**Original Article**

Seven-year follow-up of persistent postsurgical pain in cardiac surgery patients: A prospective observational study of prevalence and risk factors

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**Abstract**

**Background:** Our aim was to describe the long-term prevalence, risk factors and impact on quality of life of persistent postsurgical pain (PPP) following cardiac surgery.

**Methods:** All patients undergoing sternotomy in a single centre over 6 months were prospectively interviewed by telephone at six months and seven years following surgery.

**Results:** We analysed data from 174 patients at six months and 146 patients at seven years following surgery, revealing a PPP prevalence of 39.7% ($n = 69$) and 9.6% ($n = 14$) respectively.

At six post-operative months, younger age, higher acute pain score, intraoperative remifentanil infusion and more prolonged surgery were associated with sternotomy-site PPP. These variables, in combination, predict PPP in this study group with area under the receiver operating curve of 0.91 (95% CI 0.86–0.94) at 6 months and 0.74 (95% CI 0.57–0.86) at 7 years. Quality of life scores were significantly lower with PPP (median change in EQ-5D score $= −0.23$ [−0.57, −0.09] compared to 0.00 [0–0.24] without PPP at 7 years, $p < 0.001$). At 7 years, younger age, prolonged surgery and intraoperative remifentanil infusion were associated with sternotomy-site PPP.

**Conclusions:** To the best of our knowledge, this is the longest follow-up of PPP across all surgical specialties and certainly within cardiac surgery. Prevalence of PPP and impact on QOL after cardiac surgery are high and associated with young age, high acute pain score, use of remifentanil and long operative time. We present a predictive score to highlight patients at risk of developing PPP.

**Significance:** Seven years after cardiac surgery, almost 10% of patients in this cohort described persistent pain in and around the incision. While higher than previous reports in the literature (limited to up to five post-operative years), this assessment was made following three maximal coughs and therefore is movement or function evoked. High incident of persistent postsurgical pain may adversely affect long-term quality of life which is measured using a validated tool.
A common debilitating complication following chest surgery is the development of persistent postsurgical pain (PPP), representing a significant and growing burden for individual patients as well as healthcare systems (Bertrand et al., 1996; Landreneau et al., 1994; Wong et al., 2019).

Recent ICD-11 classification defines this phenomenon as a pain developing or increasing in intensity after a surgical procedure or a tissue and persisting beyond the healing process. The pain is either localized to the surgical field or area of injury, projected to the innervation territory of a nerve situated in this area or referred to a dermatome (Nugraha et al., 2019).

The described prevalence of PPP varies between surgical procedures. Sternotomy for cardiac surgery is reported to cause PPP in 27%–56% of patients, which is comparable to other major surgery on the chest (e.g. thoracotomy or breast cancer resection) (Guimarães-Pereira et al., 2017; Kehlet et al., 2006). The origins of PPP are complex, manifold and incompletely understood. Putative triggers include direct nerve activation, nerve damage and central sensitization (Wong et al., 2019). The literature is expansive but inconclusive.

Multimodal analgesia is increasingly adopted within contemporary cardiac surgical practice. There is some evidence for opioid sparing as well as the potential to reduce the likelihood of persistent postsurgical pain (Anwar et al., 2019).

Understanding and preventing the development of PPP has been identified as one of the most ‘important research priorities in anaesthesia and perioperative medicine’ (Boney et al., 2015). It would be useful to develop a predictive model for PPP, in the first instance to guide the perioperative team to consent and counsel the high-risk patient effectively, but also in the future, as our understanding of the pathogenesis of PPP grows, to potentially tailor our practice in these patients.

The aim of this study was to describe the long-term prevalence of PPP following cardiac surgery in addition to impact on quality of life (QOL). We investigated associations between patient and treatment-related risk factors and the development of PPP and aimed to characterize the potential predictive value of these variables as predictors of PPP in patients following cardiac surgery. Our primary outcomes were the prevalence of sternotomy-site PPP after cardiac surgery at 6 months and 7 years and the prediction of PPP using six putative risk factors; our secondary outcome was the impact of sternotomy PPP on QOL. A 7-year period was chosen as this is longer than the follow-up period in previous studies of PPP, for example, the study by Gjeilo and colleagues over 5 years following cardiac surgery (Gjeilo et al., 2017).

This study was approved in March 2010 by the East London and the City Research Ethics Committee (Reference: 11/H0703/7) and all studied patients gave informed consent to be followed up for the duration of the study. This manuscript adheres to the applicable STROBE guidelines.

