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Review

Regional anaesthesia for postoperative pain after median sternotomy in cardiac surgery: a scoping review and meta-analysis

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Abstract

Introduction: Regional anaesthesia (RA) is an established option for analgesia in cardiac surgery performed via median sternotomy. Despite the growth of minimally invasive approaches, sternotomy remains widely used and is associated with substantial postoperative pain and related complications. Perioperative analgesic management in cardiac surgery is therefore typically multimodal. The primary objective of this study was to evaluate the efficacy and limitations of RA techniques to determine whether RA could serve as a core component of postoperative pain management after sternotomy.

Methods: We conducted a systematic review of the literature across multiple databases to identify studies reporting postoperative outcomes of RA techniques with respect to reduction of post-sternotomy pain. Six studies in which the primary endpoint was postoperative pain after cardiac surgery met the eligibility criteria and were included in the meta-analysis.

Results: Pooled analysis of the six studies indicated that RA was associated with a clinically meaningful reduction in post-sternotomy pain intensity (pooled mean difference approximately −3 points on a 0–10 scale), along with decreased opioid consumption. Considerable between-study heterogeneity was observed (I^2 = 99.5%), reflecting variation in RA techniques, comparators, and perioperative protocols; nevertheless, the direction of effect consistently favoured RA.

Conclusion: RA appears effective for improving postoperative analgesia after cardiac surgery via median sternotomy and may reduce perioperative opioid requirements. Incorporation of RA into Enhanced Recovery After Cardiac Surgery pathways could support postoperative recovery and mitigate opioid-related adverse effects. Given the substantial heterogeneity across studies, further well-designed trials using standardised analgesic outcomes are warranted to refine indications and optimise technique selection.

Key words: **Regional anesthesia, cardiac surgery, pain control, review, meta-analysis.**

Introduction

More than 10,000 cardiac surgical procedures are performed annually in Belgium, representing a substantial share of invasive medical activity because of their complexity and cost. A considerable proportion of these procedures requires direct access and visualisation of the heart to ensure operative quality and safety. Although so-called minimally invasive approaches (e.g., mini-sternotomies such as MIDCAB, ENDOCAB, hemi-sternotomy, and partial sternotomy) are expanding, full median sternotomy remains a preferred approach owing to its accessibility for surgeons[1].

Despite its familiarity and wide use, median sternotomy continues to be associated with postoperative complications, chiefly respiratory infections, mediastinitis, sternal dehiscence, and significant pain that hampers early and effective rehabilitation[2,3]. These complications contribute to increased morbidity and mortality and prolong length of stay, thereby raising healthcare costs[4,5]. Postoperative pain is a direct consequence of the surgical approach and shapes the course of postoperative rehabilitation[6]. In this context, regional anaesthesia (RA) has developed as a complement and alternative to oral or intravenous analgesics, both within opioid-sparing strategies and within Enhanced Recovery After Surgery frameworks that aim to expedite return to daily activities[7]. Inadequate analgesia not only delays rehabilitation but also increases the risk of infectious complications due to prolonged bed rest (e.g., pressure ulcers)[8], and—especially—respiratory impairment that limits adequate thoracic expansion and physiotherapy exercises[9]. Conversely, inappropriate and/or excessive use of opioids to control pain exposes patients to notable adverse effects, including respiratory depression, cognitive disturbances, physical dependence, constipation, and prolonged ventilatory support[9]. Adequate pain control promotes active participation in respiratory rehabilitation and overall care, with the intent of improving well-being and supporting earlier recovery of autonomy[6,8].

To improve postoperative pain management, the French Society of Anaesthesiology and Intensive Care (SFAR) issued expert-consensus recommendations in 2021 for Enhanced Recovery After Cardiac Surgery, encouraging the use of RA techniques, such as thoracic epidural anaesthesia and paravertebral blocks, to enhance postoperative analgesia[10]. To date, despite active engagement in pain-management research, the Belgian Society of Anaesthesia and Resuscitation (BeSARPP) has not issued specific recommendations regarding the use or choice of RA in cardiac surgery.

