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RESEARCH ARTICLE

Comparison of the Efficacy between Thoracic Epidural Analgesia and Paravertebral Block in Patients Undergoing Pneumonectomy: A Retrospective Cohort Study

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ABSTRACT

Objectives: This study aimed to compare the efficacy of epidural catheter and paravertebral block methods for the management of postoperative pain in patients undergoing thoracotomy and pneumonectomy and to develop clinical routines for optimal pain control.

Methods: Hemodynamic data, arterial blood gas values, VAS scores (at ICU admission and postoperative 8, 16, and 24 h), total amount of rescue analgesics for 24 h, and mortality rates of patients undergoing pneumonectomy treated with preoperative thoracic epidural analgesia (TEA) and paravertebral block were compared.

Results: Patients' pain scores upon admission to the ICU and 8, 16, and 24 h postoperatively and the total amount of rescue analgesia administered during the study period were compared. VAS scores 8 and 16 h postoperatively were statistically similar between the groups. Additionally, postoperative ICU admission and 24-h VAS follow-up were significantly lower in the TEA group ($p<0.05$). The mean total dose (mg) of additional morphine at 24 h in PVB group was found to be statistically significantly higher than that in the TEA group ($p=0.0001$).

Conclusion: The data of 2,422 operations were analyzed, and 34 patients were included in this study. No statistically significant difference was observed between the groups in terms of mortality. In this study, we observed that postthoracotomy pain can be managed by paravertebral block with preoperative bolus bupivacaine. This study confirmed that paravertebral block is an effective method for achieving analgesia during pneumectomy, as recommended by the PROSPECT guidelines.

Keywords: Paravertebral block, pneumonectomy, thoracic epidural analgesia, thoracotomy

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Introduction

Pneumonectomy is a thoracic surgical procedure for advanced lung cancer, severe lung infections, and other life-threatening lung diseases.[1] Despite its therapeutic benefits, pneumonectomy via thoracotomy can result in severe postoperative pain, which significantly affects patient recovery and overall outcomes.[2] Effective pain management is crucial for pain reduction, facilitating early ambulation and minimizing potential postoperative complications.

Multimodal analgesia, which consists of regional anesthesia techniques, provides targeted pain relief while reducing dependence on systemic opioids and possible side effects.[3] Among these techniques, thoracic epidural catheters and paravertebral blocks (PVBs) are superior for postoperative pain management in thoracic surgery.[4] Although both regional anesthetic techniques have been shown to be effective in managing postoperative pain, a direct comparison of their efficacy in pneumonectomy with thoracotomy is limited in the literature. Optimal postoperative pain relief is important for patient comfort and recovery. The efficacy of PVB may motivate the wider use of this less-invasive method. In this retrospective study, we aimed to compare the efficacies of thoracic epidural analgesia (TEA) and PVB for the management of postoperative pain in patients undergoing

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pneumonectomy with thoracotomy and to establish and improve clinical routines for optimal pain control.

The primary objective of this retrospective study was to compare the analgesic efficacy of the TEA and PVB methods with pain scores and opioid consumption in the postoperative period. Additionally, as a secondary objective, we aimed to evaluate the effects of the two methods on intraoperative hemodynamic outcomes, adverse events, such as respiratory complications, and length of hospital stay.

Methods

Study Design and Patient Selection

This study was conducted retrospectively in the Anaesthesiology and Resuscitation Clinic of Başakşehir Çam and Sakura City Hospital with the approval of the Clinical Research Ethics Committee of Başakşehir Çam ve Sakura City Hospital (No. 2022.12.420). Adult patients who underwent thoracotomy and pneumectomy between May 2020 and November 2022 were included in the study. Patients with missing data and emergency patients were excluded (Fig. 1).

