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Review

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A Systematic Review of Factors Associated with Post-Sternotomy Pain

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ABSTRACT

Background: Chronic post-sternotomy pain remains an important complication after cardiac surgery. Earlier reviews combined several cardiac surgical approaches and did not incorporate recent sternotomy-specific evidence. This review aimed to identify and critically synthesize demographic, clinical, psychological, surgical, and perioperative factors associated with chronic post-sternotomy pain.

Subjects and Method: This systematic review followed PRISMA 2020. BASE, PubMed, and ScienceDirect were searched for English-language studies published from January 2010 to June 2025. The review question used a PECO framework: adults undergoing cardiac surgery through median sternotomy; exposure to potential prognostic factors; comparison with unexposed or lower-risk groups; and chronic post-sternotomy pain at three months or longer. Observational analytic studies were eligible. Risk of bias was assessed with design-specific CASP cohort and CASP case control checklists.

Results: Seven studies involving 3,304 participants were included in the narrative synthesis. Greater acute postoperative pain and internal thoracic or mammary artery harvesting showed the most consistent associations, each recurring in three studies. Female sex, pre-existing chronic pain, and depression or related psychological vulnerability were also reported in more than one study. Other factors included younger age, obesity, diabetes mellitus, preoperative angina, previous cardiac surgery or percutaneous coronary intervention, reduced ejection fraction, hypothyroidism, wound complications, non-elective surgery, re-sternotomy, longer hospital stay, and disability or retirement-related medical assessment. Several associations were based on single-centre or unadjusted analyses.

Conclusion: Chronic post-sternotomy pain has a multifactorial risk profile. The most consistent evidence supports severe acute postoperative pain and internal thoracic artery harvesting as clinically relevant markers. Preoperative risk assessment and effective early pain control should receive priority, while larger multi-center studies with standardized outcome definitions are needed.

Keywords: cardiac surgery; chronic postsurgical pain; prognostic factors; risk factors; sternotomy

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BACKGROUND

Cardiovascular disease remains a leading cause of death worldwide, and cardiac surgery continues to play a central role in the management of advanced coronary and valvular disease (WHO, 2023). Median sternotomy provides direct access to the heart and great vessels, but it can be followed by persistent pain around the sternum and anterior chest wall. Chronic post-sternotomy pain may disrupt sleep, restrict upper-body movement, reduce rehabilitation participation, and impair recovery and health-related quality of life (Bordoni et al., 2017; Elmistekawy & Attia, 2020; Sun et al., 2024).

Chronic postsurgical pain is generally defined as pain that develops or increases after surgery, persists beyond the expected healing period, and lasts for at least three months when other causes have been excluded (Schug et al., 2019). In patients undergoing sternotomy, the pain may involve nociceptive and neuropathic components. Tissue injury, sternal retraction, intercostal nerve injury, internal thoracic artery harvesting, wound complications, and intense acute postoperative pain may contribute to pain persistence. These mechanisms are relevant, but the present review focuses on prognostic factors rather than providing an extensive account of pain pathophysiology.

Potential prognostic factors can be organized using a biopsychosocial framework. Demographic factors include age and sex. Clinical factors include comorbidity, pre-existing pain, and cardiac function. Psychological factors include depression and prior antidepressant use. Surgical and perioperative factors include internal thoracic artery harvesting, non-elective surgery, re-sternotomy, wound complications, and the severity of early postoperative pain. Social and occupational factors may also influence pain reporting and recovery. Defining these categories clarifies the scope of the review and separates prognostic exposures from interventions intended to reduce pain.

Previous evidence has not fully resolved this issue. A narrative review described the incidence, risk factors, treatment, and prevention of chronic post-sternotomy pain (Kleiman et al., 2017). A 2020 systematic review and meta-analysis of persistent pain after cardiac surgery identified female sex, acute postoperative pain, and use of the internal mammary artery as associated factors (Bae & Shin, 2020). However, that review included a broad range of cardiac surgery populations and searched literature only through 2018. More recent sternotomy-specific cohort studies have reported additional clinical, psychological, and perioperative factors (Sudin et al., 2024; Sun et al., 2024). An updated, focused synthesis is therefore needed to determine which associations recur across studies and which findings remain preliminary.