This was a prospective, observational cohort study. We screened the electronic health records of all patients undergoing first-time midline sternotomy over a continuous 6-month period (January–June 2010) at St Bartholomew’s Hospital, London, United Kingdom, for completeness before consenting and recruiting those patients for follow-up during the post-operative period. Minimum data sets were required for potential patient-related (gender, age) and treatment-related risk factors of post-operative pain (duration of sternotomy, use of remifentanil by infusion, dissection and harvesting of the left internal mammary artery (LIMA), acute pain score at 24 hr following surgery). Patients with incomplete records or a history of chronic pain were excluded.

The post-operative analgesia protocol is standardized for cardiac patients in our centre. This comprises patient-controlled analgesia (PCA) with morphine or fentanyl in chronic kidney disease. Once the surgical drains have been removed, the PCA is taken down and oral tramadol is given as required alongside regular paracetamol. No additional potentially preventative analgesics, such as ketamine, gabapentin or pregabalin, are routinely given nor were they given to participants in this study.

Follow-up was conducted by the same blinded interviewer using structured telephone interviews, post-operatively at 6 months and 7 years. The six-month time point was selected to permit wound healing to fully take place and its period determined by the most researchers; while most healing is thought to occur within 3 months, as per most definitions of chronic pain, it may be prolonged in certain groups (Shin et al., 2015). During 6-month and 7-year time point, the interviewer used the same questionnaire.

Sternotomy-site pain was assessed with the numerical rating scale (NRS) anchored at 0 for no pain and 10 for ‘the
worst pain imaginable’. Patients were asked to describe the NRS score ‘in and around the incision site’ following three maximal coughs. Pain after three maximal coughs was used as standardized approach to measure movement-evoked pain (Srikandarajah & Gilron, 2011). It has previously been described in the literature as the trigger for the most severely rated sternal pain in the acute post sternotomy period (de Mello et al., 2014; Milgrom et al., 2004).

Quality of life was assessed using the validated UK data set of the EQ-5D tool (Herdman et al., 2011).

### 2.4 Statistical analysis

All patients in the tables and models had complete data. Results are described using mean (standard deviation) or median [interquartile range] for continuous variables, depending on distribution and % (N) for categorical data.

Binary outcomes (e.g. presence or absence of PPP) were analysed using logistic regression models. For this purpose, any NRS pain score greater than 0 was defined as PPP present. NRS of 0 was defined as PPP absent. Univariate odds ratios and 95% confidence intervals were obtained. Where numbers were small, an exact model was used. A penalized model (Firth logistic regression) was used to prevent overfitting. We constructed a risk prediction score from this model based on the 6-month data (Figure S1). The predictive ability of this risk score was assessed at 6 months and 7 years using the area under the receiver operating characteristic (ROC) curve (AUC) with permutation-based confidence intervals. In addition, we modelled severity of pain using NRS pain score as a continuous variable. We used multivariable Tobit regression models due to the zero-inflated distribution of the data.

Quality of life scores were compared using quantile regression with bootstrap confidence intervals. A p-value below 0.05 was considered statistically significant. Stata Version 16 (StataCorp, Texas) was used for all analyses.

### 3 RESULTS

#### 3.1 Demographics

A total of 312 eligible patients that underwent cardiac surgery at our centre between January and June 2010 were screened; a CONSORT diagram is shown in Figure 1. Patients with incomplete documentation of surgical procedure, pain score and recovery profile were screened out (n = 102). Data were available for 210 patients, of whom 36 patients were lost to follow up, due to inability to contact (n = 23), patient death (n = 7) and unwillingness to participate (n = 6). One hundred and seventy-four patients were prospectively interviewed. Of the 174 patients studied, 132 (76%) were men and 42 (24%) women. The mean age was 67.5 ± 12.8 years, and mean operative time was 210 ± 50 min. 129 (74%) patients underwent LIMA dissection for coronary artery bypass grafting (CABG). 126 (72%) underwent concurrent harvesting of the saphenous vein. 34 (20%) were given remifentanil by infusion in the operating theatre, none during recovery (Table 1).

#### 3.2 Acute pain

When assessed for acute pain score at 24 post-operative hours, 85 patients (49%) described no pain, 53 (30%) described mild pain (NRS between 1 and 3), 27 described (16%) moderate pain (NRS 4, 5 or 6) and the remaining nine patients (5%) described severe pain (NRS from 7 to 10) (Table 1).

