Journal of Pain Research

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Thoracic Epidural Block versus Conscious Sedation with Intercostal Nerve Block for Thermal Ablation of Lung Tumors: A Comparative Study

Chia-Ying Lin[1], Ta-Jung Chung[1], Wu-Wei Lai[2], Yau-Lin Tseng[2], Yi-Ting Yen[2,3], Yi-Sheng Liu[1], Chao-Chun Chang[2], Hung-Tsung Hsiao[4]

[1]Department of Medical Imaging, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan; [2]Division of Thoracic Surgery, Department of Surgery, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan; [3]Division of Trauma and Acute Care Surgery, Department of Surgery, National Cheng Kung University Hospital, College of Medical College, National Cheng Kung University, Tainan, Taiwan; [4]Department of Anesthesiology, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan

Correspondence: Hung-Tsung Hsiao, Department of Anesthesiology, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, No. 138, Sheng-Li Road, Tainan, 704, Taiwan, Email aneshsiao@gmail.com; Chao-Chun Chang, Division of Thoracic Surgery, Department of Surgery, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, No. 138, Sheng-Li Road, Tainan, 704, Taiwan, Email i5493149@gmail.com

Background: To evaluate the analgesic effects between thoracic epidural block (TEB) and conscious sedation with intercostal nerve block (CSINB) in patients undergoing thermal lung tumor ablation.

Methods: Medical records of patients with primary or secondary lung tumors who underwent thermal lung tumor ablation between 2011 and 2022 were reviewed. Primary outcome measures were pain intensity evaluated using the visual analog scale (VAS) and additional morphine use within 48 hours after the procedure. Secondary outcome measures were adverse events during and after surgery.

Results: Among 72 patients (median age 68, 61.1% male), 31 received CSINB and 41 received TEB. The TEB group had significantly fewer patients with VAS ≥ 5 (2.4% vs 25.8%, $p = 0.004$) and less additional morphine use (24.4% vs 77.4%, $p < 0.001$). Multivariable analysis showed that TEB reduced the risk of post-procedural pain (adjusted odds ratio [aOR], 0.04; 95% confidence interval [CI], 0.003–0.47) and additional morphine use (aOR: 0.08, 95% CI: 0.02–0.28). Hypotension occurred in 35 TEB patients and nausea in 5, both effectively managed with vasopressors and antiemetics. The incidence of fever, pneumothorax, pleural effusion, and pigtail drainage was similar between groups ($p > 0.05$).

Conclusion: TEB provides superior analgesia compared to CSINB. Although patients with reduced pulmonary function were not analyzed as a separate subgroup, the favorable analgesic outcomes and absence of respiratory depression in the TEB group—including those with prior lobectomy and limited pulmonary reserve—indicate that this technique may be appropriate for patients with compromised respiratory function.

Keywords: analgesic effect, heat-based ablation, conscious sedation, intercostal nerve block, lung tumor, opioid use, thoracic epidural block

Introduction

According to the World Health Organization, lung cancer is one of the most prevalent cancers, accounting for 2,206,771 newly diagnosed cases and 1,796,144 deaths worldwide by 2022.[1] Additionally, the lung is one of the most common sites of tumor metastasis.[2] Heat-based tumor ablation is a safe and effective minimally invasive treatment for primary and secondary lung cancers that spares the healthy parenchyma. It can be performed under local anesthesia with conscious sedation or thoracic epidural block (TEB).[3–6]

Conscious sedation is generally considered to preserve protective reflexes and respiratory function. However, in patients with compromised pulmonary reserve—such as those with prior lung surgery or underlying lung disease—it may still lead to hypoventilation or oxygen desaturation.[7]

