BJA Open

BJA Open, 11 (C): 100288 (2024)

doi: 10.1016/j.bjao.2024.100288
Original Research Article

ORIGINAL RESEARCH ARTICLE

Efficacy of parasternal peripheral nerve catheters *versus* no block for median sternotomy: a single-centre retrospective study

John E. Rubin[1], Vanessa Ng[2], Justin Chung[1], Nicolas Salvatierra[1], Brady Rippon[3], Diana Khatib[1], Natalia I. Girardi[1], Kane O. Pryor[1], Roniel Y. Weinberg[1], Silis Jiang[4], Sherif Khairallah[5], Stephanie L. Mick[5] and Tiffany R. Tedore[1,*]

[1]Department of Anesthesiology, NewYork-Presbyterian/Weill Cornell Medicine, New York, NY, USA, [2]Department of Anesthesia and Critical Care, The University of Chicago, Chicago, IL, USA, [3]Division of Biostatistics and Epidemiology, Department of Population Health Sciences, Weill Cornell Medicine, New York, NY, USA, [4]Center for Perioperative Outcomes, Department of Anesthesiology, Weill Cornell Medicine, New York, NY, USA and [5]Department of Cardiothoracic Surgery, NewYork-Presbyterian/Weill Cornell Medicine, New York, NY, USA

*Corresponding author. E-mail: tft9001@med.cornell.edu

Abstract

Background: Sternal pain after cardiac surgery results in considerable discomfort. Single-injection parasternal fascial plane blocks have been shown to reduce pain scores and opioid consumption during the first 24 h after surgery, but the efficacy of continuous infusion has not been evaluated. This retrospective cohort study examined the effect of a continuous infusion of local anaesthetic through parasternal catheters on the integrated Pain Intensity and Opioid Consumption (PIOC) score up to 72 h.

Methods: We performed a retrospective analysis of patients undergoing cardiac surgery with median sternotomy at a single academic centre before and after the addition of parasternal nerve catheters to a standard multimodal analgesic protocol. Outcomes included PIOC score, total opioid consumption in oral morphine equivalents, and time-weighted area under the curve pain scores up to 72 h after surgery.

Results: Continuous infusion of ropivacaine 0.1% through parasternal catheters resulted in a significant reduction in PIOC scores at 24 h (−62, 95% confidence interval −108 to −16; $P<0.01$) and 48 h (−50, 95% CI −97 to −2.2; $P=0.04$) compared with no block. A significant reduction in opioid consumption up to 72 h was the primary factor in reduction of PIOC.

Conclusions: This study suggests that continuous infusion of local anaesthetic through parasternal catheters may be a useful addition to a multimodal analgesic protocol in patients undergoing cardiac surgery with sternotomy. Further prospective study is warranted to determine the full benefits of continuous infusion compared with single injection or no block.

Keywords: acute pain medicine; analgesia for cardiac surgery; parasternal block; perioperative outcomes; peripheral nerve catheter

Poorly treated pain after cardiac surgery has been shown to have deleterious effects on critically ill patients, with worsened perioperative outcomes and an increased risk of continued opioid requirements 3 months after surgery.[1–3] Acute pain management in post-cardiac surgery patients is particularly challenging for multiple reasons. Patients may have incisional chest pain from sternotomy, chest tube insertion sites, or both.[4–7] One morphometric analysis of 200

Received: 2 January 2024; **Accepted:** 8 May 2024

patients demonstrated that an overwhelming majority described maximal pain from incisional sternotomy as opposed to pain from chest tube insertion sites over the first three postoperative days.[4]

Early Recovery after Cardiac Surgery (ERACS®) programmes aim to optimise perioperative outcomes for cardiac surgery patients. Multimodal pain management is a core feature of these programmes. Considerable interest has surrounded utilisation of peripheral nerve blocks to optimise postoperative analgesia and minimise opioid consumption. Many early studies assessing the efficacy of peripheral nerve blocks focused on erector spinae blocks for cardiac surgery.[8–11] More recently, parasternal fascial plane blocks, such as the deep parasternal intercostal plane (DPIP) and superficial intercostal plane (SPIP) blocks, have been used for sternotomy pain.[12–16] Previously, these blocks were known as the transversus thoracic muscle plane block and pectointercostal fascial block, respectively; however, the nomenclature has been updated based on the ASRA-ESRA Delphi consensus guidelines.[17] On a theoretical basis, it is plausible that parasternal peripheral nerve blocks are better suited for sternotomy pain because the original studies of the erector spinae block by Forero and colleagues[18] and the serratus anterior block by Blanco and colleagues[19] demonstrated midline sparing effects of the chest wall in adults. A recent randomised, placebo-controlled trial demonstrated a 50% reduction in postoperative sternotomy pain and opioid consumption when using single-injection DPIP blocks during the first 24 h after cardiac surgery.[20] As the vascular uptake from the chest wall is high, continuous infusion of local anaesthetic may provide a longer duration of analgesia than single injection block.[21]