#### 3.3 Persistent postsurgical pain

The prevalence of sternal-site PPP was 39.7% (n = 69) subjects at 6 months and 9.6% (n = 14) subjects at 7 years (Tables 2 and 3). A total of 28 patients (16%) patients were, however, excluded between the two chronic pain follow-up times mostly due to death (n = 25) (Figure 1). Interestingly, four patients without pain at 6 months subsequently developed a new peri-incisional pain at 7 years.

#### 3.4 Quality of life

Quality of life scores were significantly lower for patients with PPP than for those who were pain free, even after adjustment for potential confounders using quantile regression (Table 4). Median change from 6 months to 7 years in quality of life score was 0.00 [0–0.24] in those without pain compared to −0.23 [−0.57, −0.09] ± 0.29 for those with pain at 7 years, p < 0.001 (Figure 2). Quality of life was significantly reduced for those in pain at 7 years independent of the other factors (Table 4).

#### 3.5 Associated risk factors

Younger age, longer duration of surgery and intraoperative use of remifentanil were significantly associated with the presence of sternotomy-site PPP at both 6 months and 7 years in univariate analysis. Higher acute pain score only significantly predicted PPP presence at the 6-month follow-up point. These associations, calculated by univariate analysis, were broadly supported by significant results from multivariable Firth logistic regression models (Table 5). These variables were also
identified as significant predictors of pain severity at 6 months in multivariable Tobit regression models (Table 6).

When examined together, age, acute pain score, remifentanil use and duration of surgery yield a model that predicts the presence of PPP at 6 months with an area under the receiver operating characteristic (ROC) curve (AUC) of 0.91 (95% CI 0.86–0.94) and 0.74 (95% CI 0.57–0.86) at 7 years (Figure 3).

Discrimination was non-significantly better at 6 months compared to 7 years (p =0.058). The coefficients from this model can be used to construct a predictive risk score for PPP in this patient population (Figure S1). At a predicted probability of 0.35, this model has a sensitivity of 87% and a specificity of 82%, performing well as a predictive scoring system in this study group.

4 | DISCUSSION

We found a PPP prevalence of 39.7% (n = 69) at 6 months and 9.6% (n = 14) at 7 years following cardiac surgery in our institution. To the best of our knowledge, this is the longest follow-up of this phenomenon in the literature and certainly after cardiac surgery. The overall incidence of PPP in our study decreased over time but after seven post-operative years, seven patients (5%) continued to describe moderate to severe pain (NRS >3) with two patients still in severe pain.

4.1 | Persistent postsurgical pain

Our finding of high prevalence of PPP after cardiac surgery is in line with the most of the literature. Kalso and colleagues reported a prevalence of 28% (n = 201) chronic pain 2–3 years following CABG (Kalso et al., 2001). In a retrospective study by Claudio and colleagues, 20% (n = 63) of patients had pain after three post-operative years (Claudio et al., 2015). However, Lahtinen and colleagues reported lower PPP prevalence of chronic pain of 17% (n = 30) after only 1 year (Lahtinen et al., 2006). Likewise, Gjeilo and colleagues followed cardiac surgery patients up for five post-operative years reporting
pain in only 3.8% \( (n = 14) \) prevalence of their cohort (Gjeilo et al., 2017). This may be partially explained by the use of Brief Pain Inventory at rest in this study, as compared to our function- or movement-evoked assessment of three maximal coughs which would be expected to increase pain intensity. Other hidden confounders or variations in our respective study populations may also have contributed.

### 4.2 Quality of life

Quality of life scores were significantly lower for patients with PPP (median change in QOL score [IQR] of \(-0.23 \text{[-0.57, -0.09]}\) compared to 0.00 [0–0.24] in those without pain). Chronic pain impacts on quality of life (Wahl et al., 2009). While there are limited data in the field of pain