Several techniques are available to the anaesthetist–intensivist for optimal analgesic management: thoracic epidural analgesia, paravertebral blocks, fascial plane blocks such as the erector spinae plane (ESP) block and the pectoral nerve (PECS) block, and more recently the parasternal block[11,12]. Some studies have demonstrated the effectiveness of thoracic epidural analgesia in improving pain control after sternotomy, reducing pulmonary morbidity, and facilitating respiratory recovery[13,14]. Other recent work has likewise shown that RA techniques in this setting reduce pain in parallel with a significant decrease in opioid consumption[14,15].

Building on the available data and these encouraging findings, we conducted a systematic review and meta-analysis to assess the impact and effectiveness of RA in cardiac surgery with respect to postoperative pain and opioid requirements.

Materials and Methods

Eligibility Criteria

Studies were eligible for inclusion if they met the following criteria:

- Population: adult patients undergoing elective cardiac surgery via full median sternotomy
- Intervention: use of regional anesthesia (RA) techniques for perioperative analgesia
- Comparator: standard analgesic protocols or other forms of analgesia
- Outcomes: postoperative pain intensity and/or opioid consumption as primary outcomes
- Study design: randomized controlled trials, prospective or retrospective comparative cohort studies

Exclusion criteria included: case reports, studies on pediatric populations, animal models, non-sternotomy cardiac procedures (e.g., thoracotomy, minimally invasive approaches), and studies without extractable or analyzable data.

The comprehensive literature search was conducted in February 2025 across PubMed and Cochrane Library; other databases including Embase, CINAHL, and Scopus were not searched.

Search Strategy

The search strategy followed PRISMA-S guidance. Keywords and controlled vocabulary (MeSH terms) included combinations of: “regional anesthesia”, “cardiac surgery”, “sternotomy”, “analgesia”, “opioid consumption” (Supplementary Table 1).

Selection Process

Two independent reviewers screened the records in two stages: (1) title and abstract screening, followed by (2) full-text review for eligibility. Discrepancies were resolved by consensus. Out of 2,495 records identified, 27 duplicates were removed. Among the 2,468 records screened, 109 were selected for full-text review. After exclusions based on ineligibility (pediatric studies, non-sternotomy procedures, inaccessible full-texts, non-analgesia outcomes), a total of 6 studies were included in the final synthesis. The PRISMA 2020 flow diagram (Figure 1) details the selection process.

Data Collection Process

Data from each study were extracted independently by two authors using a standardized form. Extracted information included study characteristics, population details, RA technique, control group treatment, primary outcomes (pain scores, morphine consumption), and statistical data. Authors of studies with missing numerical data were contacted when feasible.

Data Items

Primary outcome measures:

- Postoperative pain scores (typically reported on a 10-point scale)