Anesthetic Management

Standard anesthetic monitoring (electrocardiography, noninvasive blood pressure monitoring, capnography, and SpO_2 monitoring) and bispectral index (BIS) monitoring (BIS™ Aspect Medical Systems, USA) were performed in all patients. A thoracic epidural catheter (T8–T9 or T9–T10) or a PVB (T5–T6 or T6–T7) was placed on the operating table according to the clinician's preference and sterilization policy. In the TEA group, the epidural space was entered from the midline using the loss-of-resistance technique, and the catheter was advanced toward the cephalic bone, leaving the needle tip 3–4 cm inside. Bolus 2-mg morphine HCl (2 mL) (morphine HCl, 0.01 gr/mL ampule, Galen Tic. AŞ, Kadıköy, İstanbul) and 0.5% bupivacaine (5 mL) (Buvasin 0. 5%, VEM İlaç San. ve Tic. A.Ş Çankaya/Ankara) mixture was administered via epidural catheters, and 0.25% bupivacaine 6-mL/h epidural infusion was started. In the PVB group, local anesthetic was administered using an in-plane needle technique in the sitting position under the guidance of a linear ultrasound transducer (Hitachi Healthcare Americas, ARIETTA 60, Twinsburg, OH). After confirming the needle tip position with 2–3 mL saline injection, a 20-mL bolus of 0.375% bupivacaine was administered. The efficacy of the block was confirmed after 20 min with a pinprick test on the dermatomes at the level of the targeted roots.

A 20G peripheral intravenous cannula and a 7.5-F central venous catheter (internal jugular vein) were placed for intravenous crystalloid hydration. After premedication with intravenous midazolam (2 mg), general anesthesia was induced with 2 mcg/kg fentanyl and 1.5–3 mg/kg propofol. Neuromuscular block was achieved with 0.6 mg/kg rocuronium. Anesthesia was maintained with a target BIS of 40–60 with sevoflurane (1%–2%) and remifentanil (0.05–0.2 mcg/kg/min) and oxygen/air mixture 2 L/min (50%/50%). After the induction of anesthesia, radial artery cannulation (20G) was performed to facilitate invasive blood pressure monitoring and repeated blood sampling.

Postoperative follow-up

Neuromuscular block was antagonized with 2–4 mg/kg sugammadex at the end of surgery. Additionally, intravenous tramadol (1 mg/kg), tenoxicam (20 mg), and paracetamol (1 g) were administered for analgesia. Tramadol (1 mg/kg) 2×1 and paracetamol (1 g) 3×1 are routinely administered intravenously for the first 48 h. The clinical cutoff VAS score was 4; that is, VAS score <4 was considered to be an acceptable level of pain. If VAS score ≥4, 0.05 mg/kg intravenous morphine was planned as rescue analgesia. All patients were transferred to the intensive care unit after surgery. Patients who were medically fit were then transferred to the ward after adequate follow-up.

Data collection

Patient data were retrieved from the hospital system and archived patient records and included demographic

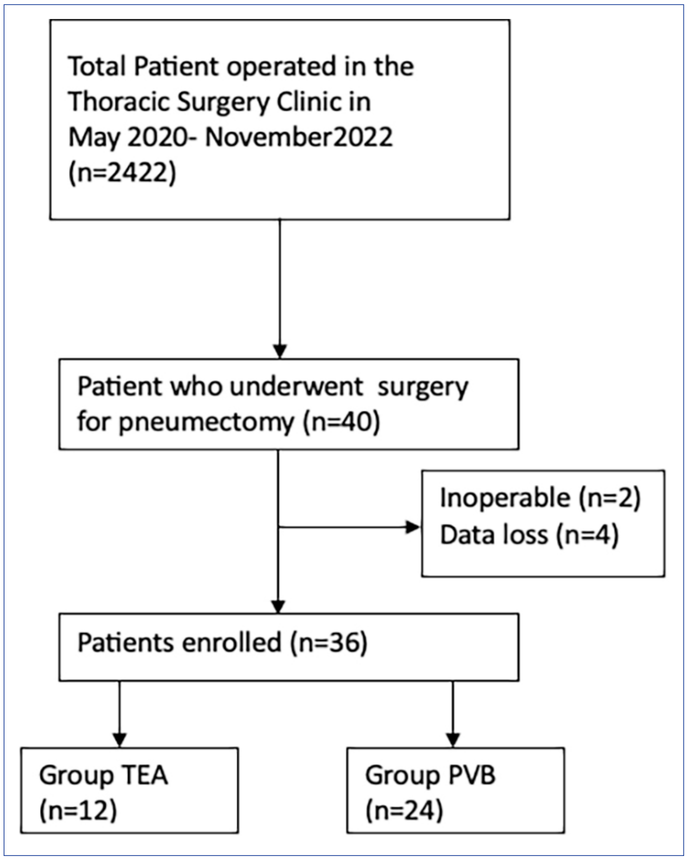

Figure 1. Flow diagram.