We have conducted a retrospective analysis of patients receiving parasternal peripheral nerve catheters to assess block efficacy up to 72 h after surgery with a primary outcome of composite Pain Intensity and Opioid Consumption (PIOC) scores.[22] PIOC is an integrated score calculated by ranking both the numerical rating scale area under the curve (AUC) pain score and the total opioid consumption across both groups. Non-pain-related perioperative outcomes were also evaluated on an exploratory basis.

Methods

Design

A standardised analgesic protocol, based on the Early Recovery after Cardiac Surgery (ERACS®) protocol, was implemented at our hospital on 1 December 2019. After its implementation, a trial programme for routine postoperative placement of parasternal peripheral nerve catheters began on 30 September 2020. As part of a Quality and Process Improvement initiative, we conducted a retrospective analysis of patients undergoing non-robotic cardiac surgery with a median sternotomy performed by a single surgeon between 1 December 2019 and 20 December 2021. Eligible patients included those aged 18–90 yr with an American Society of Anesthesiologists (ASA) classification 1–4 undergoing non-emergent cardiac surgery with a median sternotomy (full or upper hemisternotomy). Patients were excluded from the final pain analysis for robotic-converted-to-open surgery, postoperative mechanical ventilation lasting >24 h, or opioid abuse disorder. For all patients receiving peripheral nerve catheters, written informed consent was obtained for the procedure before surgery. As this retrospective review was initially conducted for quality improvement purposes, the Weill Cornell Medicine institutional review board (IRB) determined that it met the federal requirements for exemption from IRB review. Before submission for publication, however, the protocol was re-submitted as human subjects research and received expedited IRB approval.

Outcomes

The outcome of interest was integrated pain and opioid consumption (PIOC) score up to 72 h after surgery, with secondary outcomes of total opioid consumption in oral morphine equivalents (OME) and time-weighted area under the curve (AUC) pain scores. Exploratory outcomes included time to extubation (hours), ICU length of stay (days), hospital length of stay (days), time to return of bowel function (days), and incidence of postoperative delirium. Safety outcomes were also assessed, including incidence of postoperative seizure, sternal wound infection, pneumothorax, and major arrhythmias (ventricular tachycardia or ventricular fibrillation). The patients were continuously monitored for signs and symptoms of local anaesthetic toxicity in an intensive care setting for the duration of catheter infusion.

Procedural technique

Bilateral SPIP or DPIP peripheral nerve catheters were placed under sterile conditions with ultrasound guidance in the cardiothoracic intensive care unit (CTICU) during the immediate postoperative period using the Pajunk® E-Cath® Tsui® system (Pajunk Medical Produkte GmbH, Geisingen, Germany) while the patient remained intubated and sedated. Initially catheters were placed in the DPIP, but two early patients experienced postoperative pneumothoraces attributed to block and catheter placement. Subsequently, the more superficial SPIP catheters were utilised without complication. Depending on patient body habitus, either a 18G, 51 cm or 18G, 83 cm echogenic catheter-over-needle was used. For DPIP placement, a linear, high frequency ultrasound probe was used to obtain a parasagittal image of chest wall structures including the pectoralis major muscle, internal intercostal muscle, transversus thoracis muscle, ribs, pleura, and lung. The Pajunk® catheter was inserted at the level of the fourth rib in a caudad to cephalad fashion. After hydrodissection with normal saline 0.9%, ropivacaine 0.25%, 20 ml with epinephrine (5 μg ml^{-1}) was infiltrated into the fascial space between the internal intercostal muscle and the transversus thoracis muscle. After block placement a catheter was left in place and secured under a sterile dressing. This procedure was performed bilaterally with a total volume of 40 mL of ropivacaine 0.25%. SPIP block placement occurred in a similar fashion, but local anaesthetic was instead infiltrated between the pectoralis major muscle and the external intercostal muscle on each side. Ropivacaine 0.1% was infused through each catheter at 10 ml h^{-1} for 3 days. Patients were assessed daily by the acute pain service for catheter functionality, site appearance, and pain control.

