

ORIGINAL ARTICLE

Opioid-sparing analgesia in thoracic oncology surgery: the role of paravertebral block in a high opioid use context in human patients

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Submitted: 24 May 2026

Revised: 18 August 2026

Accepted: 20 August 2026

Online First: 28 August 2026



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Summary

Introduction: This pilot study aimed to evaluate whether thoracic paravertebral block (PVB) offers better postoperative analgesia than systemic morphine in thoracotomy patients, focusing on early pain scores, rescue analgesia needs, and postoperative nausea and vomiting (PONV).

Materials and Methods: We analyzed 51 thoracic surgery patients; 24 received a single-shot ultrasound-guided PVB with bupivacaine before incision, while 27 were administered intraoperative systemic morphine. Pain was assessed using the Numeric Rating Scale (NRS) at 0, 3, 6, and 12 hours, along with tracking PONV, intraoperative opioid use, and hemodynamic parameters.

Results: Pain scores were lower in the PVB group at all intervals ($p = 0.022$ at 0h, $p = 0.004$ at 3h, $p = 0.008$ at 6h, and $p = 0.009$ at 12h). By 12 hours, 50% of patients in the PVB group required no rescue analgesia compared to 3.7% in the morphine group ($p = 0.008$). PONV occurred less frequently in the PVB group (20.8% vs. 44.4%), demonstrating a clinical trend, though the difference did not reach statistical significance ($p = 0.074$). Intraoperative fentanyl consumption was significantly reduced in the PVB group ($p < 0.001$). Hemodynamic parameters were similar between groups.

Conclusion: PVB provided more effective pain relief than systemic morphine after thoracotomy, with reduced opioid consumption and a trend toward less PONV. These findings support PVB's role in enhancing postoperative recovery in thoracic surgery.

Keywords: paravertebral block, morphine, thoracotomy, postoperative pain

INTRODUCTION

Thoracic oncologic surgery imposes a dual nociceptive burden: procedure related tissue trauma and cancer-associated pain syndromes. Although videoassisted thoracoscopic surgery (VATS) attenuates cutaneous and muscular injury relative to open approaches, posterolateral thoracotomy remains one of the most painful incisions in contemporary practice.

Inadequate analgesia after thoracotomy impairs respiratory mechanics, suppresses effective coughing, delays ambulation, and consequently predisposes patients to atelectasis, pneumonia, and prolonged hospitalization. Pain arises from convergent nociceptive and neuropathic processes involving somatic and visceral afferents.

Somatic nociception originates from incision of skin, intercostal muscles, and parietal pleura; from rib retraction; and, occasionally, from costochondral disarticulation or iatrogenic rib fracture. These stimuli are conveyed via myelinated A δ and unmyelinated C fibers within the intercostal nerves (T1-T11). Visceral afferents from lung parenchyma and mediastinal structures ascend predominantly through the vagus nerve, whereas the parietal pleura – richly innervated by intercostal and phrenic branches – is exquisitely sensitive to mechanical and chemical insult.

Tissue injury initiates the release of inflammatory mediators – prostaglandins, histamine, bradykinin, potassium—that activate peripheral nociceptors, lower discharge thresholds, and produce primary sensitization. Persistent afferent barrage during and after surgery engages N-methyl-D-aspartate receptors within the dorsal horn, releases substance P and calcitonin gene-related peptide, and establishes central sensitization. Concomitant intercostal nerve trauma, chesttube irritation, and retained hemothorax further propagate neuropathic mechanisms, setting the stage for chronic post-thoracotomy pain (1).

Ipsilateral shoulder pain is common and is referred via phrenic afferents (C3–C5). Latissimus dorsi and serratus anterior myofascial pain may also contribute, mediated by the thoracodorsal and long thoracic nerves, respectively (2).

Optimal perioperative analgesia is therefore mandatory – not solely for patient comfort but as a cornerstone of enhanced recovery after thoracic surgery (ERATS) pathways. Contemporary ERATS guidelines advocate routine incorporation of regional analgesic techniques (thoracic epidural, paravertebral, or erector spinae plane blocks) alongside multimodal systemic analgesia to attenuate central sensitization and improve clinical outcomes. Historically, thoracic epidural analgesia (TEA) has been regarded as the gold standard. However, a metaanalysis by Davies et al. demonstrated that paravertebral block (PVB) provides analgesia equivalent to TEA while incurring fewer hypotensive episodes, technical failures, and block related complications. Notably, PVB, but not TEA,

significantly reduced postoperative pulmonary complications compared with systemic opioid regimens (3).