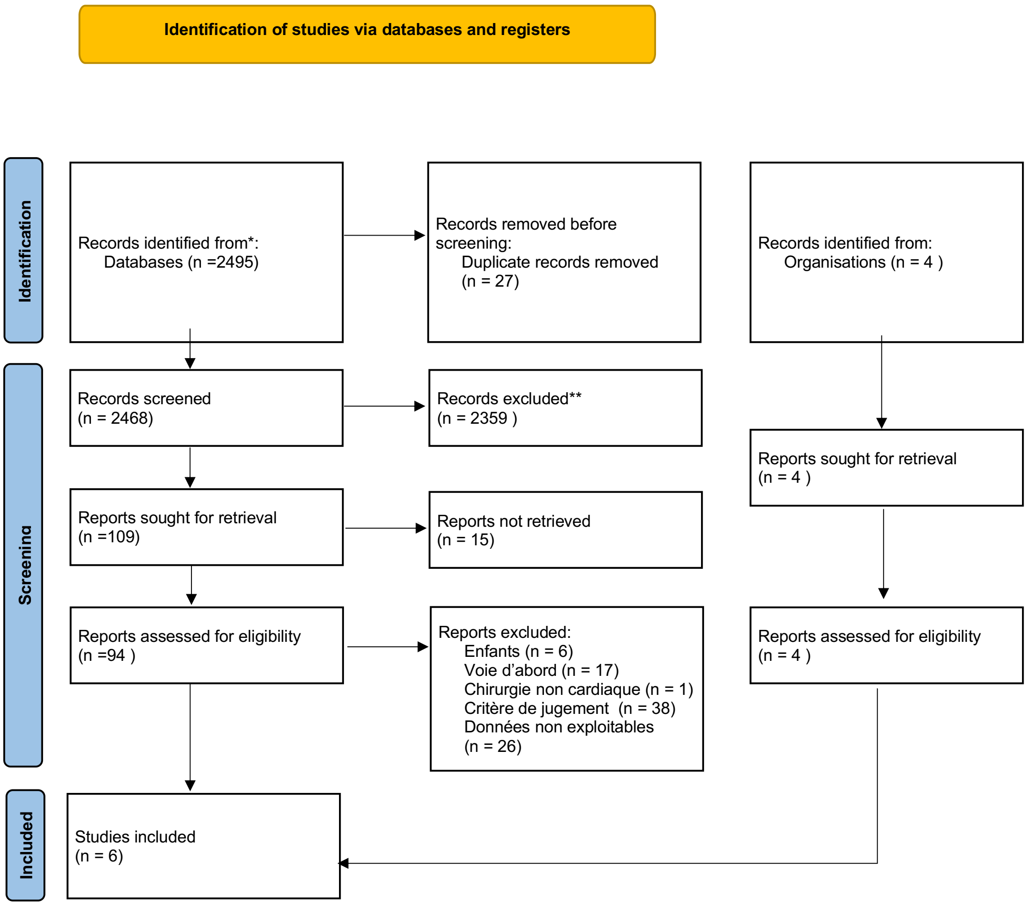

Fig. 1 — Flowchart.

- Cumulative morphine (or morphine equivalent) consumption during the first 24–72 hours postoperatively.

Secondary items included surgical type, RA technique used, study setting, and anesthetic protocol. Mean difference (MD) was used as the summary measure for continuous outcomes (pain scores and opioid consumption).

Study Risk of Bias Assessment

Risk of bias was not formally assessed due to the limited number and heterogeneity of included studies. However, all studies were monocentric and conducted under supervision in academic hospital settings, which ensured internal consistency in perioperative protocols.

Statistics

A meta-analysis using a random-effects model was performed to account for expected clinical heterogeneity. Statistical heterogeneity was evaluated using Cochran's Q test and quantified using the I^2 statistic, with $I^2 > 75\%$ considered substantial heterogeneity. Forest plots were generated to visually display pooled estimates and confidence intervals. Statistical analyses were conducted using SPSS version 29.

Results

Postoperative Pain Assessment

Postoperative pain was assessed at various time points ranging from 6 to 120 hours after surgery, depending on the study protocol. This temporal variability reflects real-world clinical practice and allows for pain monitoring beyond the immediate postoperative period. Morphine consumption was also measured across a postoperative window of 24 to 72 hours. These data contribute to the growing body of evidence supporting the analgesic efficacy of regional anesthesia (RA).

Although direct comparisons between studies are limited by methodological heterogeneity, the available data provide valuable insight from multiple clinical perspectives.

The forest plot for pain outcomes included standardized pain scores (0 to 10 scale) and revealed a pooled mean difference of –3.0 points in favor of RA, indicating a clinically significant reduction in pain intensity. The heterogeneity among studies was considerable: Cochran's Q was 398.75 with 132 degrees of freedom, well above the threshold expected under the assumption of homogeneity. The I^2 statistic was estimated at 99.5%, reflecting substantial variability across studies. This heterogeneity is likely attributable to differences in RA techniques used (e.g., thoracic epidural anesthesia [TEA], intrathecal morphine [ITM]), variations in timing of pain assessment, and diversity in perioperative analgesic protocols.

