 doi:10.20944/preprints202209.0178.v1

Article

A Prospective Cohort Study: Erector Spinae Plane Block Decreases Chronic Postoperative Pain Severity in Patients Undergoing Coronary Artery Bypass Grafting

Marcin Wiech[1], Sławomir Żurek[2], Arkadiusz Kurowicki[2], Beata Horeczy[3], Mirosław Czuczwar[1], Paweł Piwowarczyk[1], Kazimierz Widenka[2], and Michał Borys[1]

[1] Second Department of Anesthesia and Intensive Therapy, Medical University of Lublin, Staszica 16, 20-081 Lublin, Poland
[2] Department of Cardiac Surgery, Medical Faculty, University of Rzeszów, Lwowska 60, 35-301 Rzeszów, Poland
[3] Pro-Familia Hospital, Rzeszów School of Medicine, Witolda 6B, 35-302 Rzeszów, Poland
* Correspondence: author: Michał Borys: Tel: +48 81 5322713; Fax: +48 81 5322712

Abstract: Up to 56% of patients develop chronic postsurgical pain (CPSP) after coronary artery bypass grafting (CABG). CPSP can affect patients' moods and decrease daily activities. The primary aim of this study was to investigate CPSP severity in patients following off-pump (OP)-CABG using the Neuropathic Pain Symptom Inventory (NPSI). This was a prospective cohort study conducted in a cardiac surgery department of a teaching hospital. Patients undergoing OP-CABG were enrolled in an erector spinae plane block (ESPB) group (n = 27) or a control (CON) group (n = 24). Before the induction of general anesthesia, ESPB was performed on both sides under ultrasound guidance using 0.375% ropivacaine. The secondary outcomes included cumulative oxycodone consumption, acute pain intensity, mechanical ventilation time, hospital length of stay, and postoperative complications. CPSP intensity was lower in the ESPB group than in the CON group 1, 3, and 6 months postsurgery ($p < 0.001$). Significant between-group differences were also observed in other outcomes, including postoperative pain severity, opioid consumption, mechanical ventilation time, and hospital length of stay in favor of the ESPB group. Preemptive ESPB appears to decrease the risk of CPSP development in patients undergoing OP-CABG. Reduced acute pain severity and shorter mechanical ventilation times and hospital stays should improve patients' satisfaction and reduce perioperative complications.

Keywords: chronic postoperative pain; erector spinae plane block; coronary artery bypass grafting; Neuropathic Pain Symptom Inventory

1. Introduction

Coronary artery bypass grafting (CABG) is one of the common types of cardiac surgeries performed worldwide, with 44 procedures per 100,000 individuals completed annually [1]. Up to 56% of patients develop chronic postsurgical pain (CPSP) after CABG [2,3]. CPSP following CABG surgery can decrease patients' moods and performance of daily activities [3]. A Cochrane meta-analysis found that thoracic epidural analgesia (TEA) could prevent CPSP in patients following thoracic surgery [4]. In our previous study, we showed that continuous paravertebral block lowered CPSP severity and reduced the incidence of CPSP after thoracic surgery [5]. However, not much is known about the use of regional anesthesia techniques in the prevention of CPSP in cardiac surgery.

Erector spinae plane block (ESPB) is a relatively new regional anesthesia technique described by Forero [6]. In the years since its introduction, ESPB has been used in different types of surgical procedures, including cardiac surgery [7–9]. In previous research, we described this type of fascial block in patients undergoing mitral and/or tricuspid valve repair via a right mini-thoracotomy and off-pump CABG (OP-CABG) [10,11]. However,

 doi:10.20944/preprints202209.0178.v1

we did not evaluate the incidence of CPSP in the months following patient discharge. This study aimed to assess the severity and incidence of CPSP in patients undergoing OP-CABG via sternotomy with preemptive, bilateral ESPB.