#### TABLE 2 Baseline measures of sternotomy pain at 6 months and 7 years

|                         | Six-month follow-up | Seven-year follow-up |
|-------------------------|---------------------|----------------------|
|                         | No PPP | PPP | No PPP | PPP |
| Age [years]             | 72.7 ± 9.3 | 59.6 ± 13.5 | 67.3 ± 12.7 | 58.6 ± 15.8 |
| Gender: male n (%)      | 76 (72.4%) | 55 (79.7%) | 98 (74.2%) | 13 (92.9%) |
| LIMA harvesting n (%)   | 76 (72.4%) | 53 (76.8%) | 98 (74.2%) | 11 (78.6%) |
| Duration of surgery [min]| 194.7 ± 43.6 | 233.6 ± 51.2 | 207.8 ± 47.7 | 229.3 ± 64.7 |
| Remifentanil use n (%)  | 12 (11.4%) | 22 (31.9%) | 24 (18.2%) | 7 (50.0%) |
| NRS at 24 hr n (%)      | 72 (68.6%) | 13 (18.8%) | 55 (49.2%) | 2 (14.3%) |
| Pain free [NRS 0]       | 24 (22.9%) | 29 (42.0%) | 41 (31.1%) | 5 (35.7%) |
| Moderate pain [NRS 4–6] | 7 (6.7%) | 20 (29.0%) | 19 (14.4%) | 5 (35.7%) |
| Severe pain [NRS 7–10]  | 2 (1.9%) | 7 (10.1%) | 7 (5.3%) | 2 (14.3%) |

Note: Plus–minus values are means ±SD.
PPP, persistent post-operative pain.
aData are complete for all variables.

#### TABLE 3 Measures of sternotomy pain at 6 months and 7 years by categories

|                    | Six-month follow-up | Seven-year follow-up |
|--------------------|---------------------|----------------------|
|                    | N = 174 | N = 146 |
| Pain free [NRS 0]  | 105 (60.3%) | 132 (90.4%) |
| Mild pain [NRS 1–3]| 38 (21.8%) | 7 (4.8%) |
| Moderate pain [NRS 4–6]| 23 (13.2%) | 5 (3.4%) |
| Severe pain [NRS 7–10]| 8 (4.6%) | 2 (1.4%) |
| Median NRS [IQR]   | 0 [0–2] | 0 [0–0] |

#### TABLE 4 Quantile regression analysis for EQ-5D quality of life (QOL) scores

| EQ5D-index score | PPP | No PPP | Median difference (95% CI) | Adjusted median difference\(^a\) |
|------------------|-----|--------|---------------------------|---------------------------------|
| 6 months         |     |        |                           |                                 |
| PPP Median [IQR] | 0.557 [0.355 to 0.725] | 0.782 [0.632 to 1] | \(-0.225 \text{(-0.387 to -0.063)}\) | \(-0.174 \text{(-0.307 to -0.040)}\) |
| N                 | 105 | 69     |                           | \(p = 0.007\)                   |
| 7 years           |     |        |                           |                                 |
| PPP Median [IQR] | 0.024 [-0.215 to 0.205] | 0.825 [0.639 to 1] | \(-0.801 \text{(-1.100 to -0.502)}\) | \(-0.590 \text{(-0.900 to -0.280)}\) |
| N                 | 13  | 129    |                           | \(p < 0.0001\)                  |
| Change from 6 months to 7 years |     |        |                           |                                 |
| PPP Median [IQR] | \(-0.231 \text{[-0.569 to -0.087]}\) | 0.001 [0 to 0.241] | \(-0.586 \text{(-0.777 to -0.394)}\) | \(-0.573 \text{(-0.779 to -0.36)}\) |
| N                 | 13  | 129    |                           | \(p < 0.0001\)                  |

Note: PPP, persistent post-operative pain.
\(^a\)Adjusted for age, sex, acute pain score, theatre time and LIMA harvesting.
medicine on the magnitude of meaningful change in EQ-5D, a recent randomized trial by the CODA Collaborative on a surgical population powered their study on a minimal clinically important differences of 0.05 for EQ-5D and the psychology literature suggests similar differences to be clinically relevant (CODA Collaborative, 2020; Le et al., 2013).

4.3 | Associate risk factors

In this study, younger age, higher acute pain score, intraoperative use of remifentanil and longer operative time were associated with PPP at 6 months. While many potential associations have been identified and some interventions such as regional blocks (Bayman et al., 2017; Wong et al., 2019) and neuraxial anaesthesia (Andreae & Andreae, 2013; Guimarães-Pereira et al., 2017) have been associated with reduced prevalence of PPP, data collection is often subjective and retrospective, with variable response rates and short periods of follow-up (Mejdahl et al., 2013) leading to a lack of generalizable conclusions (Jääskeläinen et al., 2004).