This systematic review aimed to identify and critically synthesize demographic, clinical, psychological, surgical, perioperative, and social factors associated with chronic post-sternotomy pain in adults after cardiac surgery.

SUBJECTS AND METHOD

1. Study Design

The design of this study is a systematic review that uses secondary data obtained from previous research in the BASE, ScienceDirect, and PubMed databases, covering 2010 to 2025. PubMed was selected for biomedical and clinical literature, ScienceDirect for peer-reviewed health and surgical publications, and BASE for broader academic and open-access coverage. However, the absence of Embase,

Scopus and Web of Science may have limited the retrieval of relevant studies and is acknowledged as a limitation. The search keywords used include: (sternotomy OR "median sternotomy" OR "open heart surgery" OR "cardiac surgery") AND ("postoperative pain" OR "persistent pain" OR "chronic pain" OR "chronic postsurgical pain" OR "post-sternotomy pain") AND ("risk factor*" OR predictor* OR determinant* OR prognos* OR associat*). PECO in this study Population: Adults aged 18 years or older who underwent cardiac surgery through median sternotomy, Exposure: Potential prognostic or risk factors, including demographic, clinical, psychological, behavioral, surgical, perioperative, and social factors., Comparison: Patients without the exposure, patients in a lower-risk category, or the reference category used in the primary study., and Outcome: Chronic post-sternotomy pain located in the sternotomy or thoracic region and assessed at least three months after surgery, or a comparable study-defined persistent pain outcome.

2. Systematic Review Step

We conducted a systematic review using five steps, which comprised:

1) Formulating review-related questions;
2) Finding pertinent work
3) Evaluating the caliber of research
4) Recapitulating the evidence
5) Interpreting the results

3. Inclusion Criteria

Eligible studies included adult patients aged 18 years or older who underwent cardiac surgery via median sternotomy. Only analytical observational studies were considered. The studies were required to evaluate persistent postoperative pain occurring at least three months after surgery, analyze at least one prognostic factor associated with persistent pain, and report an interpretable measure of association or statistical analysis..

4. Exclusion Criteria

The exclusion criteria for this study were articles using other than English and was published before 2010.

5. Operational Definition of Variables

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage. It serves as a protective mechanism, alerting the body to injury or illness.

Post-sternotomy refers to the period following a sternotomy, a surgical procedure in which the sternum (breastbone) is divided to access the heart or thoracic organs (coronary artery bypass grafting, valve surgery, or other cardiac procedures).

6. Study Instruments

The article search process is guided by the PRISMA flow diagram. The methodological quality of the included studies was assessed using design-specific Critical Appraisal Skills Programme checklists. Six cohort studies were evaluated using the CASP Cohort Study Checklist, while one case-control study was evaluated using the CASP Case-Control Study Checklist.

7. Data Analysis

The data from primary articles were reviewed accordingly.

RESULTS

A. Characteristic of Study

The searches identified 94 records. After removing 18 duplicates, 76 records underwent title and abstract screening. Sixty-six records were excluded, and 10 full-text articles were assessed for eligibility. Three articles were excluded for specified reasons, resulting in 7 studies included in the narrative synthesis (Figure 1).