Postoperative Opioid Consumption

Regarding opioid use in the postoperative period (measured in milligrams of morphine equivalents), the forest plot for opioid consumption similarly demonstrated a significant reduction in patients who received regional anesthesia. The overall effect strongly favored RA, with reductions ranging from a few milligrams to more than 25 mg depending on the study.

The heterogeneity assessment for this outcome mirrored that of pain intensity: Cochran's Q was again 398.75 and I^2 was 99.5%, highlighting pronounced variability across the included studies. This reinforces the influence of differing clinical contexts, RA modalities, and outcome measurement intervals.

Discussion

The growing interest in regional anaesthesia (RA) for cardiac surgery via median sternotomy is supported by this meta-analysis, which indicates benefits for postoperative pain control and reductions in opioid consumption. Contemporary anaesthetic practice increasingly favours targeted, individualised strategies aligned with functional recovery goals; RA fits within this paradigm by addressing pain at its source and facilitating early mobilisation, reduced exposure to opioid-related adverse effects, and adherence to enhanced recovery protocols across the care pathway.

Beyond analgesia, it is physiologically plausible, though not directly demonstrated by the outcomes analyzed in this meta-analysis, that RA may contribute to improved respiratory rehabilitation by enabling earlier participation in physiotherapy and ambulation, potentially limiting complications associated with prolonged bed rest and high opioid use. As this review did not analyse respiratory endpoints, these potential benefits should be considered hypothesis-generating and await confirmation in adequately powered trials with dedicated pulmonary outcome measures. Taken together, these features position RA as a promising component of multimodal perioperative care after sternotomy.

Study limitations

This review has several limitations. First, there was substantial heterogeneity in RA techniques across the included studies: intrathecal morphine, intercostal blocks, thoracic epidural analgesia, intrapleural techniques, and various fascial plane approaches were used, with differences in implementation (single-shot vs catheter), injection levels, and local anaesthetic regimens. This diversity complicates direct comparisons and constrains generalisability.

Second, postoperative pain was assessed using different scales and assessment modes (observer-rated vs self-reported), introducing potential measurement bias. Timing of assessments also varied widely, from the recovery room to several days postoperatively, limiting temporal harmonisation.

Third, some studies were conducted many years ago, which may reduce applicability to current practice. Intraoperative anaesthetic regimens (e.g., propofol, sevoflurane, isoflurane) differed and could have influenced postoperative analgesic needs. Elements of multimodal postoperative analgesia (paracetamol, NSAIDs, dexamethasone, etc.) were inconsistently reported or isolated, and there was likely inter-operator variability even within the same surgical approach. Additional limitations include modest sample sizes, incomplete blinding in several trials, and a lack of standardised secondary endpoints beyond pain (e.g., duration of intubation, time to mobilisation, pulmonary complications). The small number of studies included reduces overall statistical power, and publication bias cannot be excluded.

Fourth, the search was limited to PubMed and the Cochrane Library; Embase, CINAHL, and Scopus were not queried, which may have resulted in omission of relevant studies and constitutes a source of potential selection bias.

Fifth, several studies contribute multiple data points to the forest plot (Figure 2), corresponding to distinct postoperative time points rather than independent patient cohorts; readers should therefore interpret the apparent volume of evidence with caution, as this does not reflect a greater number of studies or patients.

Finally, no formal subgroup analysis comparing central (neuraxial) versus peripheral RA techniques was performed, owing to the very limited number of studies in each category; this clinically important distinction is flagged as a priority for future meta-analyses.