Postoperative sedation/analgesia

As part of the cardiac analgesic protocol (Supplementary Fig. S1), all patients without contraindications received oral

Table 1 Patient characteristics. AVR, aortic valve replacement; CABG, coronary artery bypass graft; DPIP, deep parasternal intercostal plane; MV, mitral valve; MVR, mitral valve replacement; SPIP, superficial intercostal plane; TV, tricuspid valve. *Median (inter-quartile range); *n* (%). †Wilcoxon rank sum test; Fisher's exact test.

Variable	Overall, *N*=68*	Control, *N*=34*	Intervention, *N*=34*	*P*-value†
Age (yr)	68 (59–71)	63 (58–70)	69 (63–72)	0.1
Sex				0.8
Female	32 (47)	15 (44)	17 (50)	
Male	36 (53)	19 (56)	17 (50)	
BMI	25.6 (23.0–29.0)	25.0 (23.0–28.0)	26.2 (23.5–29.2)	0.5
Height (cm)	165 (160–178)	165 (160–180)	164 (159–175)	0.8
Weight (kg)	76 (64–85)	78 (60–86)	75 (65–82)	0.9
Block				**<0.01**
No block	34 (50)	34 (100)	0 (0)	
SPIP	17 (25)	0 (0)	17 (50)	
DPIP	17 (25)	0 (0)	17 (50)	
ASA score				0.6
3	23 (34)	13 (38)	10 (29)	
4	45 (66)	21 (62)	24 (71)	
Surgery				
CABG	27 (39)	13 (37)	14 (40)	>0.9
AVR	28 (41)	15 (44)	13 (38)	0.8
MVR	17 (25)	5 (15)	12 (35)	0.09
MV repair	17 (25)	11 (32)	6 (18)	0.3
TV repair	6 (8.8)	2 (5.9)	4 (12)	0.7
Ascending aorta replacement	5 (7.4)	1 (2.9)	4 (12)	0.4
Subaortic membrane resection	1 (1.5)	0 (0)	1 (2.9)	>0.9
Full sternotomy	58 (85)	26 (76)	32 (94)	0.08
Re-operative status	7 (10)	3 (8.8)	4 (12)	>0.9
Intraoperative midazolam	55 (81)	33 (97)	22 (65)	**<0.01**
Dose (mg)	5.00 (2.50–5.00)	5.00 (3.00–5.00)	3.25 (2.00–5.00)	**0.02**
Postoperative medications				
Vasopressor	62 (91)	28 (82)	34 (100)	**0.03**
Inotrope	55 (81)	28 (82)	27 (79)	>0.9
Acetaminophen	68 (100)	34 (100)	34 (100)	
Intravenous ketorolac	50 (74)	26 (76)	24 (71)	0.8
Dexmedetomidine	42 (62)	15 (44)	27 (79)	**<0.01**
Complications				
Pneumothorax	8 (12)	3 (8.8)	5 (15)	0.7
Seizures	0 (0)	0 (0)	0 (0)	
Sternal wound infections	1 (1.5)	1 (2.9)	0 (0)	>0.9
Block-related arrhythmia	0 (0)	0 (0)	0 (0)	

Bolded values indicate statistical significance.

acetaminophen 650 mg every 6 h or i.v. acetaminophen 1000 mg every 8 h (when unable to tolerate oral medications), and i.v. ketorolac 15 mg every 6 h after surgery. I.V. dexmedetomidine was used for sedation weaning in most patients. I.V. or oral opioids were administered to patients based on capability to tolerate oral medications and patient-reported pain scores after extubation. While intubated, patients were administered i.v. hydromorphone based on objective Critical Care Pain Observation Tool scores by CTICU nursing staff. Medications were given to the patient based on mild (pain score 1–3), moderate (4–6), or severe (7–10) pain, with opioids given for pain scores >3. I.V. opioids were given to patients while intubated if the Critical Care Pain Observation Tool score was >3.

Pain calculations

After tracheal extubation, pain scores were collected from the electronic medical record (EMR) based on self-reported numerical rating scale scores every hour while in the ICU and every 4 h while on the postoperative ward. The AUC pain score was calculated by integrating pain scores over time. Only pain scores after tracheal extubation were analysed. Because each patient had a different time to tracheal extubation, the AUC pain score was divided by the duration of time after extubation for a given time period (time-weighted AUC pain score). PIOC scores were calculated as previously described[22,23] by integrating opioid consumption with time-weighted AUC pain scores. PIOC is an integrated score calculated by ranking both the numeric rating scale AUC pain score and the total opioid consumption across both groups. PIOC is the summation of the deviations from the mean ranks for both measurements and is expressed as −200% to +200% for each subject. Scores above zero indicate increased summed AUC pain scores and opioid consumption compared with the entire subject group (intervention plus placebo).[23,24]