Received: 2 January 2025
Accepted: 28 July 2025
Published: 20 August 2025

Additionally, effective pain control is clinically important following thermal lung ablation, as pain can impair ventilation, delay recovery, and increase opioid requirements. TEB provides effective analgesia without impairing respiratory drive, and may therefore be more suitable in selected patients with impaired lung function. It uses a local anesthetic that provides effective pain relief in fast-track surgery, such as thoracoabdominal surgery, and reduces postoperative ileus by avoiding intravenously administered opioid.[2,8–10] Some patients with lung tumors who undergo lobectomy experience worsening of respiratory function which is associated with pulmonary complications after thoracic surgery.[11–13] A meta-analysis showed that TEB reduces the risk of postoperative pneumonia and the need for prolonged mechanical ventilation compared with that associated with general anesthesia after thoracic and abdominal surgery.[12] Another meta-analysis found that epidural block reduced the operative time and hospital stay compared with intravenous general anesthesia in patients undergoing thoracic surgery.[14]

However, no studies to date have directly compared the analgesic efficacy and safety of TEB versus conscious sedation with intercostal nerve block (CSINB) in patients undergoing heat-based lung tumor ablation. Therefore, this retrospective study aimed to evaluate the safety and pain control outcomes associated with these two anesthetic approaches in this setting.

Materials and Methods

This retrospective study reviewed the medical records of patients who underwent heat-based lung tumor ablation between July 2011 and December 2022. Inclusion criteria were: 1) age > 20 years, 2) diagnosis of primary or secondary lung tumor, and 3) heat-based lung tumor ablation, including radiofrequency ablation and microwave ablation. Patients who underwent cold ablation were excluded. Demographic information, clinical characteristics including tumor status, tumor number, forced expiratory volume in one second (FEV1), and information during the heat-based ablation procedure were collected. The study protocol was reviewed and approved by the Institutional Review Board, and the requirement for signed informed consent was waived due to the nature of the study.

Cold ablation was excluded because the cooling of tissues and nerves during cryoablation provides an inherent anesthetic effect, making it generally less painful than heat-based techniques such as microwave or radiofrequency ablation. In our clinical experience, patients undergoing cryoablation typically require only intercostal nerve block, without the need for additional conscious sedation or TEB. Including these cases would have introduced heterogeneity in pain management strategies and confounded the comparative evaluation of anesthesia techniques.

Ethics Statement

The study protocol was reviewed and approved by the Institutional Review Board of National Cheng Kung University Hospital (Approval No. B-ER-112-288), and the requirement for signed informed consent was waived due to the retrospective nature of the study. All patient data were anonymized and de-identified prior to analysis to protect confidentiality. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and conformed to the applicable laws and local regulations.

Anesthesia

Patients were classified into two groups according to the method of anesthesia for thermal ablation, which was determined by the physician's judgement. The TEB group included patients who received thoracic epidural block, without receiving any conscious sedation; and the CSINB group included patients who received conscious sedation with intercostal nerve block. Both procedures were performed by an experienced anesthesiologist.

In the TEB group, patients were placed in the lateral decubitus position and an 18G epidural catheter (Perifix® 301 Mini Set, B. Braun Medical Inc., Allentown, PA, USA) was inserted at the thoracic segment (T4-5 for the upper lung region, or T9-10 for the lower region near the diaphragm), 0.5% bupivacaine (Marcaine®, AstraZeneca) 6–10 mL and 50 μg/mL fentanyl (Sublimaze®) 0.3–0.5 mL were injected via the catheter. To verify catheter placement, we injected a total of 5mL of diluted contrast medium, prepared by mixing iohexol (Omnipaque® 300; GE Healthcare) with normal saline in a 1:2 ratio (3 mL contrast to 6 mL saline).[15] After 45–60 minutes, 4–8 mL of 0.5% bupivacaine was administered through the epidural catheter. The epidural catheter was removed immediately after the ablation procedure; therefore, no medication was administered via the epidural catheter for postoperative pain control.