Perspectives for RA in cardiac surgery

RA has emerged as a potential pillar of postoperative analgesia, supported by advances in technique standardisation (e.g., erector spinae plane, paravertebral, parasternal blocks), improved

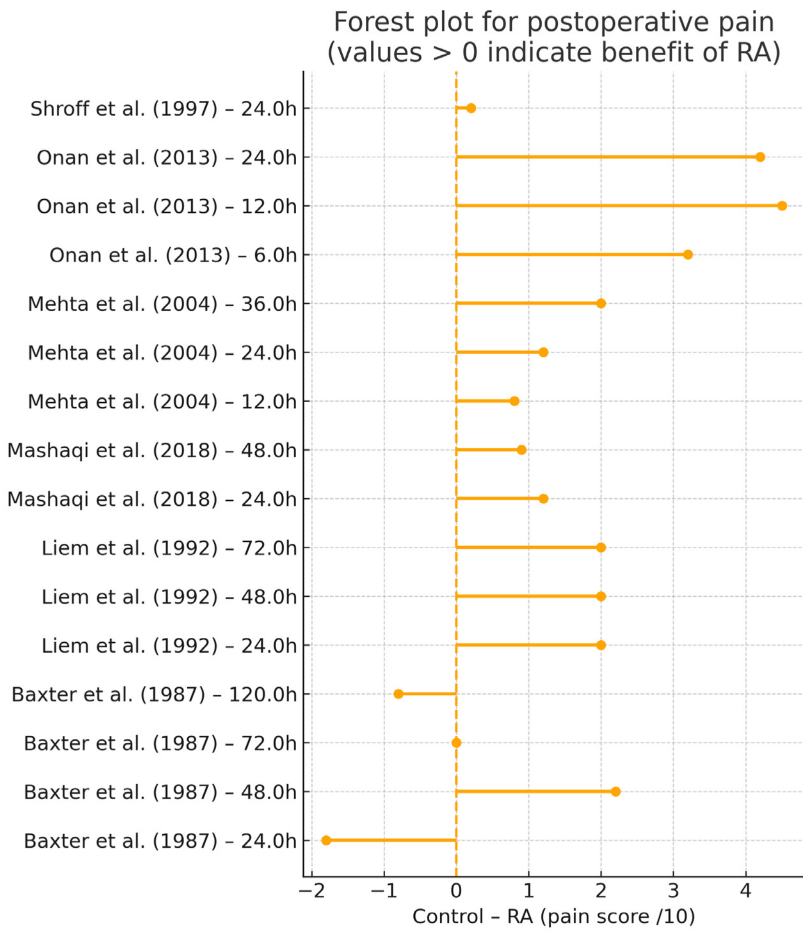

Fig. 2 — Forest plots for postoperative pain scores (top) and opioid consumption (bottom). Note: individual studies may appear more than once, corresponding to distinct postoperative assessment time points (e.g., 6 h, 24 h, 48 h); these entries derive from the same patient cohorts and do not represent independent studies or additional patients. CI, confidence interval; MD, mean difference; RA, regional anaesthesia.

safety through ultrasound guidance and monitoring, and broader dissemination beyond expert centres. The principal aims remain minimising opioid exposure and supporting timely recovery.

An important distinction that warrants emphasis for future research is the biomechanical difference between central (neuraxial) and peripheral RA techniques in this setting. Of the six RCTs included in this review, four involved (peri)medullary approaches (thoracic epidural analgesia or intrathecal morphine), which provide dermatomal coverage extending to the thoracic paraspinal and costovertebral regions. This coverage is particularly relevant when surgeons harvest the internal mammary arteries, a manoeuvre that involves significant sternal elevation and costovertebral strain, generating deep posterior pain that peripheral chest-wall blocks (e.g., intercostal, intrapleural techniques) may not adequately address. The two remaining RCTs used peripheral approaches with predominantly anterior chest-wall coverage. Although the small number of studies in each category precluded a formal subgroup analysis, this anatomical distinction is clinically important and should be explicitly accounted for in the design of future trials. Based on the evidence reviewed, the most pressing clinical question is whether peripheral fascial plane blocks, specifically bilateral continuous parasternal intercostal plane blocks or the erector spinae plane (ESP) block, which offer a more favourable safety profile in anticoagulated cardiac surgical patients, can match the analgesic efficacy of neuraxial approaches. We therefore propose that the priority design for the next landmark RCT should directly compare one of these peripheral techniques against TEA or intrathecal morphine as an active comparator, using standardised, prolonged pain and functional outcome assessment.

