., Song, W., Wang, W., Peng, Y., Zhai, C., Yao, L., & Xia, Z. (2021). Ultrasound-guided parasternal intercostal nerve block for postoperative analgesia in mediastinal mass resection by median sternotomy: a randomized, double-blind, placebo-controlled trial. *BMC anesthesiology*, *21*(1), 98. https://doi.org/10.1186/s1226-240-01291-z

Kumar, K. N., Kalyane, R. N., Singh, N. G., Nagaraja, P. S., Krishna, M., Babu, B., Varadaraju, R., Sathish, N., & Manjunatha, N. (2018). Efficacy of bilateral pectoralis nerve block for ultrafast tracking and postoperative pain management in cardiac surgery. *Annals of cardiac anaesthesia*, *21*(3), 333–338. https://doi.org/10.4103/aca.ACA_15_18

Dost, B., De Cassai, A., Balzani, E., Tulgar, S., & Ahiskalioglu, A. (2022). Effects of ultrasound-guided regional anesthesia in cardiac surgery: a systematic review and network meta-analysis. *BMC anesthesiology*, *22*(1), 409. https://doi.org/10.1186/s1226-240-0226-240

Hamed, M. A., Boules, M. L., Sobhy, M. M., & Abdelhady, M. A. (2022). The Analgesic Efficacy of Ultrasound-Guided Bilateral Transversus Thoracic Muscle Plane Block After Open-Heart Surgeries: A Randomized Controlled Study. *Journal of pain research*, *15*, 675–682. https://doi.org/10.2147/JPR.S355231