In the CSINB group, remifentanil (Ultiva®) 0.05–0.2 mcg/kg/min was infused continuously. Prior to needle insertion, 10 mL of 0.5% bupivacaine was injected into the intercostal space at the ablation site for an intercostal nerve block. Propofol 1–2.5 mg/kg was then administered and maintained at a rate of 0.05–0.2 mg/kg/min. Patients were monitored with electrocardiography, pulse oximetry, and noninvasive intermittent blood pressure monitoring. The procedures were performed under deep sedation, which is defined as a drug-induced depression of consciousness during which patients are not easily aroused but may respond purposefully following repeated or painful stimulation. In this state, spontaneous ventilation may be inadequate and airway assistance may be required, although cardiovascular function is usually maintained.

During the procedure, regardless of whether patients were in the prone or supine position, oxygen supplementation was provided via nasal cannula at a flow rate of 3–5 L/min in both groups.

CT Guided Thermal Ablation of Lung Tumors

Each ablation procedure was performed by a broad-certified radiologist (C.Y.L. or T.J.C., with 10 and 24 years of experience, respectively). The procedures were performed percutaneously under CT guidance (Optima 660; General Electric, Milwaukee, WI, USA). Prior to the procedure, patients were placed in a supine, prone, or lateral decubitus position, depending on the planned needle trajectory. Once the trajectory, ablation power, and time were selected, a straight antenna was positioned. A cool-tip probe (Covidien, Medtronic, Minneapolis, MN, USA) was used for radiofrequency ablation. The probe was connected to an RF generator and a grounding pad (placed on the patient's skin). For microwave ablation, either a 16-gauge antenna (Medwaves, San Diego, CA, USA) or a 13.5-gauge antenna (Emprint Microwave Ablation System, Medtronic, Boulder, CO, USA) was used. The choice of the ablation method was at the operator's discretion. Multiple sequential ablations were performed when tumor size, location, and geometry precluded ablation in a single session.

At the end of the procedure, a final set of CT scans was performed immediately to detect any potential complications. The patient was encouraged to lie still and breathe gently during the 4-hour recovery period. Chest radiographs were obtained 4 hours after the procedure.

In addition, baseline hemodynamic stability was assessed prior to the procedure, with continuous intra-procedural monitoring for any significant changes—such as hypotension or arrhythmias—that might require intervention. Post-procedural evaluations were also conducted to identify complications, including shock or bleeding.

Post-Ablation Pain Control

After the procedure, patients in both groups received 25 mg of oral diclofenac was administered every 6 hours for pain control, except for tramadol 37.5 mg and acetaminophen (375 mg), which were given every 12 hours to patients with chronic kidney disease. If patients still requested analgesia after the procedure, additional morphine 0.1 mg/kg was administered intravenously with an interval $\geqq$ 4 h and a daily upper limit of 0.6 mg/kg.

Outcome Measures

The primary outcome measures were pain status, evaluated by the visual analog scale (VAS) score on the same day, the first day, and the second day after procedure, as well as additional morphine use within 48 hours after the procedure. Secondary outcome measures were complications and adverse events during and after surgery. Complications included fever, pneumothorax, pleural effusion, and dural puncture (Figure 1). Adverse events included nausea, hypotension, and respiratory depression. Hypotension was defined as a decrease in systolic blood pressure of more than 25% from the patient's baseline value. Respiratory depression was defined as the need for FiO_2 support > 50%.

Statistical Analysis

All statistical analyses were performed using the SAS software package (version 9.4; SAS Institute Inc., Cary, NC, USA). Continuous data are presented as median, minimum, and maximum where appropriate. Since the data did not