TEA: Thoracic epidural analgesia; PVB: Paravertebral block.

data (age, sex, and BMI), ASA score, hemodynamic data (CTA, SpO_2, $etCO_2$, and TA), perioperative data (duration of surgery, duration of anesthesia, total fluid, urine, bleeding, and TAV duration), arterial blood gas data (pH, pO_2, pCO_2, lactate and basal excretion [BE], and hemoglobin), duration of postoperative hospital and ICU stay, bleeding, TAV duration, arterial blood gas data (pH, pO_2, pCO_2, lactate and BE, and hemoglobin), duration of postoperative hospital and ICU stay, airway status in ICU (intubated or extubated), need and duration of mechanical ventilation, mortality, and VAS (ICU arrival and postoperative 8, 16, and 24 h), and the amount of additional morphine administered were recorded.

Statistical Analysis

Categorical variables are presented as numbers and percentages and compared using the chi-squared test. The distribution of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed variables are presented as mean and standard deviation and are compared using Student's t-test. Continuous variables that were not normally distributed are presented as means and 25^{th}–75^{th} percentiles, and they were compared using the Mann–Whitney U test. The paired Student's t-test and Wilcoxon test were used to compare blood gas analysis results among groups according to variable distribution. Statistical significance was set at $p<0.05$ for all statistical analyses. Statistical analyses were performed using SPSS for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA).

Results

Patient data from 2,422 surgeries performed in the Thoracic Surgery Clinic of our hospital between May 2020 and November 2022 were scanned into a digital and written database. Overall, 40 patients underwent pneumonectomy. 2 patients were considered inoperable and the operation was not completed, and 2 patients had incomplete data; therefore, 4 patients were excluded from the study. A total of 36 patients were included in the study; among them, patients were divided into two groups: 12 and 24 patients who underwent TEA (TEA group) and PVB (PVB group), respectively (Fig. 1).

When demographic data, ASA scores, and BMI data of the patients were compared, a homogeneous distribution was observed between the groups (Table 1). The duration of surgery and anesthesia was similar between the groups. No significant difference was observed between total fluid replacement and loss (Table 2).

The perioperative hemodynamic data and SpO_2 monitoring results are presented in Table 3. No clinically significant differences were observed between the groups upon data analysis. The arterial blood gas values of the patients are paresented in Table 4. Although pO_2 after intubation ($p=0.043$) and BE after TAV ($p=0.022$) were statistically different between the groups, no clinical difference was observed.

VAS scores at ICU admission and 8, 16, and 24 h postoperatively and the total amount of rescue analgesia for 24 h are presented in Table 5. VAS scores 8 and 16 h postoperatively were statistically similar between the groups. Additionally, postoperative ICU admission and VAS score at 24-h follow-up were statistically significantly low in the TEA group ($p<0.05$). Although the mean 24-h total additional morphine dose (mg) in the PVB group was statistically significantly higher than that in the TEA group ($p=0.0001$), no adverse events were reported in patients in either group.

Table 1. Characteristics of patients

	TEA group (n=12)		PVB group (n=24)		p
	n	%	n	%	
Age	59.33±11.78		59.77±6.21		0.887†
Sex					0.941+
Male	11	91.67	20	90.91	
Female	1	8.33	2	9.09	
ASA score					
2	8	66.67	7	31.82	0.111+
3	4	33.33	15	68.18	
BMI (kg/m^2)	24.9±2.42		24.51±2.59		0.674†

†: Independent t-test; +: Chi-squared test. TEA: Thoracic epidural analgesia; PVB: Paravertebral block; ASA: American Society of Anesthesiologists; BMI: Body mass index.

Table 2. Perioperative follow-up

	TEA group (n=12)	PVB group (n=24)	p
Duration of surgery (min)	197.5±48.87	167.95±60.07	0.155†
Duration of anesthesia (min)	254.17±60.11	217.27±63.43	0.109†
Total fluid replacement (mL)	1,612.5±529.2	1,272.73±517.49	0.079†
Blood loss (mL)	666.67±492.37	352.27±284.72	0.068‡
Diuresis (mL)	545.83±206.11	415.91±182.83	0.071‡