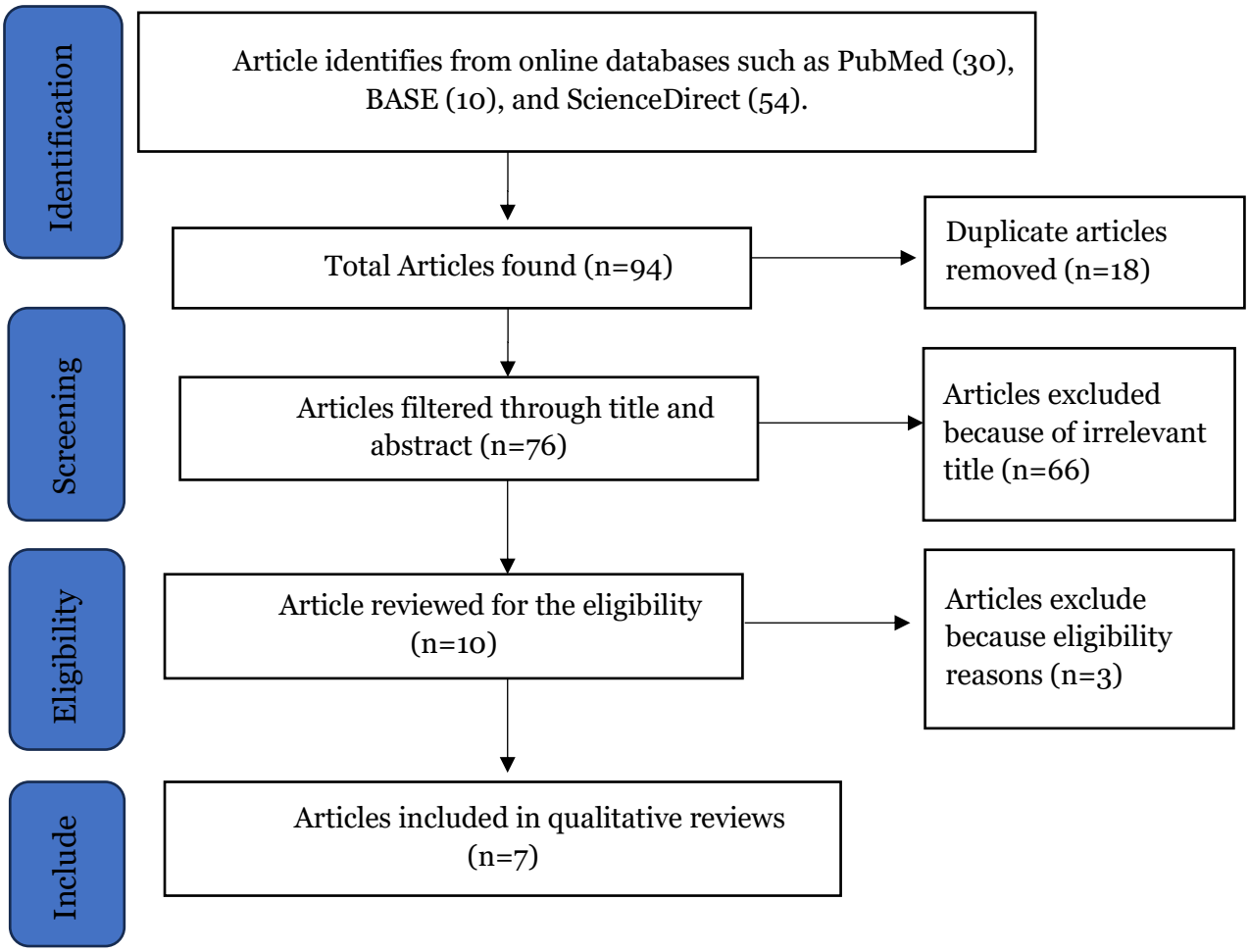

Figure 1. PRISMA flow diagram of study selection for factors associated with chronic post-sternotomy pain

Figure 2. Geographical distribution of the included studies on chronic post-sternotomy pain

Seven articles consisted of study from Brazil, Turkey, Malaysia, Iran Netherland, and Canada (there were 7 studies in the Figure 2). The design study vary from case control and cohort. This review involved 3,304 patients undergo open-heart surgery (table 2).