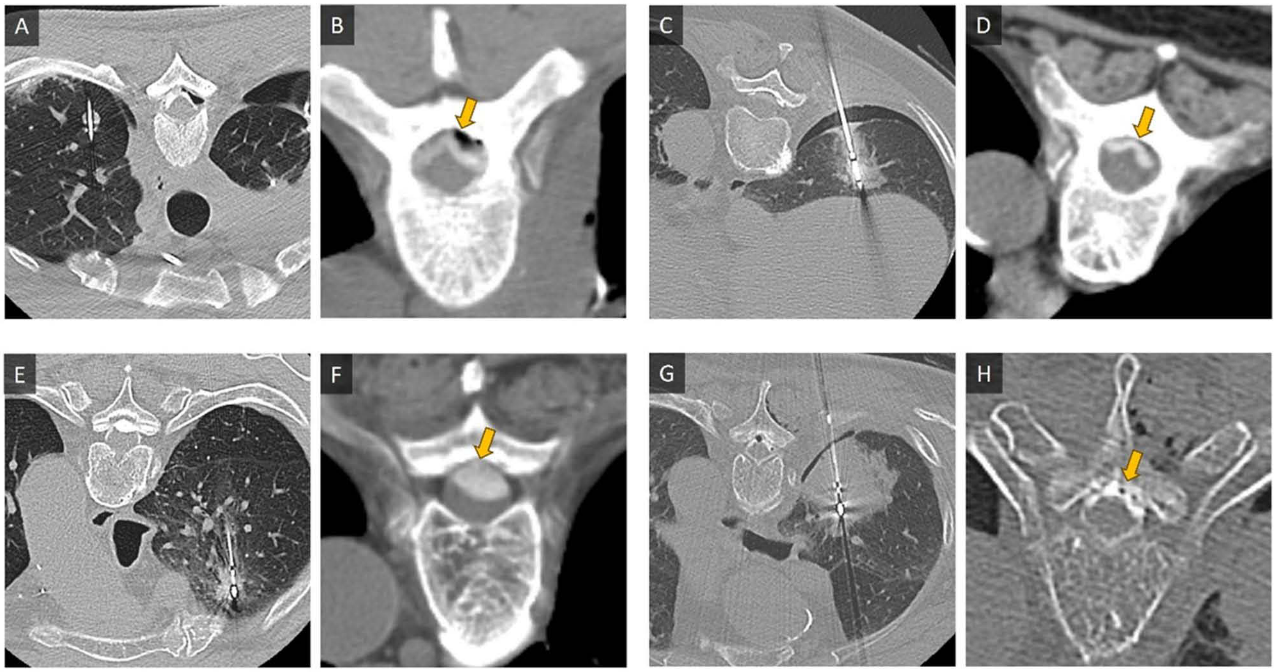

Figure 1 Representative computed tomography images of dural puncture. (**A** and **B**) Computed tomography images of a 55-year-old man who had undergone microwave ablation for left upper lobe lung metastatic tumor. (**B**) Axial imaging at T8 level showed contrast medium and air in the subdural space with inverted Mercedes-Benz sign (arrow), indicating a traumatic dural puncture. Tiny air bubbles in the epidural space was also depicted. The patient had post dural puncture headache and the symptom improved after conservative treatment. (**C** and **D**) Computed tomography images of a 72-year-old man with synchronous multifocal lung adenocarcinoma who had undergone microwave ablation for enlarged right lower lobe lung tumor. (**D**) Axial imaging at T6 level showed contrast medium in the subdural space with inverted Mercedes-Benz sign (arrow), indicating a traumatic dural puncture. The patient was asymptomatic. (**E** and **F**) Computed tomography images of a 80-year-old man who had undergone microwave ablation for right upper lobe metastatic tumor. (**F**) Axial imaging at T3 level showed contrast medium in the subdural space, indicating a traumatic dural puncture (arrow). And the spinal cord was compressed. However, the patient was asymptomatic. (**G** and **H**) Computed tomography images of a 80-year-old women with right lower lobe squamous cell carcinoma post video-assisted thoracoscopic surgery right lower lobe wedge resection who had undergone microwave ablation for right lower lobe recurrent tumor. (**H**) Axial imaging at T4 level showed contrast medium and air in the epidural space (arrow), confirming the absence of dural puncture.

normally distribute, results were analyzed using the Wilcoxon rank sum test. Categorical data are presented as counts and percentages and were analyzed using the chi-squared test or Fisher's exact test, as appropriate. Logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) for postoperative pain and opioid use. The multivariable model was adjusted for age, sex, tumor status, number, and size. VAS ≥ 5 was identified as pain needs to be relieved. Statistical significance was defined as a two-sided p value < 0.05.