To clarify the role of RA, large multicentre randomised controlled trials are needed, with rigorous and prolonged pain assessment (at least 72 to 120 hours) to capture the full acute pain trajectory. Trials should directly compare specific RA techniques (e.g., paravertebral, ESP, parasternal) against appropriate controls, ideally using double-blind designs to mitigate patient expectation effects and assessor bias. Methodological harmonisation, block type and dose, timing of administration, and standardised outcome measures and assessment methods, will be essential to maximise reproducibility and between-centre comparability.

Given the integration of Enhanced Recovery After Cardiac Surgery pathways into routine care for this population, future studies should include comprehensive health-economic evaluations (opioid consumption, ward/ICU length of stay, and postoperative complications, even when not directly attributable to RA). Strengthening the incorporation of RA into ERAS pathways and expert guidance may help consolidate its role and support wider, standardised adoption of RA techniques after median sternotomy.

Conclusion

This meta-analysis provides preliminary evidence supporting a potential role for regional anaesthesia (RA) in cardiac surgery via median sternotomy. Despite substantial heterogeneity across the six included studies ($I^2 = 99.5\%$), the direction of effect consistently favoured RA, with a trend toward reduced acute postoperative pain intensity and opioid consumption, which may facilitate recovery and limit opioid-related adverse effects. These findings should be interpreted with caution given the limited number of studies, high heterogeneity, and absence of formal subgroup analyses. These findings are consistent with current SFAR guidance supporting stronger integration of RA within Enhanced Recovery After Cardiac Surgery (ERACS) pathways. They also highlight the need for standardisation of RA techniques and outcome assessment to enable reliable replication of clinical benefits.

Broader dissemination across care settings, targeted practitioner training, and rigorously designed studies are required to refine indications and identify the most effective techniques. Collectively, these steps are key to consolidating the role of RA in postoperative management after sternotomy.

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Supplentary table I.

Date	First author (Name et al.)	Origin hospital	Academic (University hospital)	Design	Inclusion criteria	Exclusion criteria	Type of RA	n	Regional anesthesia (drug, dose)	Timing of RA administration	Postoperative analgesia
2018	B. Mashaqi et al.	Hannover Medical School (Germany)	Yes	Double-blind RCT (patient, surgeon, staff)	CABG with CPB, median sternotomy	Arrhythmia, COPD, allergy to lidocaine, hepatic/renal insufficiency	Con-trol	20	NaCl 0.9% intrapleural via double-lumen drain, 2 injections POD1 & POD2	Postoperative	Paracetamol 1 g × 3/day; Metamizole 1 g × 3/day; RA repeated POD1 & POD2
							IPLA	20	Lidocaine 2% intrapleural via double-lumen drain, 2 injections POD1 & POD2		

Supplentary table I. — Continued.