While convenient to group operations by incision, areas of the body, surgical discipline or presenting pathology, it is not clear whether variation in the extent of surgical dissection affects post-operative pain in patients who have nominally undergone the same procedure. In cardiac surgery,

**FIGURE 2** Box and whisker plot of change in quality of life (QOL) from 6 months to 7 years with pain at 7 years

| TABLE 5 | Logistic regression analysis for the presence of sternotomy-site PPP at 6 months and 7 years by variable odds ratio (95% CI) |
| --- | --- |
| **Six-month follow-up** | **Firth logistic model (multivariable)** | **Seven-year follow-up** | **Firth logistic model (multivariable)** |
| **Univariate associations** | **Multivariable** | **Univariate** | **Multivariable** |
| Age [year] | 0.90 [0.86–0.93] | 0.90 [0.86–0.94] | 0.96 [0.92–0.99] | 0.97 [0.93–1.01] |
| Sex [M:F] | 1.50 [0.73–3.10] | 1.12 [0.39–3.16] | 3.15 [0.56–17.80] | 2.41 [0.41–14.16] |
| LIMA harvesting [Y:N] | 1.26 [0.63–2.56] | 0.82 [0.26–2.58] | 1.27 [0.33–4.83] | 1.25 [0.23–6.84] |
| Duration of surgery | 1.02 [1.01–1.03] | 1.02 [1.01–1.03] | 1.01 [1.00–1.02] | 1.00 [0.99–1.02] |
| Remifentanil use Y:N | 3.63 [1.65–7.96] | 2.92 [1.07–7.98] | 4.43 [1.47–13.34] | 3.02 [0.95–9.62] |
| Acute pain score (NRS)\(^a\) | 3.67 [2.34–5.73] | 2.42 [1.44–4.06] | 1.51 [0.81–2.79] | 1.55 [0.81–2.97] |

**Note:** Bold values denote statistical significance at the \( p < 0.05 \) level.

\(^a\)Per category.

| TABLE 6 | Tobit regression analysis for severity of sternotomy-site PPP at 6 months and 7 years by variable B (95% CI) |
| --- | --- |
| **Six-month follow-up** | **Multivariable B (se) Univariable Multivariable** | **Seven-year follow-up** | **Multivariable B (se) Univariable Multivariable** |
| Age [year] | \(-0.20 [-0.25, -0.15]\) | \(-0.14 [-0.19, -0.10]\) | \(-0.18 [-0.34, -0.02]\) | \(-0.12 [-0.29 to 0.05]\) |
| Sex [M:F] | 1.07 [-0.82, 2.96] | 0.28 [-0.95 to 1.51] | 5.08 [-2.19, 12.35] | 3.38 [-3.01 to 9.77] |
| LIMA harvesting [Y:N] | 0.16 [-1.67, 1.99] | -0.01 [-1.38 to 1.37] | 1.02 [-4.32, 6.37] | 0.99 [-5.04 to 7.03] |
| Duration of surgery | 0.04 [0.02, 0.05] | 0.02 [0.01 to 0.03] | 0.04 [-0.00, 0.08] | 0.03 [-0.02 to 0.07] |
| Remifentanil use Y:N | 3.21 [1.39, 5.03] | 1.40 [0.23 to 2.57] | 5.89 [0.83, 10.95] | 3.93 [-0.46 to 8.33] |
| Acute pain score (NRS)\(^a\) | 2.72 [1.95 to 3.48] | 1.44 [0.86 to 2.01] | 3.15 [0.65, 5.66] | 1.42 [-0.88 to 3.72] |

**Note:** Bold values denote statistical significance at the \( p < 0.05 \) level.

\(^a\)Per category.
harvesting the left internal mammary artery (LIMA) with dissection of the anterior chest wall under retraction may be associated with injury to the intercostal nerves and pain greater than that experienced by other patients undergoing, for example, isolated valve replacement, although both fall under ‘sternotomy’. Associations have been made between persistent postsurgical pain and a diverse range of variables, including younger age, female sex and longer duration of surgery (Gan, 2017). Another emerging intraoperative risk factor for postsurgical pain is the intraoperative use of remifentanil, likely due to opioid-induced hyperalgesia (Anwar & O’ Brien, 2021; Bischoff et al., 2012; Bruce et al., 2003; Kalso et al., 2001).