2. Materials and Methods

This was a prospective cohort study conducted in a cardiac surgery department of a teaching hospital. The study protocol was approved by the Bioethics Committee of the Medical University of Lublin, Lublin, Poland (permit number KE-0254/219/2018). Informed consent was obtained from the patients, and the study was conducted in accordance with the tenets of the Declaration of Helsinki for medical research involving human subjects.

2.1. Participants

Patients undergoing a OP-CABG procedure were enrolled in an ESPB group or a control (CON) group. Patients were enrolled consecutively. The same two surgeons performed each surgery. First, we recruited patients to the CON group, then to the ESPB group. The inclusion criteria were adult patients (≥ 18 years) scheduled for elective surgery. Patients with chronic pain at admission, a history of alcohol or recreational drug abuse, known bleeding disorders, allergies to the drugs used during the study, antidepressant or epileptic drug treatment, and chronic use of painkillers were excluded.

2.2. General anesthesia

For induction of general anesthesia, the following was used: 0.2–0.4 mg/kg of etomidate, 2–4 μg/kg of fentanyl, and 0.6 mg of rocuronium. Fentanyl infusion was continued at a flow of 25–100 μg/hour, and sevoflurane (0.5–1.0 minimal alveolar concentration) was administered for anesthesia maintenance. The patients received additional doses of rocuronium every 30–40 minutes and norepinephrine or nitroglycerine as required.

2.3. Regional block and postoperative care

In the ESPB group, before the induction of general anesthesia, single-shot bilateral ESPB was performed, as described in our previous study [12]. On each side, 0.2 $ml.kg^{-1}$ of 0.375% ropivacaine (Ropimol, Molteni, Italy) was administered. The total volume of local anesthetic solution did not exceed 40 ml per patient.

About 20–30 minutes before the end of the surgery, the patients received 0.1 mg of oxycodone hydrochloride (up to 10 mg) intravenously (i.v.) and acetaminophen (1.0 g i.v.). Each patient was then transferred to the postoperative care unit. In each case, extubation and weaning from mechanical ventilation were performed according to the attending physician's discretion. The attending physician measured acute postoperative pain intensity using the Numerical Rating Scale (NRS, 0–10) immediately after extubation. The attending nurse then assessed pain severity every 6 hours.

Standard pain treatment included oxycodone administered i.v. via a patient-controlled analgesia pump (1 mg/ml, 1 ml bolus, 5 minutes refraction time). In additionally, the patients received 1.0 g of acetaminophen every 6 hours, ketoprofen i.v., 100 mg twice daily, and ondansetron i.v. (4 mg twice daily) as nausea and vomiting prophylaxis. In cases of severe pain (i.e., exceeding 4 on the NRS), the attending nurse was permitted to administer a bolus of oxycodone (5 mg).

2.4. Persistent postoperative pain

For the assessment of persistent postoperative pain, we used the Neuropathic Pain Symptom Inventory (NPSI) developed by Bouhassira et al. [13], as employed in our previous study [14]. All patients were interviewed via telephone 1, 3, and 6 months postsurgery.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 13 September 2022 doi:10.20944/preprints202209.0178.v1

2.5. Outcomes

The primary outcome was CPSP severity 1, 3, and 6 months surgery. The secondary outcomes included the cumulative oxycodone dose, acute pain intensity on the NRS, mechanical ventilation time, hospital length of stay, and postoperative complications. Patients without NPSI results were excluded from further analysis.

2.6. Statistics

The Student's t-test was used to analyze parametric data. The data are presented as means and 95% confidence intervals. Nonparametric data were calculated using the Mann–Whitney U test and are presented as medians and interquartile ranges. Categorical variables were analyzed using Fisher's exact test. All measurements were performed using Statistica 13.1 software (Stat Soft. Inc., Tulsa, OK, United States).

3. Results

The study was conducted from March 2019 to April 2020. In total, 74 patients were enrolled. Twenty-three patients were lost to follow-up. The final study comprised data from 51 patients: 24 in the CON group and 27 in the ESP group. Patient demographics, time of mechanical ventilation, length of hospital stay, and preoperative results of ASA scoring systems are presented in Table 1.