Date	First author (Name et al.)	Origin hospital	Academic (University hospital)	Design	Inclusion criteria	Exclusion criteria	Type of RA	n	Regional anesthesia (drug, dose)	Timing of RA administration	Postoperative analgesia
2013	Onan Burak et al.	Ankara University Hospital	No	Prospective randomized	Elective CABG, median sternotomy	LVEF < 40%, emergency surgery, prior cardiothoracic surgery	Con-trol	20	No treatment	Preoperative	Acetaminophen or tramadol
							TEA	20	Epidural catheter T2–T3/T3–T4; bolus bupivacaine 20 mg (0.25%) 1h pre-op; intraop infusion 20 mg/h; postop infusion 10–20 mL/h 24h		
2004	Y. Mehta et al.	Escorts Heart Institute, New Delhi	Yes	Single-blind prospective randomized (assessor)	CABG, normal LVEF	Age > 70, FEV1 or FVC < 60%, neurologic dysfunction	Con-trol	47	Placebo (subcutaneous NaCl 0.9%)	Preoperative	IV morphine or IM diclofenac
							ITM	53	Intrathecal morphine 8 µg/kg		
							ITM	11	Intrathecal morphine 500 µg + sufentanil 50 µg		IV nicomorphine pre-extubation, PCA morphine post-extubation, ibuprofen
1997	A. Shroff et al.	VA Medical Center, Seattle (Univ. affiliated)	Yes	Single-blind prospective randomized (assessor)	Male ASA III–IV, elective CABG, no anticoagulants/ aspirin 7d	Recent anticoagulants/ aspirin, hepatic/renal insufficiency	ITM	12	Intrathecal morphine 10 µg/ kg + fentanyl 25 µg (L3–L4/L4–L5)	Preoperative	IV morphine on demand (ICU boluses), IV midazolam on demand
							Con-trol	9	No treatment		
1992	T.H. Liem et al.	Ulm Hospital, Germany	Yes	Randomized controlled trial	Elective CABG	Urgent surgery	TEA	25	Continuous infusion bupivacaine 0.125% + sufentanil (1:1,000,000)	Intraoperative	Infusion maintained 72 h
							Con-trol	25	No treatment		IV nicomorphine q6h

Supplentary table I. — Continued.

Date	First author (Name et al.)	Origin hospital	Academic (University hospital)	Design	Inclusion criteria	Exclusion criteria	Type of RA	n	Regional anesthesia (drug, dose)	Timing of RA administration	Postoperative analgesia
1987	A.D. Baxter et al.	Memorial Univ. Health Sciences Centre, Newfoundland	Yes	Single-blind prospective randomized (assessor)	Elective cardiac surgery with sternotomy (CABG, valve replacement, or both)	Not formally listed; ASA II–IV; no exclusion by age/sex	CIB	20	Bupivacaine 0.25% via bilateral intercostal catheters	Postoperative	20 mL bupivacaine 0.25% q6h for 36–48 h
							Control	20	No treatment		IV morphine 2–5 mg on demand + diazepam