Table 1. Critical appraisal of the cohort studies included in the systematic review

Primary Article	Criteria											
	1	2	3	4	5	6	7	8	9	10	11	Total
van Gulik et al. (2011)	2	2	2	2	2	2	1	2	2	2	2	21
Kamalipour et al. (2014)	2	1	2	1	1	0	1	2	1	2	2	15
Girgin and Gölboyu (2023)	2	1	2	2	1	0	1	2	1	2	2	16
Xiao et al. (2023)	2	2	2	2	2	2	1	2	2	2	2	21
Sudin et al. (2024)	2	2	2	2	2	0	1	2	1	2	2	18
Sun et al. (2024)	2	1	2	2	2	2	1	2	2	2	2	20

Question Description:

1. Did the study address a clearly focused issue?
2. Was the cohort recruited in an acceptable way?
3. Was the exposure accurately measured to minimize bias?
4. Was the outcome accurately measured to minimize bias?
5. Did the authors identify the important confounding factors?
6. Did the authors account for the confounding factors in the study design or analysis?
7. Was the follow-up of participants sufficiently complete?
8. Was the follow-up period sufficiently long?
9. Were the results credible and adequately supported by the analysis?
10. Could the results be applied to the population of interest?
11. Were the findings consistent with other available evidence?

No = 0
Can't tell = 1
Yes = 2

Quality classification

- High quality = 19–22
- Moderate quality = 15–18
- Low quality = below 15

Table 2. Critical appraisal of the case-control study included in the systematic review

Primary Article	Criteria											
	1	2	3	4	5	6	7	8	9	10	11	Total
Costa et al. (2015)	2	2	1	2	1	2	2	2	2	2	2	20

Question Description:

1. Did the study address a clearly focused issue?
2. Did the authors use an appropriate study design to answer the research question?
3. Were the cases recruited in an acceptable way?
4. Were the controls selected in an acceptable way?
5. Was the exposure accurately measured to minimize bias?

6. Were important confounding factors identified and addressed in the design or analysis?
7. Were the association estimates clearly reported and clinically interpretable?
8. Were the estimates sufficiently precise?
9. Were the results credible after considering chance, bias, and confounding?
10. Could the results be applied to the population of interest?
11. Were the findings consistent with other available evidence??

No = 0
Can't tell = 1
Yes = 2

Quality classification

- High quality = 19–22
- Moderate quality = 15–18
- Low quality = below 15

Acute postoperative pain

Greater early postoperative pain was the most consistent potentially modifiable factor. Severe pain on postoperative day 3 independently predicted chronic thoracic pain at one year in van Gulik et al. (2011). Moderate-to-severe acute pain within the first five postoperative days was associated with higher pain scores at three months in Xiao et al. (2023). Higher pain on postoperative day 1 also predicted chronic post-sternotomy pain at six months in Sun et al. (2024). The direction of association was consistent across all three studies that examined this factor.

Internal thoracic artery harvesting

Use of the internal thoracic or internal mammary artery was associated with chronic post-sternotomy pain in Kamalipour et al. (2014), Costa et al. (2015), and Sudin et al. (2024). Kamalipour et al. found a higher prevalence and severity of pain in the internal mammary artery group, while Costa et al. reported an adjusted hazard ratio of 1.39. This recurring association is biologically plausible because artery harvesting may increase chest-wall tissue and nerve injury, but the magnitude of risk may depend on harvesting technique and other surgical factors.

Demographic factors

Female sex was an independent predictor in van Gulik et al. (2011) and was associated with higher pain scores at three months in Xiao et al. (2023). Younger age was associated with post-sternotomy pain syndrome in Sudin et al. (2024). These findings indicate demographic risk markers, but they were not uniformly confirmed across all studies and should not be interpreted as deterministic predictors.

Clinical and psychological factors

Preoperative chronic pain and depression were associated with persistent pain in both Xiao et al. (2023) and Sun et al. (2024). Xiao et al. also identified previous cardiac surgery and higher pain catastrophizing scores. Costa et al. (2015) identified antidepressant use and hypothyroidism. Girgin and Gölboyu (2023) reported diabetes mellitus and preoperative angina, while Sudin et al. (2024) reported obesity, previous percutaneous coronary intervention, ejection fraction below 50%, and absence of chronic kidney disease. Several of these factors were reported by one study only. The finding involving absence of chronic kidney disease was counterintuitive and should not be interpreted as protective or causal.