A single-injection PVB is safe but shows variable dermatome spread; multi-level injections provide more predictable analgesia for breast, thoracic, and upper-abdominal procedures (4,5). Despite the rise of regional techniques, morphine remains a universal postoperative adjunct owing to robust analgesic potency, widespread availability, and synergism with paracetamol or nonsteroidal antiinflammatory drugs (NSAIDs).

The primary objective of this study was to compare the efficacy of PVB versus systemic morphine for postoperative analgesia after thoracotomy. The secondary objective was to evaluate the incidence of postoperative nausea and vomiting.

MATERIALS AND METHODS

Subjects of the Study

This retrospective cohort study was conducted between January 2022 and December 2024 at a tertiary care oncology center. This study included all patients >18 years of age with an ASA physical status of I–II who underwent thoracic surgery and received either a preoperative paravertebral block (PVB) without additional regional anesthesia or systemic morphine administered approximately one hour before the end of surgery.

Patients were excluded if they had depression, cardiovascular disease, renal failure, hematologic disorders, a history of substance abuse or chronic opioid use, known drug allergies, morbid obesity (BMI >40), or pregnancy. Additional exclusions applied to patients with incomplete data or those not managed in accordance with generic standards for premedication, PVB administration, and intra- or postoperative monitoring.

We registered preoperative, perioperative, and postoperative data in the clinic's patient database. The Institutional Review Board (Ethics Committee of the Institute for Oncology and Radiology of Serbia - IORS) of our Institute approved the study (approval No. 014/2025/1664, date: May 30, 2025). We obtained written informed consent for participation and publication of anonymized data from all participants. All patients underwent a clinical assessment during the preoperative visit.

Experimental Protocols

Premedication consisted of intravenous midazolam (0.03 mg/kg) and dexamethasone (4 mg), and all patients received antibiotic prophylaxis in the preoperative preparation room. Patients included in the study underwent thoracic surgery with thoracotomy or VATS. Depending on the type of analgesia received (PVB or systemic morphine therapy), patients were divided into two groups.

In the first group, the PVB was performed 60 minutes before incision with the patient in the prone position under continuous non-invasive monitoring (ECG, non-invasive blood pressure, SpO₂). Intravenous access and full resuscitative equipment were immediately available. Using a high-frequency linear transducer, the operator identified surface landmarks by counting caudally from the C7 spinous process to the fifth and sixth thoracic transverse processes. After aseptic skin preparation, a single-injection, ultrasound-guided, in-plane technique was employed at T5, depositing 20 mL of 0.25% bupivacaine within the paravertebral space. Real-time sonography verified needle trajectory, costotransverse ligament breach (visualized as a subtle “pop”), and negative aspiration. Incremental injections (5 mL aliquots) confirmed hydrodissection and downward displacement of the pleura (“step sign”), thereby excluding intravascular placement or pneumothorax. The anticipated cranio-caudal spread encompassed 4–5 dermatomes, adequate for posterolateral thoracotomy.

The second group was treated according to the standard anesthesia procedure for thoracic surgery. These patients received morphine intravenously at a dose of 0.1 mg/kg of body weight one hour before the end of the surgery.

All patients were induced in general anesthesia using Fentanyl at a dose of 1 µg/kg, Propofol 2 mg/kg, and Rocuronium 0.8 mg/kg. Tracheal intubation used a double-lumen endotracheal tube to facilitate one-lung ventilation, managed with lung-protective parameters: tidal volume 6–8 mL/kg, PEEP 5cm H₂O, while maintaining driving pressure < 15 cm H₂O and plateau pressure < 30 cm H₂O. Maintenance employed sevoflurane in an oxygen-air mixture titrated to 1.0 MAC.

Pain Assessment and Clinical Monitoring

Pain intensity was evaluated using the Numeric Rating Scale (NRS) at 0, 3, 6, and 12 hours after surgery. At the same intervals, the presence of nausea and vomiting was recorded, as well as the requirement for rescue analgesia.

We recorded the need for rescue analgesia systematically. Patients with mild pain (NRS <3) did not receive additional treatment. For moderate pain (NRS 4–6), a

nonsteroidal anti-inflammatory drug (NSAID) was administered, while severe pain (NRS >6) was managed with a combination of an NSAID and an opioid analgesic.