References

1. Pettinari M, Navarra E, Noirhomme P, Gutermann H. The state of robotic cardiac surgery in Europe. Ann Cardiothorac Surg [Internet]. 2017 Jan 1 [cited 2025 Sep 1];6(1):1. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5293627/
2. Hota P, Dass C, Erkmen C, Donuru A, Kumaran M. Poststernotomy Complications: A Multimodal Review of Normal and Abnormal Postoperative Imaging Findings. AJR Am J Roentgenol [Internet]. 2018 Dec 1 [cited 2025 Sep 1];211(6):1194–205. Available from: https://pubmed.ncbi.nlm.nih.gov/30300004/
3. Kirshenboim ZE, Duman E, Lee EM, Lacomis JM, Serna-Gallegos DR, Sultan I, et al. Poststernotomy Imaging: Pictorial Review of Expected Postsurgical Findings and Complications. Radiographics [Internet]. 2025 May 1 [cited 2025 Sep 1];45(5). Available from: https://pubmed.ncbi.nlm.nih.gov/40272997/
4. Lapar DJ, Speir AM, Crosby IK, Fonner E, Brown M, Rich JB, et al. Postoperative atrial fibrillation significantly increases mortality, hospital readmission, and hospital costs. Ann Thorac Surg [Internet]. 2014 [cited 2025 Sep 1];98(2):527–33. Available from: https://pubmed.ncbi.nlm.nih.gov/25087786/
5. Maeßen T, Korir N, Van de Velde M, Kennes J, Pogatzki-Zahn E, Wu C, et al. Pain management after cardiac surgery via median sternotomy: A systematic review with procedure-specific postoperative pain management (PROSPECT) recommendations. Eur J Anaesthesiol [Internet]. 2023 Oct 1 [cited 2025 Sep 1];40(10):758–68. Available from: https://pubmed.ncbi.nlm.nih.gov/37501517/
6. Gissing CA, Roos R. Respiratory muscle strength, pain and pulmonary complications in adult patients following median sternotomy during hospital stay: a longitudinal observational study. Bulletin of Faculty of Physical Therapy 2024 29:1 [Internet]. 2024 Nov 21 [cited 2025 Sep 1];29(1):1–9. Available from: https://bfpt.springeropen.com/articles/10.1186/s43161-024-00233-3
7. Zhou K, Li D, Song G. Comparison of regional anesthetic techniques for postoperative analgesia after adult cardiac surgery: bayesian network meta-analysis. Front Cardiovasc Med [Internet]. 2023 [cited 2025 Sep 1];10:1078756. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10239891/
8. Dos Reis Viana LB, De Oliveira EJSG, De Oliveira CMB, Moura ECR, Viana LHL, Da Silva Nina VJ, et al. Assessment of pain and quality of life in patients undergoing cardiac surgery: a cohort study. Rev Assoc Med Bras (1992) [Internet]. 2023 [cited 2025 Sep 1];69(3):473–8. Available from: https://pubmed.ncbi.nlm.nih.gov/36820781/
9. Ingason AB, Geirsson A, Gudbjartsson T, Muehlschlegel JD, Sigurdsson MI. The Incidence of New Persistent Opioid Use Following Cardiac Surgery via Sternotomy. Ann Thorac Surg [Internet]. 2022 Jan 1 [cited 2025 Sep 1];113(1):33–40. Available from: https://pubmed.ncbi.nlm.nih.gov/33930358/
10. Jiang T, Ting A, Leclerc M, Calkins K, Huang J. Regional Anesthesia in Cardiac Surgery: A Review of the Literature. Cureus [Internet]. 2021 Oct 16 [cited 2025 Sep 1];13(10). Available from: https://pubmed.ncbi.nlm.nih.gov/34804666/
11. Chin KJ, Versyck B, Pawa A. Ultrasound-guided fascial plane blocks of the chest wall: a state-of-the-art review. Anaesthesia [Internet]. 2021 Jan 1 [cited 2025 Sep 1];76(S1):110–26. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/anae.15276/
12. Schmedt J, Oostvogels L, Meyer-Frießem CH, Weibel S, Schnabel A. Peripheral Regional Anesthetic Techniques in Cardiac Surgery: A Systematic Review and Meta-

Analysis. J Cardiothorac Vasc Anesth [Internet]. 2024 Feb 1 [cited 2025 Sep 1];38(2):403–16. Available from: https://pubmed.ncbi.nlm.nih.gov/38044198/

13. Chiew JK, Low CJW, Zeng K, Goh ZJ, Ling RR, Chen Y, et al. Thoracic Epidural Anesthesia in Cardiac Surgery: A Systematic Review, Meta-Analysis, and Trial Sequential Analysis of Randomized Controlled Trials. Anesth Analg [Internet]. 2023 Sep 1 [cited 2025 Sep 1];137(3):587–600. Available from: https://pubmed.ncbi.nlm.nih.gov/37220070/
14. Li Q, Liao Y, Wang X, Zhan M, Xiao L, Chen Y. Efficacy of bilateral catheter superficial parasternal intercostal plane blocks using programmed intermittent bolus for opioid-sparing postoperative analgesia in cardiac surgery with sternotomy: A randomized, double-blind, placebo-controlled trial. J Clin Anesth [Internet]. 2024 Aug 1 [cited 2025 Sep 1];95. Available from: https://pubmed.ncbi.nlm.nih.gov/38537393/
15. Wong HMK, Chen PY, Tang GCC, Chiu SLC, Mok LYH, Au SSW, et al. Deep Parasternal Intercostal Plane Block for Intraoperative Pain Control in Cardiac Surgical Patients for Sternotomy: A Prospective Randomized Controlled Trial. J Cardiothorac Vasc Anesth [Internet]. 2024 Mar 1 [cited 2025 Sep 1];38(3):683–90. Available from: https://pubmed.ncbi.nlm.nih.gov/38148266/

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