Based on these variables, we present a predictive scoring system for PPP with high sensitivity and specificity in our patient population in this study (Figure S1). If externally validated, we propose the use of this system to highlight patients at high risk of PPP who may benefit from targeted management. Although a multimodal approach to post-operative analgesia is the standard of care for most complex surgery (De Jong & Shysh, 2018), including cardiac surgery. High-risk patients may benefit from the use of specific multimodal approaches to limit acute pain (including regional or neuraxial analgesic strategies) wherein there is evidence to support lower prevalence of PPP (Andreae & Andreae, 2013; Bertrand et al., 1996; Kehlet & Rathmell, 2010; Nugraha et al., 2019). LIMA dissection was used as a surrogate variable to represent more extensive surgical dissection, which is otherwise difficult to measure. We failed to detect an association between LIMA dissection and subsequent PPP. However, future work using more representative variables may yield different results.

4.4 | Strengths and limitations

This study provides perhaps the longest post-operative observation data on chronic or persistent pain following surgery, certainly for cardiac surgery through first-time sternotomy. We failed to follow up only 16% of patients between 6 months and 7 years after surgery largely due to the integration of our primary care database with the electronic health record used by our cardiology department. We also deployed a standardized approach to measure movement-evoked pain in all patients rather than static measures at rest alone. Additional to the univariate model, we have supported our finding by a robust multivariable logistic regression model.

Our study has several limitations. We prospectively ‘convenience sampled’ patients who had surgery in our unit over an arbitrary time period potentially introducing selection bias. As a result, we were unable to collect baseline psychological status, quality of life or pain experience as it was not a part of routine preoperative assessment. Our risk factors were chosen based on the biological plausibility and availability.
of data set, other factors are potentially missing, as they were not available for inclusion. There is an increasing evidence for a psychological contribution to the development of PPP (Kehlet & Rathmell, 2010). In retrospect, we could have strengthened this work with baseline and post-operative objective measurements of pain and nervous system function, for example, using quantitative sensory testing (Anwar et al., 2019).

We purposely disregarded data for wound infection, nerve injuries, rib or sternal fractures or subcategories for surgery by urgency or emergency as well as specific surgeon, anaesthetist, intensivists etc. This pragmatic approach was based on the premise that changes in the peripheral as well as central nervous system handling of pain are independent of these treatment variables, but this could arguably have confounded our reported outcomes, particularly as regards sternal wound breakdown requiring subsequent debridement and adjunct therapies.

We could have included infusion rate of remifentanil infusion or adjusted dose for body weight. As previous work which linked remifentanil to PPP identified a dose-dependent relationship (Van Gulik et al., 2012), so it is possible that the use of variable infusion rates of remifentanil limited our ability to detect a relationship at seven post-operative years by multivariate analysis.

We recognize that a single assessment of pain intensity 24 hr post-operatively is not necessarily sufficient to capture the complexity of acute post-operative pain and could have extended this to hospital discharge perhaps with a Kaplan–Meir analysis for time to ‘less than moderate pain’.

### 4.5 Future directions

Detailed longitudinal follow-up will be important to tease out the dynamic nature of PPP; our study may well have underestimated the true prevalence and complex trajectory of this condition by excluding time points between the first post-operative day and 6 months following surgery and then again to the 7-year time point. The logistics of regular pain assessment following hospital discharge limit the understanding of transition from acute to persistent pain states following surgery (Kehlet & Rathmell, 2010).

PPP negatively impacts quality of life months and years after surgery. The low EQ-5D scores of patients with PPP are comparable to the UK National Pain Audit for other chronic pain conditions (De Hoogd et al., 2016), demonstrating significant long-term morbidity and disability. One interpretation is that postoperative pain leads to worse quality of life (QOL); however, worse QOL may be a composite marker for patient factors that confer a greater risk of developing PPP. As we collected data during the post-operative period only, the opportunity for baseline QOL assessment was missed. This should be addressed in subsequent studies.

Persistent postsurgical pain (PPP) is a common, under-recognized and poorly understood chronic condition. The literature is predominantly observational, with varying data collection methods that limit comparisons between studies, and little prospective or interventional data (Kehlet & Rathmell, 2010).

### 5 Conclusions

We identified high prevalence of PPP after cardiac surgery: 39.7% (n = 69) at 6 months and 9.6% (n = 14) at 7 years. The overall prevalence of PPP in our study decreased over time but with some patients developing new, late-onset PPP after the 6-month time point. Four variables were significantly associated with PPP: younger age, higher acute pain score, use of remifentanil and longer operative time.

### Conflict of Interest

The authors report no conflict of interest.

### Author Contributions

S.R.H and S.A were involved in the conception and design of this study as well as the analysis and interpretation of data. M.Z wrote the manuscript with input from all authors. J.C contributed on the statistical analysis. All authors revised the manuscript for important intellectual content and approved the final version of the manuscript.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section.

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