†: Independent t-test; ‡: Mann–Whitney U test

Table 3. Perioperative hemodynamic data

	TEA group (n=12)	PVB group (n=24)	p[‡]
SAB (mmHg)			
Induction	144.08±12.31	131.73±11.19	**0.006**
After intubation	128.42±14.72	120.5±13.2	0.118
After one lung ventilation	111±10.98	112.05±12.28	0.807
Postoperative	109.58±10.72	113.91±16.39	0.418
DAB (mmHg)			
Induction	85.92±10.98	79±13.25	0.133
After intubation	78.17±9.44	73.27±11.46	0.216
After one lung ventilation	67.08±5.81	70±10.07	0.365
Postoperative	68.08±8.9	72.77±10.52	0.201
Pulse rate per minute			
Induction	90.25±11.05	94.59±14.69	0.379
After intubation	85.67±5.61	88.55±6.86	0.223
After one lung ventilation	82.08±17.41	80.68±7.71	0.525
Postoperative	88.42±10.22	86.14±9.69	0.746
SpO_2			
Induction	99±1.86	98.41±2.02	0.408
After intubation	99.17±1.19	98.32±1.78	0.151
After one lung ventilation	96.25±2.56	95.68±2.42	0.526
Postoperative	97.42±2.23	97.68±1.46	**0.678**

[‡]: Mann–Whitney U test. SAB: Systolic blood pressure; DAB: Diastolic blood pressure; SpO_2: Peripheral oxygen saturation.

Table 4. Perioperative Arterial Blood Gas

	TEA group (n=12)	PVB group (n=24)	p
PO_2			
After intubation	141.32±47.01	182.5±57.84	0.043[†]
After one lung ventilation	113.47±42.98	103.53±26.43	0.408[†]
Postoperative	110.97±33.11	111.64±31.84	0.954[†]
PCO_2			
After intubation	40.26±5.87	41.22±5.25	0.628[†]
After one lung ventilation	40.7±4.77	41.32±4.51	0.708[†]
Postoperative	40.38±5.04	40.78±7.28	0.869[†]
Hemoglobin			
After intubation	11.66±1.53	11.89±1.62	0.692[†]
After one lung ventilation	10.77±1.75	11.29±1.49	0.364[†]
Postoperative	10.6±1.78	11.04±1.79	0.496[†]
Lactate			
After intubation	1.8±1.08	1.28±0.65	0.120[‡]
After one lung ventilation	1.97±0.8	1.77±0.68	0.310[‡]
Postoperative	2.03±0.81	1.87±0.68	0.678[‡]
BE			
After intubation	1.08±2.68	1.71±3.24	0.800[‡]
After one lung ventilation	2.33±2.28	0.66±1.82	0.022[‡]
Postoperative	1.02±2.12	1.78±2.28	0.188[‡]
pH			
After intubation	7.38±0.04	7.05±1.49	0.456[†]
After one lung ventilation	7.37±0.06	7.37±0.03	0.961[†]
Postoperative	7.36±0.05	7.39±0.05	0.092[†]

[†]: Independent t-test; [‡]: Mann–Whitney U test. PO_2: Partial pressure of oxygen; PCO_2: Partial carbon dioxide pressure; BE: Base excess; pH: Potential hydrogen.

When analyzing the postoperative follow-up of the patients, the type of ICU admission, need for mechanical ventilation, length of ICU and hospital stay, and discharge status data are presented in Table 6. The length of ICU stay was statistically significantly long in the TEA group (p<0.05). No statistically significant difference was observed between the distribution of the presence of mortality in the TEA and PVB groups (p=0.282). When investigating the causes of mortality, thromboembolic events and septic shock were associated with patients lost to follow-up.

Discussion

This study aimed to compare the early outcomes of TEA and PVB applications for pain management after pneumonectomy. A total of 34 patients were included in this study by analyzing data from 2,422 operations performed between May 2020 and November 2022. The homogeneous distribution of demographic characteristics, surgical procedure, duration of anesthesia, and perioperative hemodynamic data was observed between the groups. Although the groups were similar in terms of hemodynamic stability, there were significant differences in respiratory parameters and duration of anesthesia during the perioperative period.

The fact that patients in the TEA group had lower VAS scores in the postoperative period than those in the PVB group underlines the effectiveness of TEA for pain control, as expected. This may indicate a reduction in analgesic requirements and length of hospital stay. However, when the VAS scores of the PVB group were analyzed, clinically effective pain control was achieved with PVB.