Statistical Analysis

Statistical analyses included the independent samples t-test, Mann–Whitney U test, chi-square test, Friedman test, and Wilcoxon signed-rank test, as appropriate. Hypothesis testing was performed at a significance level of $\alpha = 0.05$. Numerical data with a normal distribution and no extreme values are presented as the arithmetic mean $\pm$ standard deviation. Numerical data that deviate from a normal distribution, contain extreme values, or are ordinal are presented as the median and range (minimum–maximum value). Nominal data and ordinal data with few categories are presented as n (%). All statistical analyses were conducted in accordance with the SAMPL Guidelines using IBM SPSS Statistics, version 24 (IBM Corp., Armonk, NY, USA), with exact p-values reported to the third decimal place.

RESULTS

51 patients were included: 24 received paravertebral block (PVB) and 27 received systemic morphine. **Table 1** summarizes baseline patient demographics and surgical characteristics. There were no statistically significant differences between the PVB and morphine groups regarding age (64.8 ± 8.0 vs. 61.8 ± 9.7 years, $p = 0.395$; Student's t-test), gender distribution ($p = 0.749$; Chi-square test), or surgical approach (VATS vs. thoracotomy, $p = 0.104$; Chi-square test). However, intraoperative fentanyl consumption was significantly lower in the PVB group compared to the morphine group (250.0 µg vs. 400.0 µg, $p < 0.001$; Mann-Whitney U test).

Hemodynamic parameters at induction and intraoperatively showed no statistically significant differences between the two study groups (**Table 2**). Mean arterial pressure (MAP) and heart rate (HR) were comparable both at induction and during the intraoperative period ($p > 0.05$ for all comparisons; Student's t-test). (**Table 2**).

Table 1. Patient Demographics and Surgical Characteristics

Characteristics	PVB	Morphine	P value
Number of patients in groups, n (%)	24 (47.1)	27 (52.9)	-
Sex, n (%)	Male: 7 (29.2)	Male: 9 (33.3)	0.749
	Female: 17 (70.8)	Female: 18 (66.7)	
Age, Mean (SD)	64.8 (8.0)	61.8 (9.7)	0.395
Surgery technique, n (%)	Thoracotomy: 20 (83.3)	Thoracotomy: 17 (63)	0.104
	VATS: 4 (16.7)	VATS: 10 (37)	
Fentanyl Consumption (µg)	250.0 (100.0–400.0)	400.0 (100–1450.0)	<0.001

Values are presented as mean $\pm$ SD, median (Min–Max), or n (%) as appropriate. Statistical significance was calculated using Student's t-test (age), Mann-Whitney U test (fentanyl consumption), and Chi-square test (sex and surgery technique). PVB: Paravertebral Block; VATS: Video-Assisted Thoracoscopic Surgery; SD: Standard Deviation.

Table 2. Hemodynamic Parameters at Induction and Intraoperatively

Parameter	PVB	morphine	P value
MAP induction (mmHg)	90.8 ± 14.2	92.6 ± 10.9	0.604
MAP intraoperative (mmHg)	68.4 ± 8.5	74.4 ± 12.3	0.053
HR induction (beats/min)	77.5 ± 11.7	79.6 ± 13.3	0.558
HR intraoperative (beats/min)	77.0 ± 10.3	78.3 ± 11.7	0.670

Values are presented as mean ± SD. Differences between groups were analyzed using an independent-samples Student's t-test. MAP: Mean Arterial Pressure; HR: Heart Rate; SD: Standard Deviation.

Table 3. Numeric Rating Scale at time points after surgery

NRS	Group	mean	SD	med	min	max	p-value
0h	PVB	4.5	3.5	4.5	0.0	10.0	0.022
	morphine	6.4	1.6	6.0	4.0	10.0	
3h	PVB	4.1	2.6	4.0	0.0	9.0	0.004
	morphine	6.0	1.4	6.0	4.0	9.0	
6h	PVB	4.1	2.3	3.5	0.0	8.0	0.008
	morphine	5.8	1.1	6.0	4.0	9.0	
12h	PVB	3.5	2.5	3.5	0.0	8.0	0.009
	morphine	5.1	0.9	5.0	3.0	7.0	

Values are presented as mean ± SD. Differences between groups were analyzed using an independent-samples Student's t-test. MAP: Mean Arterial Pressure; HR: Heart Rate; SD: Standard Deviation.