Statistical methodology

No power analysis was conducted as this was a retrospective study with a convenience sample based on available data. After extraction of pertinent data from the EMR, matched cohorts were created for each group before statistical analysis using 1:1 nearest neighbour propensity score matching. Two predetermined variables were used for the matching

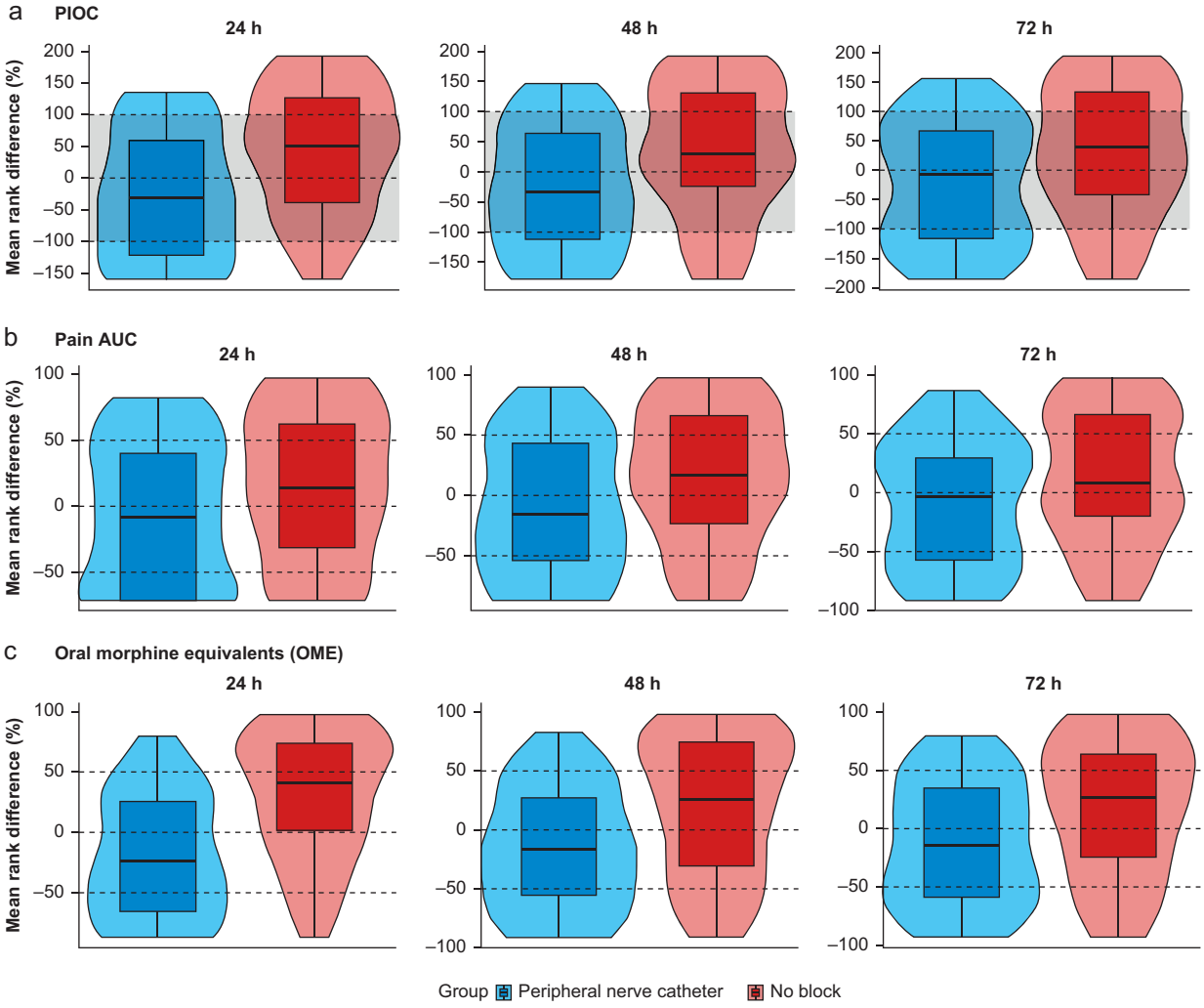

Fig 1. Pain outcomes. Violin plots demonstrate the median and inter-quartile range of each distribution via a box-and-whisker plot that is overlaid with a kernel density estimation. The overlaid density estimation further depicts the distribution of data for each parameter. Data are also documented in numerical form in Supplementary Table S1. (a) Integrated pain and opioid consumption (PIOC), (b) area-under-the-curve (AUC) pain scores, (c) cumulative opioid consumption in oral morphine equivalents (OME) between peripheral nerve catheter group (blue) and no block (red) at 24, 48, and 72 h after ICU admission. PIOC, Pain Intensity and Opioid Consumption.