Table 5. Pain follow-up

	TEA group (n=12)	PVB group (n=24)	p‡
Arrival in the ICU	2.52±0.98	3.46±1.05	**0.02**
8 h	2.38±0.81	2.92±1.12	0.085
16 h	2.38±0.74	3±1.08	0.123
24 h	1.62±0.74	2.31±0.75	**0.016**
Rescue analgesic (mg)	2.59±1.68	8.5±1.51	**0.0001**

‡: Mann–Whitney U test. ICU, intensive care unit.

It is noteworthy that patients in the TEA group had a longer ICU stay than the PVB group. In Öztürk et al.,[5] hypotension was observed in 28% of patients receiving epidural analgesia. These findings indicate that thoracic epidural administration may have affected the length of ICU stay through its effect on hemodynamics. However, more research is required in this area.

There were no significant differences in mortality between the groups. However, because of the limited sample size, this outcome requires confirmation in a larger patient population. In thoracic surgery, surgical trauma combined with volume depletion due to resection results in prolonged recovery. Additionally, anesthetic procedures can exacerbate the procedure-related lung condition. Lung injury during single-lung ventilation leads to postoperative pulmonary complications.[6] Postoperative pulmonary complications may cause an increased mortality rate and prolonged hospitalization. Kaufmann et al.[7] recommend VATS, TEA, lung protective ventilation, and targeted fluid therapy if possible to reduce PPC. Again, if we examine the ERATS protocols, it is emphasized that anesthesia should focus on airway trauma, ventilation-related lung injury, fluid management, and postoperative analgesia.[8,9]

The protective pulmonary effects of neuraxial blockade and trunk block are an area of ongoing research, but it is reasonable to speculate that epidural anesthesia may provide partial superior analgesia. This approach facilitates early postoperative mobilization and adequate volume ventilation. Epidural analgesia has been shown to reduce postoperative pulmonary complications.[10–12] Again, Sentürk et al.[13] showed that TEA is the gold standard for reducing postoperative complications in patients undergoing thoracotomy. In contrast, recent studies have shown similar analgesic results for PVB and TEA in patients undergoing thoracotomy.[5,14]

Table 6. Postoperative follow-up

	TEA group (n=12)		PVB group (n=24)		p
	n	%	n	%	
Status in the ICU					0.175+
Intubated	4	33.33	3	13.64	
Extubated	8	66.67	19	86.36	
Length of ICU stay (days)	2.42±1.44		1.77±1.57		0.033‡
Length of hospital stay (days)	13.92±10.24		16.14±14.13		0.534‡
Mechanical ventilation (days)	0.33±0.49		0.41±1.14		0.436‡
Mortality	0	0	2	9.09	0.282+

‡: Mann–Whitney U test; +: Ki Kare test.

Thoracic epidural application has significant possible side effects, such as spinal hematoma and severe hypotension caused by sympathetic blockade. Additionally, the TEA application is difficult and requires advanced skills. It has been emphasized that continuous PVB application is effective in the multimodal approach in the management of procedure-specific analgesia.[15,16] In our study, postthoracotomy pain was managed with preoperative PVB application with bolus bupivacaine. The findings of this study may help in compare the effects of thoracic epidural and PVB applications in terms of pain control and clinical outcomes after pneumonectomy. Our study shows that PVB is an effective method for analgesia in patients undergoing pneumectomy with torcotomy, in addition to being a recommended postoperative pain treatment.[17,18] However, prospective studies, including assessments of long-term effects, patient satisfaction, and cost analysis, are required.

However, this study had some limitations. Because the study was retrospective, long-term results could not be recorded. This study was conducted in a single center, and the number of cases could not be reached because pneumonectomy surgery was performed using a limited indication.

Disclosures

Ethics Committee Approval: The study was approved by The Başakşehir Çam and Sakura City Hospital Ethics Committee (no: 2022.12.420, date: 24/12/2022).

Authorship Contributions: Concept – Ö.A.; Design – Ö.A., E.M.; Supervision – Ö.A., O.S., F.G.Ö.; Materials – Ö.A., O.S., E.M.; Data collection &/or processing – Ö.A., O.S.; Analysis and/or interpretation – Ö.A., O.S., T.A.; Literature search – E.M., Ö.A.; Writing – Ö.A., O.S.; Critical review – T.A., F.G.Ö.

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