Table 4. Level of pain at time points after surgery

Time points	Group	Pain levels			p-value
		Mild	Moderate	Severe	
0h	PVB	11 (45.8%)	6 (25.0%)	7 (29.2%)	0.008
	morphine	0 (0.0%)	15 (55.6%)	12 (44.4%)	
3h	PVB	11 (45.8%)	9 (37.5%)	4 (16.7%)	0.001
	morphine	0 (0.0%)	18 (66.7%)	9 (33.3%)	
6h	PVB	12 (50.0%)	7 (29.2%)	5 (20.8%)	0.006
	morphine	0 (0.0%)	21 (77.8%)	6 (22.2%)	
12h	PVB	12 (50.0%)	9 (37.5%)	3 (12.5%)	0.008
	morphine	1 (3.7%)	25 (92.6%)	1 (3.7%)	

Values are presented as mean ± SD. Differences between groups were analyzed using an independent-samples Student's t-test. MAP: Mean Arterial Pressure; HR: Heart Rate; SD: Standard Deviation.

Postoperative pain intensity evaluated by the Numeric Rating Scale (NRS) was significantly lower in the PVB group across all evaluated time points (0, 3, 6, and 12) compared to the systemic morphine group ($p < 0.05$; Mann-Whitney U test) (Table 3). Categorical assessment of pain severity showed a significantly higher proportion of patients with mild pain in the PVB group, whereas moderate-to-severe pain predominated in the morphine group across all time intervals ($p < 0.05$; chi-square test) (Table 4).

Regarding secondary outcomes, the overall incidence of postoperative nausea and vomiting (PONV) was lower in the PVB group (20.8%, $n = 5$) compared to the systemic morphine group (44.4%, $n = 12$), although this difference did not reach statistical significance ($p = 0.074$; Chi-square test) (Table 5).

Table 5. Frequency of nausea and vomiting

PONV	PVB		morphine	
	n	%	n	%
No	19	79.2	15	55.6
Yes	5	20.8	12	44.4
Total	24	100.0	27	100.0

Values represent n (%). Group comparison was performed using Chi-square analysis ($p = 0.074$). PONV: Postoperative Nausea and Vomiting; PVB: Paravertebral Block.

DISCUSSION

This retrospective pilot study compared paravertebral block (PVB) with systemic morphine for postoperative analgesia in thoracic surgery.

The main findings were that PVB was associated with improved early postoperative analgesia and lower rescue analgesia requirements, together with reduced intraoperative opioid use. These results support the concept that unilateral thoracic paravertebral blockade can provide effective segmental analgesia for thoracotomy and related thoracic procedures, while limiting systemic opioid exposure.

Hemodynamic parameters were comparable between groups, and no clinically meaningful instability was observed. This is consistent with prior work suggesting that PVB can provide effective analgesia with a favorable hemodynamic profile compared with more extensive neuraxial techniques and systemic opioid-based regimens (3).

An opioid-sparing effect is clinically relevant because reducing perioperative opioid exposure may decrease opioid-related adverse effects, including respiratory depression, nausea and vomiting, pruritus, and opioid-induced hyperalgesia (3,7). Prior studies and meta-analyses have reported similar opioid-sparing benefits with PVB in thoracic surgery populations, supporting the external validity of the present findings (6,8).

Postoperative pain intensity was lower in the PVB group across the first twelve hours after surgery. This pattern is consistent with previous reports demonstrating improved pain control after thoracic surgery when PVB is used as part of multimodal analgesia (3,9). In addition, rescue analgesia requirements were reduced in the PVB group, reinforcing that the observed analgesic benefit translated into decreased need for supplemental medication.

Postoperative nausea and vomiting occurred less frequently in the PVB group, although this difference did not reach statistical significance. A directional reduction is plausible given the lower overall opioid exposure and has been reported in other thoracic surgical cohorts receiving paravertebral analgesia (10).

Several limitations of this study must be acknowledged. Given its retrospective design, some selection bias is unavoidable, as treatment allocation was based on routine clinical practice rather than prospective randomization. Second, this was a pilot study conducted on a relatively small cohort of patients, which limits the statistical power for secondary outcomes such as the incidence of PONV; thus, these secondary findings should be interpreted with caution. Finally, our cohort included patients undergoing both open thoracotomy and video-assisted thoracoscopic surgery (VATS). Although baseline distribution between groups showed no statistically significant difference,

procedural differences in tissue trauma may influence postoperative pain dynamics, warranting further investigation in larger, homogeneous prospective trials.