process—sternotomy type (full *vs* upper hemisternotomy) and re-operative status. Data were reported as median and inter-quartile range. A Wilcoxon rank sum test was used to calculate statistical significance, taking into account the possibility of a skewed distribution of data. Adjusted associations between treatment status and PIOC, pain AUC and opioid consumption were further evaluated using multivariable linear regression. This multivariable regression was utilised to better assess the primary outcome given the possibility of confounding factors in this retrospective analysis. Alpha was set *a priori* at 0.05 for statistical significance. All analysis was performed using Rv4.2.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Between the control cohort and peripheral nerve catheter cohort, there were initially 95 patients eligible for analysis (Supplementary Fig. S2), of whom 18 were excluded for reasons including robotic-converted-to-open surgery (n=3), prolonged postoperative mechanical ventilation lasting longer than 24 h (n=14), and preoperative history of opioid abuse disorder (n=1). Three additional patients were excluded from analysis because >50% of pain measurements in the first 24 h post-extubation were missing. Thus, 74 patients were included in the final unadjusted analysis for pain outcomes. Forty cases were matched to 34 eligible controls. After matching, there were 68 patients eligible for analysis (34 patients in each cohort). In the peripheral catheter group, 17 patients had DPIP and 17 had SPIP catheters. Within the matched cohorts, 76% of control group patients underwent full sternotomy compared with 94% in the catheter group, and 9% of the control operations were classified as re-operative compared with 12% in the catheter group. Neither of these differences was significant.

Table 2 Associations with pain-related outcomes. AUC, area under the curve; CI, confidence interval; PIOC, Pain Intensity and Opioid Consumption. *Adjusted for age and sex.

Characteristic	24 h			48 h			72 h		
	Beta*	95% CI*	P	Beta*	95% CI*	P	Beta*	95% CI*	P
PIOC									
Treatment			**<0.01**			**0.04**			0.11
No block	—	—		—	—		—	—	
Catheter	−62	−108 to −16		−50	−98 to −2.2		−40	−88 to 9.2	
Pain AUC									
Treatment			0.13			0.07			0.07
No block	—	—		—	—		—	—	
Catheter	−0.49	−1.1 to 0.15		−0.32	−0.67 to 0.02		−0.24	−0.50 to 0.02	
Oral morphine equivalents									
Treatment			**<0.001**			**<0.01**			**0.03**
No block	—	—		—	—		—	—	
Catheter	−20	−30 to −9.8		−22	−39 to −5.5		−26	−50 to −2.1	

Bolded values indicate statistical significance.

Patient characteristics (Table 1)

All data were normally distributed. There were no statistical differences in terms of patient characteristics, ASA score, cardiac surgery risk factors, surgery type, cardiopulmonary bypass time, or cross-clamp time between groups. There were no differences between the groups in terms of risk factors for developing severe postoperative pain, including history of chronic pain, use of home opioids, history of anxiety disorder, active preoperative tobacco use, preoperative alcohol use, and preoperative drug use.

Pain outcomes (Fig. 1, Table 2, Supplementary Tables S1 and S2)

After adjusting for age and gender, there was a significant difference in PIOC score in the catheter group compared with control at 24 h (−62, 95% confidence interval [CI] −108 to −16; $P<0.01$) and at 48 h (−50, 95% CI −97 to −2.2; $P=0.04$), but not at 72 h. This was driven by a significant reduction in opioid consumption (oral morphine equivalent) at all time points: 24 h (−20 mg, 95% CI −30 to −9.8 mg; $P<0.001$), 48 h (−22 mg, 95% CI −39 to −5.5 mg; $P<0.01$), and 72 h (−26 mg, 95% CI −50 to −2.1 mg; $P=0.03$). No statistically significant differences in time-weighted AUC pain scores were observed at 24, 48, and 72 h. No differences in outcomes were seen between patients receiving SPIP and those receiving DPIP catheters.

Perioperative outcomes and complications (Table 3)

There were no differences between the catheter and no block groups in terms of time to tracheal extubation, ICU length of stay, and hospital length of stay. There was no statistical difference in the incidence of block complications, including pneumothorax, seizures, sternal wound infections, and postoperative arrythmias.