Table 3. Characteristics of studies included in the systematic review

Author (Year)	Country	Study Design	Sample	Population	Exposure / Risk Factors	Comparison	Outcome
van Gulik et al. (2011)	Nether-lands	Prospective cohort	146 enrolled; 120 analyzed	Adults admitted to the intensive care unit after cardiac surgery through median sterno-tomy.	Female sex; non-elective surgery; re-sternotomy; severe pain (NRS ≥4) on postopera-tive day 3.	Patients without the exposure or the reference category used in the regression model.	Chronic thoracic pain at 10–12 months. Indepen-dent predictors were non-elective surgery (OR 4.22), re-sternotomy (OR 3.38), severe day-3 pain (OR 2.89), and female sex (OR 2.39).
Kamalipour et al. (2014)	Iran	Comparative cohort	188 patients: 94 IMA group and 94 non-IMA group	Adults assessed at least three months after open cardiac surgery through median sterno-tomy.	Internal mammary artery harvesting during coronary artery bypass grafting.	Patients undergoing other open-heart procedures without internal mammary artery harvesting.	Pain lasting more than three months occurred in 88.3% of the IMA group and 75.5% of the non-IMA group (p=0.023). Pain severity was also higher in the IMA group (p=0.001).
Costa et al. (2015)	Brazil	Case-control	453 patients: 178 cases and 275 controls	Patients evaluated more than six months after cardiac surgery through sterno-tomy.	Use of the internal thoracic artery; antidepressant use; hypothyroi-dism; surgical wound compli-cations; disability benefits or retire-ment-related medical assess-ment.	Patients without chronic post-sternotomy pain.	Chronic post-sternotomy pain. Significant adjusted associations were internal thoracic artery use (HR 1.39), antidepressant use (HR 2.40), hypothyroidism (HR 1.27), wound com-plications (HR 1.69), and disability/ retirement assessment (HR 2.05).
Girgin and Gölboyu (2023)	Türkiye	Retrospective cohort	129 patients	Adults who under-went open-heart surgery through median sterno-tomy and were	Diabetes mellitus; preoperative angina; length of hospital stay.	Patients without chronic neuropathic pain.	Chronic neuropathic pain assessed using S-LANSS. Incidence was 14.7%. Diabetes mellitus (p= 0.048), preoperative

Author (Year)	Country	Study Design	Sample	Population	Exposure / Risk Factors	Comparison	Outcome
				assessed from three months to more than one year after surgery.			angina (p= 0.030), and longer hospital stay (p= 0.046) were associated with neuropathic pain.
Xiao et al. (2023)	Canada	Prospective cohort	767 patients with at least one follow-up assessment	Adults undergoing cardiac surgery, followed at 3, 6, and 12 months.	Female sex; pre-existing chronic pain; previous cardiac surgery; preoperative depression; higher pain catastrophizing; moderate-to-severe acute post-operative pain.	Patients without the exposure or the reference category in the multivariable model.	Chronic postsurgical pain at 3, 6, and 12 months. Pain prevalence was 29%, 19%, and 15%, respectively. The listed demographic, psychological, and perioperative factors were associated with greater pain at follow-up.
Sudin et al. (2024)	Malaysia	Retrospective observational cohort	1,395 patients	Adults who underwent open cardiac surgery through sternotomy at the National Heart Institute, Malaysia.	Age <60 years; BMI >30 kg/m²; previous percutaneous coronary intervention; ejection fraction <50%; internal mammary artery harvesting.	Patients without each exposure or the reference category used in the analysis.	Post-sternotomy pain syndrome at least three months after surgery. Several factors were significant in univariable analysis; interpretation requires caution because adjusted estimates were limited.
Sun et al. (2024)	Canada	Prospective cohort	252 respondents at six months; 64 patients with pain reassessed at 12 months	Adults undergoing cardiac surgery through median sternotomy.	Higher pain score on postoperative day 1; preoperative chronic pain; history of depression.	Patients without chronic post-sternotomy pain or without the exposure.	Chronic post-sternotomy pain at six months occurred in 29%. Adjusted risk factors were post-operative day-1 pain, preoperative chronic pain, and depression.