Table 1. Patient demographics

Parameters	ESPB	CON	Probability
Number of patients	27	24	
Male (%)	24 (88.9)	22 (91.7)	1.0
Age (years)	64.7 (62.0-67.4)	67.1 (63.4-70.7)	0.28
Weight (kg)	85.2 (80.4–90.0)	83.7 (77.9–89.4)	0.68
Height (cm)	171.1 (167.7–174.5)	170.6 (167.1–174.1)	0.85
BMI	29.1 (27.8-30.3)	28.6 (27.1-30.1)	0.65
ASA	3 (2–3)	3 (3–3)	0.45
Anesthesia time (minutes)	194 (174–215)	201 (141–185)	0.63
Surgery time (minutes)	159 (140–179)	163 (177–225)	0.79

Patient age, weight, and height are presented as means and confidence intervals. ASA, American Society of Anesthesiologists; BMI, body mass index; ESPB, erector spinae plane block group; CON, control group.

3.1. Primary outcome

CPSP severity was significantly higher in the CON group than in the ESPB group 1, 3, and 6 months after OP-CABG surgery (Table 2). As presented in Table 3, fewer patients in the ESPB group showed signs of persistent pain.

Table 2. Severity of persistent postoperative pain.

After discharge	ESPB	CON	p value
1 month	1 (0–2)*	4 (3–6)	< 0.001
3 months	0 (0–1)*	4 (2–6)	< 0.001
6 months	0 (0–0)*	2 (14)	< 0.001

The severity of post-thoracotomy pain syndrome was detected with the NPSI (0–100). Data are shown as medians (interquartile ranges). * Denotes a significant between-group difference. ESPB, erector spinae plane block group; CON, control group.

Table 3 shows the number of patients who experienced CPSP 1, 3, and 6 months postsurgery

Table 3. Incidence of chronic postsurgical pain (CPSP)

After discharge	Number of patients (%)	p value

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 13 September 2022 doi:10.20944/preprints202209.0178.v1

	ESPB	CON	
1 month	17 (63)*	23 (96)	< 0.01
3 months	8 (30)*	23 (96)	< 0.001
6 months	6 (22)*	22 (92)	< 0.001

* Denotes a significant between-group difference. ESPB, erector spinae plane block group; CON, control group.

3.2. Secondary outcomes

Acute pain severity was significantly lower in the ESPB group than in the CON group (Table 4). The patients in the ESPB group used less oxycodone via PCA than the CON group (4 [2–8] vs. 25 [20–25] mg, $p < 0.001$) (Fig. 1).

The mechanical ventilation time was shorter in the ESPB group than in the CON group (2 [1–3] vs. 10.5 [8–13.25] hours, $p < 0.001$). Moreover, the length of hospital stay was shorter in the ESPB group than in the CON group (7 [6–9] vs. 10 [8–12] days, $p < 0.001$). There was no between-group difference in postoperative complications. Figure 1 presents postoperative oxycodone consumption administered via PCA.