Additional findings (Table 1)

There was a modest but significant difference between the proportion of patients receiving intraoperative midazolam, with 97% of the control group and 65% of the catheter group receiving midazolam ($P<0.01$). More patients in the catheter group received dexmedetomidine for postoperative sedation (79% *vs* 44%, $P<0.01$). In the control cohort, 82% of patients required vasopressor compared with 100% of patients in the catheter group ($P=0.03$).

Discussion

The primary finding of this retrospective analysis was that continuous parasternal catheter infusion as part of a multimodal analgesic protocol was associated with a decreased integrated pain and opioid consumption (PIOC) score at 24 and 48 h when compared with a multimodal analgesic protocol alone. The decrease in PIOC score was driven largely by opioid consumption, with catheter infusions associated with a significant decrease in oral morphine equivalent consumption up to 72 h. There was no significant difference in pain AUC between groups at any time point.

There has been recent interest in the use of DPIP and SPIP blocks for sternotomy pain after cardiac surgery in both adults and children.[12,25–27] All of these studies have investigated

Table 3 Perioperative outcomes. *Median (IQR); *n* (%). †Wilcoxon rank sum test; Fisher's exact test.

Variable	Overall, N=68*	Control, N=34*	Intervention, N=34*	P-value†
Time to extubation (h)	11.0 (7.0–16.0)	10.5 (6.0–16.0)	12.0 (7.0–16.0)	0.5
ICU length of stay (days)	5.00 (3.00–6.00)	4.00 (3.25–6.00)	5.00 (3.00–7.00)	0.5
Hospital length of stay (days)	8.0 (6.0–10.0)	6.5 (5.2–10.0)	8.0 (7.0–10.0)	0.2
Time to first bowel movement (days)	3.00 (2.00–4.00)	3.00 (3.00–4.75)	3.00 (2.00–4.00)	0.5
Incidence of ICU delirium	6 (8.8)	4 (12)	2 (5.9)	0.7
Intraoperative opioid consumption (OME)	285 (206–315)	308 (278–405)	225 (169–285)	0.001
Pre-extubation opioid consumption (OME)	6 (0–15)	14 (8–23)	3 (0–6)	0.001

single-shot blocks compared with an opioid-based analgesic control group and have shown a significant decrease in opioid consumption and a variable decrease in pain scores within the first 12–24 h. For example, Aydin and colleagues[20] and Abdelbaser and Mageed[25] found a nearly 50% reduction in postoperative opioid consumption for 24 h after extubation for adult and paediatric patients receiving a single injection DPIP block. Vascular uptake of local anaesthetic after chest wall blocks is high,[21,28] suggesting that continuous infusions might more reliably extend analgesia beyond 12 to 24 h. To date no data have been published regarding continuous parasternal catheter infusions as part of a multimodal analgesic protocol after cardiac surgery with sternotomy.

PIOC was used as the primary outcome for this analysis. Although pain scores or opioid consumption on their own have mainly been used as the primary acute pain metrics, we believe PIOC is a superior method for capturing the true efficacy of a pain intervention.[23,24,29] Pain scores and opioid consumption are interdependent variables; by combining the two variables, PIOC results in increased statistical power compared with analysing the longitudinal AUC pain measure and opioid consumption separately, and adds a time component to the pain measure without multiple significance tests that increase the risk of type I error.[22]

Limitations

There was a difference in the proportion of patients receiving intraoperative midazolam, with 65% of the catheter group and 97% of the control group receiving this drug. This difference likely resulted from an anaesthetic protocol change at our institution resulting in decreased midazolam administration after May 2021.

More patients in the catheter group received postoperative sedation with dexmedetomidine (79%) compared with the control group (44%) before extubation. Although only post-extubation pain scores were included in the analysis, it is possible that dexmedetomidine may have influenced pain scores and opioid consumption after termination of the drug. Study results have been mixed regarding the influence of dexmedetomidine on postoperative pain scores and opioid consumption.[30,31]

There was a significant difference between groups with respect to postoperative vasopressor use, with 100% of the peripheral catheter group and 82% of the control group requiring vasopressors. It is possible that the peripheral nerve block itself (the initial bolus plus the subsequent infusion) led to a higher incidence of hypotension requiring vasopressor; however, there may have been reasons unrelated to the block as well, such as the increased use of dexmedetomidine before extubation in the catheter group.[32]

Patients in the catheter cohort received either an SPIP or a DPIP catheter, with a change in practice driven by two cases of pneumothorax after DPIP. There were no differences in any of the endpoints in patients receiving DPIP compared with SPIP catheters. From our experience it appears that both SPIP and DPIP catheters may be similarly efficacious, but the SPIP may have the superior safety profile in terms of reduction in the incidence of pneumothorax.