CONCLUSION

This pilot study suggests that paravertebral block (PVB) offers more effective postoperative analgesia than systemic morphine in patients undergoing thoracic surgery. Patients who received PVB reported lower pain scores on the Numeric Rating Scale (NRS), required less rescue analgesia, and had less frequent PONV. However, this difference was not statistically significant. While mean arterial pressure (MAP) was slightly lower in the PVB group, the difference was not statistically significant and did not appear to translate into meaningful hemodynamic compromise. Heart rate remained stable across both groups. These findings align with previous studies supporting the efficacy and safety of PVB in thoracic surgical settings. Importantly, the opioid-sparing effect of PVB may contribute to improved recovery by reducing opioid-related side effects such as PONV. Taken together, these results support the use of PVB as a valuable component of multimodal analgesia and suggest it should be considered a first-line option, particularly within enhanced recovery after surgery (ERAS) pathways (11).

Acknowledgments: N/A

Funding Information: The authors declare that the study received no funding.

Conflicts of Interest: The authors have no conflicts of interest to report.

Author Contributions: Conceptualization, A.C., B.Đ., and D.S.; Data Curation, A.J., N.J., and D.B.; Formal Analysis, A.C. and M.B.; Writing – Original Draft Preparation, A.C. and B.Đ.; Writing – Review & Editing, M.B. and D.S. All authors have read and agreed to the published version of the manuscript.

Ethical approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Institute of Oncology and Radiology of Serbia on May 30, 2025. Approval No. 014/2025/1664.

Informed Consent: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

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ANALGEZIJA SA SMANJENOM UPOTREBOM OPIOIDA U GRUDNOJ ONKOHIRURIGIJI: UTICAJ PARAVERTEBRALNOG BLOKA U SREDINAMA SA VISOKOM UPOTREBOM OPIOIDA KOD LJUDI

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Sažetak

Uvod: Ova pilot studija imala je za cilj da proceni da li torakalni paravertebralni blok (PVB) pruža bolju postoperativnu analgeziju u poređenju sa sistemskim morfinom kod pacijenata nakon torakotomije, sa fokusom na rane vrednosti intenziteta bola, potrebu za dodatnom analgezijom i pojavu postoperativne mučnine i povraćanja (PONV).

Metode: Analiziran je 51 pacijent podvrgnut torakalnoj hirurgiji; 24 pacijenta primila su ultrazvučno vođeni PVB sa bupivakainom u vidu pojedinačne injekcije pre incizije, dok je 27 pacijenata primilo intraoperativni sistemski morfin. Intenzitet bola procenjivan je numeričkom ocenom skale bola (NRS) u 0., 3., 6. i 12. satu, uz praćenje PONV-a, intraoperativne upotrebe opioida i hemodinamskih parametara.

Rezultati: Vrednosti skale bola bile su niže u PVB grupi u

svim intervalima ($p = 0.022$ u 0h, $p = 0.004$ u 3h, $p = 0.008$ u 6h, i $p = 0.009$ u 12h). Do 12. sata, 50% pacijenata u PVB grupi nije zahtevalo dodatnu analgeziju u poređenju sa 3.7% u grupi koja je primala morfin ($p = 0.008$). PONV se javljao ređe u PVB grupi (20.8% naspram 44.4%), pokazujući klinički trend, iako razlika nije dostigla statističku značajnost ($p = 0.074$). Intraoperativna potrošnja fentanila bila je značajno smanjena u PVB grupi ($p < 0.001$). Hemodinamski parametri bili su slični između grupa.

Zaključak: PVB je obezbedio efikasnije ublažavanje bola u poređenju sa sistemskim morfinom nakon torakotomije, uz smanjenu potrošnju opioida i izražen trend ka manjoj učestalosti PONV-a. Ovi nalazi podržavaju ulogu PVB-a u poboljšanju postoperativnog oporavka u torakalnoj hirurgiji.

Ključne reči: paravertebralni blok, morfin, torakotomija, postoperativni bol

Primljen: 24.05.2026. | **Revidiran:** 18.08.2026. | **Prihvaćen:** 20.08.2026. | **Online First:** 28.08.2026.

Medicinska istraživanja 2026