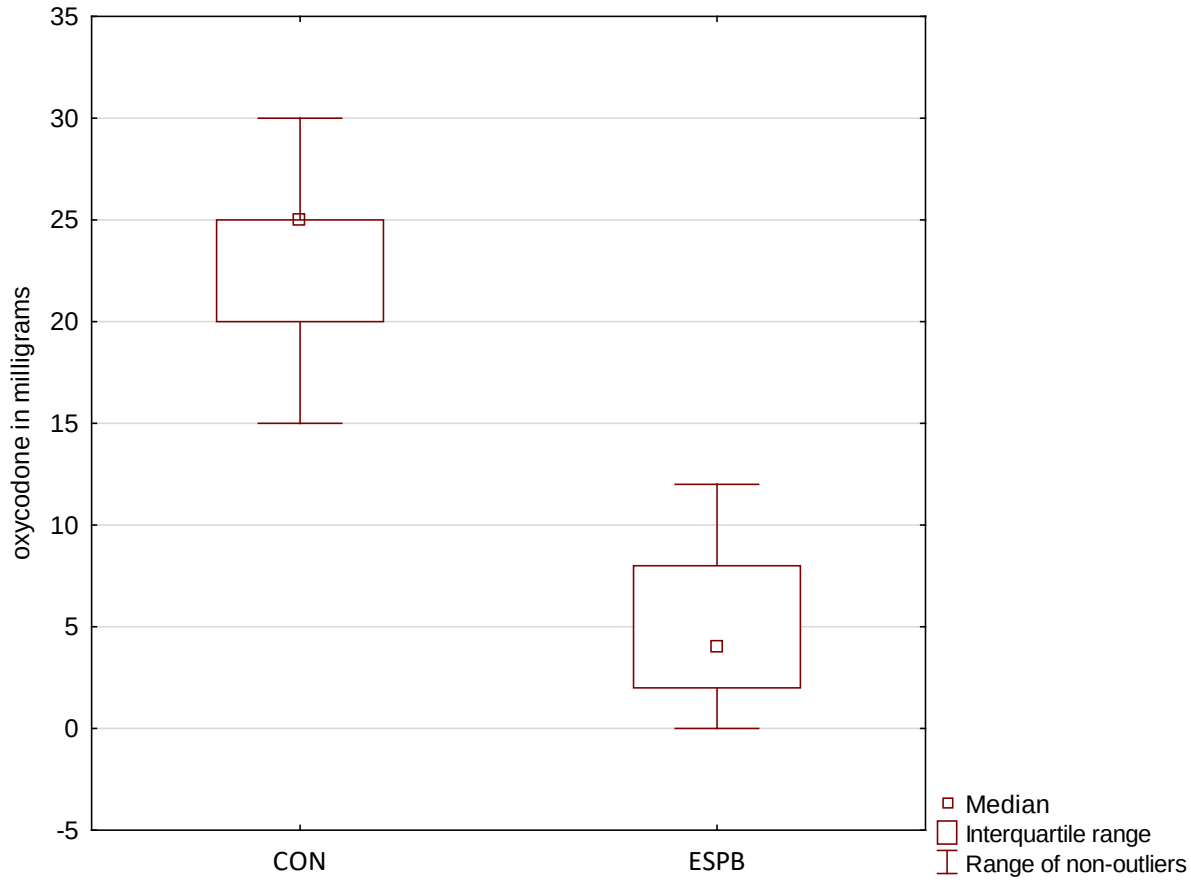

Figure 1. Oxycodone consumption.

ESPB, erector spinae plane block group; CON, control group

Table 4. Acute pain severity

Hours after extubation	ESPB	CON	p value
0	3.0 (2.0–4.5)*	5.0 (4.0–5.8)	< 0.001
6	2.5 (2.0–4.0)*	4.5 (3.5–5.0)	< 0.001

 doi:10.20944/preprints202209.0178.v1

12	3.0 (2.0–3.5)*	4.0 (3.0–4.0)	< 0.01
18	2.0 (0.0–3.0)*	3.0 (2.0–4.0)	< 0.01
24	0.0 (0.0–1.5)*	3.0 (1.0–3.5)	< 0.001

Data are shown as medians (interquartile ranges). *Denotes a significant between-group difference. ESPB, erector spinae plane block group; CON, control group.

4. Discussion

Our results suggest that ESPB can alleviate CPSP severity after an OP-CABG procedure. As shown in 3, fewer patients had signs of persistent pain after the regional block. Moreover, acute pain severity and oxycodone consumption were minor in patients following the regional block. The regional block group also had shorter postoperative mechanical ventilation and hospital length of stay times.