This was a single-institution retrospective study, and although we attempted to reduce confounding by creating a matched cohort using predetermined variables, unrecognised confounding and bias could be present. For example, changes in anaesthetic and ICU protocols over time with regard to midazolam and dexmedetomidine administration may have influenced results. Further research using a rigorous, prospective design is required to elucidate a causative effect on pain outcomes for the use of continuous parasternal catheters for postoperative pain control in patients undergoing sternotomy. Results from this study may inform the design of such a future trial, including power analysis calculations.

Conclusions

This retrospective cohort study demonstrated that a continuous infusion of ropivacaine 0.1% via parasternal catheters as part of a multimodal analgesic protocol was associated with a significant reduction in the composite Pain Intensity and Opioid Consumption (PIOC) score and a reduction in opioid consumption up to 48 h compared with no block after cardiac surgery with a sternotomy incision. The reduction in PIOC was driven by a reduction in opioid consumption up to 72 h. Further prospective study is warranted to determine the full benefits of continuous infusion compared with single injection or no block.

Funding

Funding was provided by the Department of Anesthesiology, New York-Presbyterian/Weill Cornell Medicine.

Authors' contributions

Study design: JER, VN, KOP, SLM, TT
Data collection and analysis: JER, VN, JC, BR, SJ, SK
Manuscript: JER, VN, NS, DK, NIG, KOP, RYW, SLM, TT

Declarations of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bjao.2024.100288.

References

1. Caruso TJ, Lawrence K, Tsui BCH. Regional anesthesia for cardiac surgery. *Curr Opin Anaesthesiol* 2019; **32**: 674–82
2. Mori M, Brooks C, Dhruva SS, et al. Trajectories of pain after cardiac surgery: implications for measurement, reporting, and individualized treatment. *Circ Cardiovasc Qual Outcome*. 2021; **14**, e007781
3. Hui V, Marhoon N, Bailey M, et al. Opioid prescription after cardiac surgery. *Heart Lung Circ* 2022; **31**: 602–9
4. Mueller XM, Tinguely F, Tevaearai HT, Revelly JP, Chioléro R, von Segesser LK. Pain location, distribution, and intensity after cardiac surgery. *Chest* 2000; **118**: 391–6
5. Schelling G, Richter M, Roozendaal B, et al. Exposure to high stress in the intensive care unit may have negative effects on health-related quality-of-life outcomes after cardiac surgery. *Crit Care Med* 2003; **31**: 1971–80
6. Mazzeffi M, Khelemsky Y. Poststernotomy pain: a clinical review. *J Cardiothorac Vasc Anesth* 2011; **25**: 1163–78
7. Milgrom LB, Brooks JA, Qi R, Bunnell K, Wuestfeld S, Beckman D. Pain levels experienced with activities after cardiac surgery. *Am J Crit Care* 2004; **13**: 116–25