Surgical, perioperative, and social factors

Non-elective surgery, re-sternotomy, and surgical wound complications were associated with chronic pain. Previous cardiac surgery was also identified by Xiao et al. (2023), while Girgin and Gölboyu (2023) found a longer hospital stay among patients with chronic neuropathic pain. These factors may indicate greater tissue injury, perioperative complexity, complications, or disrupted recovery. Costa et al. (2015) also reported an association with disability benefits or retirement-related medical assessment. This social or occupational finding may reflect interactions among health status, work capacity, psychological distress, and pain reporting, but replication is lacking.

Potential protective perioperative associations

Sun et al. (2024) observed lower risk among patients who received intraoperative dexmedetomidine or ketamine. Because treatment allocation was not randomized for this prognostic analysis, confounding by indication and other perioperative differences cannot be excluded. This finding is hypothesis-generating and should not be presented as evidence of intervention effectiveness.

DISCUSSION

This updated review identified a multifactorial pattern of chronic post-sternotomy pain across seven studies. The strongest recurring evidence concerned severe acute postoperative pain and internal thoracic or mammary artery harvesting. Each factor was supported by three independent studies. Female sex, pre-existing chronic pain, and depression or psychological vulnerability also recurred across more than one study. Other clinical, surgical, and social factors were reported by one study or depended on unadjusted analyses. The evidence supports structured risk assessment, but it does not justify causal claims for most individual factors.

The findings confirm the earlier meta-analysis by Bae and Shin (2020), which identified acute postoperative pain, internal mammary artery use, and female sex as factors related to persistent pain after cardiac surgery. The present review adds evidence on pre-existing chronic pain, depression, pain catastrophizing, previous cardiac surgery, diabetes mellitus, preoperative angina, obesity, previous percutaneous coronary intervention, reduced ejection fraction, and perioperative medication exposure. Despite the larger evidence base, substantial variation remained in definitions, measurement times, and analytic methods.

The association between acute and chronic pain has direct clinical relevance. Severe pain during the first postoperative days may mark greater tissue injury, inadequate analgesia, heightened pain sensitivity, or early central sensitization. Acute pain scores can be measured repeatedly and incorporated into routine nursing and medical assessment. Patients with persistent moderate or severe pain should receive prompt reassessment of analgesia, respiratory exercises, mobilisation, sleep, mood, and possible neuropathic pain features. Effective acute pain control may be a reasonable prevention target, although intervention trials are required to establish whether modifying early pain reduces chronic pain incidence.

Internal thoracic artery harvesting also deserves attention during preoperative counselling and postoperative surveillance. The procedure has major cardiovascular benefits in coronary artery bypass grafting, so the findings do not support avoiding its use. Instead, clinicians should recognize it as

a potential marker of chest-wall injury and consider surgical technique, nerve-sparing approaches, and targeted follow-up. The benefits and risks of each graft strategy must remain grounded in cardiac outcomes rather than pain risk alone.

Psychological and pre-existing pain factors were clinically important. Depression, antidepressant use, and chronic pain before surgery may identify patients with greater vulnerability to persistent pain. These factors should not be interpreted as evidence that pain is purely psychological. They support a biopsychosocial assessment that considers nociceptive injury, mood, prior pain experience, coping, sleep, function, and social context. Screening can help tailor education and follow-up without stigmatizing patients.

Some associations require careful interpretation. The relationship between absence of chronic kidney disease and pain in Sudin et al. (2024) may reflect selection, treatment patterns, competing morbidity, or residual confounding. Similarly, the apparent protective associations with dexmedetomidine or ketamine in Sun et al. (2024) came from observational data and cannot demonstrate treatment effects. These examples show why adjusted analyses, replication, and explicit distinction between prognostic association and causation are essential.

AUTHOR CONTRIBUTION

Musta'in was responsible for study conception, design, data collection, analysis, and manuscript drafting. Tri Yuniarti and Aris Widiyanto contributed to literature screening, data extraction, and quality appraisal. Hakim Anasulafalah contributed to data interpretation and critical revision of the manuscript. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest.

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