Although continuous TEA reduces postoperative pain and opioid demand and likely prevents the risk of CPSP, many cardiac anesthesiologists do not use this technique due to systemic anticoagulation during CABG surgery [15]. However, the chance of epidural hematoma in cardiac surgery after TEA is very low (1:5493) [16]. The risk of potential complications after preemptive bilateral ESPB appears to be even lower if this procedure is performed under ultrasound guidance using the single-shot technique. According to the results of previous research, regional anesthesia procedures might prevent the occurrence of CPSP [4]. TEA reduced the incidence of CPSP in patients following thoracic surgery, and paravertebral block was effective in alleviation CPSP severity after breast surgeries. New regional anesthesia techniques have been explored extensively in acute postoperative pain treatment. However, their potential effect on prevention of CPSP development requires further studies.

Limited treatment modalities can prevent CPSP development following cardiac surgery procedures [17]. In a meta-analysis by Carley et al. concerning prophylaxis of CPSP with drugs following surgeries, only gabapentoids showed to prevent persistent pain three months after cardiac surgery [18]. However, as stated by the authors of this meta-analysis, the results should be interpreted cautiously due to the small study sizes.

Our study has some limitations. It was an observational study. Thus, selection bias is possible. In addition, we enrolled a relatively small group of patients, and we did not examine the quality of regional block with the pinprick technique.

To conclude, our results suggest that preemptive ESPB can decrease the risk of CPSP development in patients after the OP-CABG procedure. The lower acute pain severity and shorter mechanical ventilation times and hospital stays associated with the procedure Lower acute pain severity and shorter mechanical ventilation times and hospital stays should improve patients' satisfaction, reduce hospital costs and perioperative complications.

Author Contributions: Conceptualization, M.B. and M.W.; Methodology, M.B. and B.H.; Formal Analysis, M.B..; Investigation, S.Ż., A.K. B.H.; Resources, K.W. and B.H.; Data Curation, S.Ż., A.K., M.C.; Writing – Original Draft Preparation, M.W., M.B., P.P.; Writing – Review & Editing, M.C, M. W.; Visualization, M.W.; Supervision, M.B.; Project Administration, K.W.

Funding: This research received no external funding.