8. Roy N, Brown ML, Parra MF, et al. Bilateral erector spinae blocks decrease perioperative opioid use after pediatric cardiac surgery. *J Cardiothorac Vasc Anesth* 2021; **35**: 2082–7
9. Krishna SN, Chauhan S, Bhoi D, et al. Bilateral erector spinae plane block for acute post-surgical pain in adult cardiac surgical patients: a randomized controlled trial. *J Cardiothorac Vasc Anesth* 2019; **33**: 368–75
10. Athar M, Parveen S, Yadav M, et al. A randomized double-blind controlled trial to assess the efficacy of ultrasound-guided erector spinae plane block in cardiac surgery. *J Cardiothorac Vasc Anesth* 2021; **35**: 3574. 0
11. Finnerty DT, McMahon A, McNamara JR, Hartigan SD, Griffin M, Buggy DJ. Comparing erector spinae plane block with serratus anterior plane block for minimally invasive thoracic surgery: a randomised clinical trial. *Br J Anaesth* 2020; **125**: 802–10
12. Fujii S, Roche M, Jones PM, Vissa D, Bainbridge D, Zhou JR. Transversus thoracis muscle plane block in cardiac surgery: a pilot feasibility study. *Reg Anesth Pain Med* 2019; **44**: 556–60
13. Ueshima H, Kitamura A. Blocking of multiple anterior branches of intercostal nerves (Th2-6) using a transversus thoracic muscle plane block. *Reg Anesth Pain Med* 2015; **40**: 388
14. Ueshima H, Kitamura A. Clinical experiences of ultrasound-guided transversus thoracic muscle plane block: a clinical experience. *J Clin Anesth* 2015; **27**: 428–9
15. Liu V, Mariano ER, Prabhakar C. Pecto-intercostal fascial block for acute poststernotomy pain: a case report. *A A Pract* 2018; **10**: 319–22
16. Jones J, Murin PJ, Tsui JH. Opioid free postoperatively using pecto-intercostal fascial block (PIFB) with multimodal analgesia (MMA) in a patient with myasthenia gravis underwent thymectomy via sternotomy. *J Clin Anesth* 2020; **59**: 32–3
17. El-Boghdadly K, Wolmarans M, Stengel AD, et al. Standardizing nomenclature in regional anesthesia: an ASRA-ESRA Delphi consensus study of abdominal wall, paraspinal, and chest wall blocks. *Reg Anesth Pain Med* 2021; **46**: 571–80
18. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. *Reg Anesth Pain Med* 2016; **41**: 621–7
19. Blanco R, Parras T, McDonnell JG, Prats-Galino A. Serratus plane block: a novel ultrasound-guided thoracic wall nerve block. *Anaesthesia* 2013; **68**: 1107–13
20. Aydin ME, Ahiskalioglu A, Ates I, et al. Efficacy of ultrasound-guided transversus thoracic muscle plane block on postoperative opioid consumption after cardiac surgery: a prospective, randomized, double-blind study. *J Cardiothorac Vasc Anesth* 2020; **34**: 2996–3003
21. Johnson MD, Mickler T, Arthur GR, Rosenburg S, Wilson R. Bupivacaine with and without epinephrine for intercostal nerve block. *J Cardiothorac Anesth* 1990; **4**: 200–3
22. Dai F, Silverman DG, Chelly JE, Li J, Belfer I, Qin L. Integration of pain score and morphine consumption in analgesic clinical studies. *J Pain* 2013; **14**: 767. 77.e8
23. Sort R, Brorson S, Gögenur I, et al. Peripheral nerve block anaesthesia and postoperative pain in acute ankle fracture surgery: the AnAnkle randomised trial. *Br J Anaesth* 2021; **126**: 881–8
24. Andersen LPK, Gögenur I, Torup H, Rosenberg J, Werner MU. Assessment of postoperative analgesic drug efficacy: method of data analysis is critical. *Anesth Analg* 2017; **125**: 1008–13
25. Abdelbaser II, Mageed NA. Analgesic efficacy of ultrasound guided bilateral transversus thoracis muscle plane block in pediatric cardiac surgery: a randomized, double-blind, controlled study. *J Clin Anesth* 2020; **67**, 110002
26. Hamed MA, Abdelhady MA, Hassan AASM, Boules ML. The analgesic effect of ultrasound-guided bilateral pectointercostal fascial plane block on sternal wound pain after open heart surgeries: a randomized controlled study. *Clin J Pain* 2022; **38**: 279–84
27. Kaya C, Dost B, Dokmeci O, Yucel SM, Karakaya D. Comparison of ultrasound-guided pecto-intercostal fascial block and transversus thoracic muscle plane block for acute poststernotomy pain management after cardiac surgery: a prospective, randomized, double-blind pilot study. *J Cardiothorac Vasc Anesth* 2022; **36**: 2313–21
28. Rosenberg PH, Veering BT, Urmey WF. Maximum recommended doses of local anesthetics: a multifactorial concept. *Reg Anesth Pain Med* 2004; **29**: 564–75. ; discussion 24
29. Benzon HT, Mascha EJ, Wu CL. Studies on postoperative analgesic efficacy: focusing the statistical methods and broadening outcome measures and measurement tools. *Anesth Analg* 2017; **125**: 726–8
30. Blaudszun G, Lysakowski C, Elia N, Tramèr MR. Effect of perioperative systemic α2 agonists on postoperative morphine consumption and pain intensity: systematic review and meta-analysis of randomized controlled trials. *Anesthesiology* 2012; **116**: 1312–22
31. Naik BI, Nemergut EC, Kazemi A, et al. The effect of dexmedetomidine on postoperative opioid consumption and pain after major spine surgery. *Anesth Analg* 2016; **122**: 1646–53
32. Keating GM. Dexmedetomidine: a review of its use for sedation in the intensive care setting. *Drugs* 2015; **75**: 1119–30

Handling editor: Phil Hopkins