Ethics Statements: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the ethics committee of the Medical University of Lublin, Lublin, Poland (permit number KE-0254/219/2018, 29 November 2018). Informed consent was obtained from all the patients involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Head, S.J.; Milojevic, M.; Taggart, D.P.; Puskas, J.D. Current practice of state-of-the-art surgical coronary revascularization. *Circulation* **2017**, *136*, 1331–1345.
2. Kalso, E.; Mennander, S.; Tasmuth, T. Chronic post-sternotomy pain. *Acta Anaesthesiol Scand* **2001**, *45*, 935–939.
3. Eisenberg, E.; Pultorak, Y.; Pud, D.; Bar-El, Y. Prevalence and characteristics of post coronary artery bypass graft surgery pain (PCP). *Pain* **2001**, *92*, 1–2, 11–7.
4. Andreae, M.H.; Andreae, D.A. Regional anaesthesia to prevent chronic pain after surgery: a Cochrane systematic review and meta-analysis. *Br J Anaesth* **2013**, *111*, 711–720.
5. Borys, M.; Hanych, A.; Czuczwar, M. Paravertebral block versus preemptive ketamine effect on pain intensity after posterolateral thoracotomies: A randomized controlled trial. *J. Clin. Med*, **2020**, *9*, 793.
6. Forero, M.; Rajarathinam M.; Adhikary S.; Chin J.K. continuous erector spinae plane block for rescue analgesia in thoracotomy after epidural failure: A case report. *A A Case Rep* **2017**, *8*, 254–256.
7. Nagaraja, P.S.; Ragavendran S.; Singh N.G.; Omshubham A.; Bhavya G.; Manjunath N.; Rajesh K. Comparison of continuous thoracic epidural analgesia with bilateral erector spinae plane block for perioperative pain management in cardiac surgery. *Ann Card Anaesth* **2018**, *21*, 323–327.
8. Krishna S.N.; Chauhan S.; Bhoi D.; Kaushal B.; Hasija S.; Sangdup T.; Bisoi A.K. 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*, 368–375.
9. Borys M.; Gawęda B.; Horeczy B.; Kolowca M.; Olszówka P.; Czuczwar M. Erector spinae-plane block as an analgesic alternative in patients undergoing mitral and/or tricuspid valve repair through a right mini-thoracotomy – an observational cohort study. *Videosurgery and Other Miniinvasive Techniques* **2020**, *15*, 208–214.
10. Gawęda B.; Borys M.; Belina B.; Bąk J.; Czuczwar M.; Wołoszczuk-Gębicka B.; Kolowca M.; Widenka K. Postoperative pain treatment with erector spinae plane block and pectoralis nerve blocks in patients undergoing mitral/tricuspid valve repair - a randomized controlled trial. *BMC Anesthesiol* **2020**, *20*,1 51.
11. Borys M.; Żurek S.; Kurowicki A.; Horeczy B.; Bielina B.; Sejboth J.; Wołoszczuk-Gębicka B.; Czuczwar M.; Widenka K. Implementation of enhanced recovery after surgery (ERAS) protocol in off-pump coronary artery bypass graft surgery.A prospective cohort feasibility study. *Anaesthesiol Intensive Ther* **2020**, *52*, 10–14.
12. Borys, M.; Potręć-Studzińska, B.; Wiech, M.; Piwowarczyk, P.; Sysiak-Sławecka, J.; Rypulak, E.; Gęca, T.; Kwaśniewska, A.; Czuczwar, M. Transversus abdominis plane block and quadratus lumborum block did not reduce the incidence or severity of chronic postsurgical pain following cesarean section: A prospective, observational study. *Anaesthesiol Intensive Ther* **2019**, *51*, 257–261.
13. Bouhassira, D.; Attal, N.; Fermanian, J.; Alchaar, H.; Gautron, M.; Masquelier, E.; Rostaing, S.; Lanteri-Minet, M.; Collin, E.; Grisart, J.; Boureau, F. Development and validation of the neuropathic pain symptom inventory. *Pain* **2004**, *108*, 248–257.
14. Borys, M.; Zamaro, A.; Horeczy, B.; Gęszka, E.; Janiak, M.; Węgrzyn, P.; Czuczwar, M.; Piwowarczyk, P. Quadratus lumborum and transversus abdominis plane blocks and their impact on acute and chronic pain in patients after cesarean section: A randomized controlled Study. *Int J Environ Res Public Health* **2021**, *18*, 3500.
15. Bignami E.; Landoni G.; Biondi-Zoccai G.G.; Boroli F.; Messina M.; Dedola E.; Nobile L.; Buratti L.; Sheiban I.; Zangrillo A. Epidural analgesia improves outcome in cardiac surgery: a meta-analysis of randomized controlled trials. *J Cardiothorac Vasc Anesth* **2010**, *24*, 586–597.
16. Hemmerling T.M.; Cyr S.; Terrasini N. Epidural catheterization in cardiac surgery: The 2012 risk assessment. *Ann Card Anaesth* **2013**, *16*, 169–77.
17. Kleiman A.M., Sanders D.T., Nemergut E.C., Huffmyer J.L. Chronic Poststernotomy Pain: Incidence, Risk Factors, Treatment, Prevention, and the Anesthesiologist's Role. *Reg Anesth Pain Med* **2017**, 42, 698-708.
18. Carley, M. E., Chaparro, L. E., Choinière, M., Kehlet, H., Moore, R. A., Van Den Kerkhof, E., Gilron, I.Pharmacotherapy for the Prevention of Chronic Pain after Surgery in Adults: An Updated Systematic Review and Meta-analysis. *Anesthesiology* **2021**, 135, 304–325.