Results

This study included 72 patients, with 31 in the CSINB group and 41 in the TEB group. Table 1 shows the characteristics of the patients. The median age of the patients was 68 years. The majority of the patients were male (61.6%) and had a single tumor (93.1%). The median tumor size was 2.2 cm. The groups did not differ significantly in age, sex, tumor status, tumor location, procedure time, distance from tumor to pleura, or comorbidity (Table 1).

Table 1 Patient Characteristics

Characteristics	Total	CSINB (n=31)	TEB (n=41)	p-value
Demography				
Age, years	68 (27–86)	68 (27–86)	66 (35–85)	0.357
Sex				0.136
Female	28 (38.9)	9 (29.0)	19 (46.3)	
Male	44 (61.1)	22 (71.0)	22 (53.7)	

(*Continued*)

Table 1 (Continued).

Characteristics	Total	CSINB (n=31)	TEB (n=41)	p-value
Clinical characteristics				
Tumor status				0.404
Primary early	10 (13.9)	6 (19.4)	4 (9.8)	
Primary advanced	33 (45.8)	12 (38.7)	21 (51.2)	
Secondary metastasis	29 (40.3)	13 (41.9)	16 (39.0)	
Tumor number				1.000[a]
1	67 (93.1)	29 (93.5)	38 (92.7)	
2	5 (6.9)	2 (6.5)	3 (7.3)	
Total tumor size, cm	2.2 (0.4–6.1)	2.5 (0.4–6.1)	2.2 (0.7–6.0)	0.246
FEV1< 60%				0.171[a]
No	62 (86.1)	29 (93.6)	33 (80.5)	
Yes	10 (13.9)	2 (6.5)	8 (19.5)	
Procedure time, minutes	43 (17–97)	41 (22–97)	49 (17–94)	0.300
Comorbidity				
Diabetes	15 (20.8)	7 (22.6)	8 (19.5)	0.751
Hypertension	27 (37.5)	12 (38.7)	15 (36.6)	0.854
Chronic kidney disease	9 (12.5)	4 (12.9)	5 (12.2)	1.000[a]
Coronary artery disease	12 (16.7)	5 (16.1)	7 (17.1)	0.915
Cerebrovascular accident	5 (6.9)	1 (3.2)	4 (9.8)	0.382[a]
Tumor location (each)	n= 77	n= 33	n= 44	0.178[a]
LLL	10 (13)	5 (15.2)	5 (11.4)	
LUL	26 (33.8)	9 (27.3)	17 (38.6)	
RLL	19 (24.7)	12 (36.4)	7 (15.9)	
RML	7 (9.1)	1 (3)	6 (13.6)	
RUL	15 (19.5)	6 (18.2)	9 (20.5)	
Distance to pleura, mm (each)	10 (3–18)	10 (3–18)	11.5 (3–18.5)	0.942

Notes: [a]Fisher's exact test. Continuous data are presented as median (minimum - maximum) because of data without normal distribution; categorical data are presented as n (%). Statistical significances (p-values <0.05) are shown in bold.
Abbreviations: TEB, thoracic epidural block; CSINB, conscious sedation with intercostal nerve block; FEV1, force expiratory volume in one second; LLL, left lower lobe; LUL, left upper lobe; RLL, right lower lobe; RML, right middle lobe; RUL, right upper lobe.

During the 48 hours after the procedure, a significantly higher proportion of patients in the CSINB group required additional morphine for pain relief than in the TEB group (77.4% vs 24.4%, $p < 0.001$). No statistical significance was found between the groups in the median post-procedural VAS score on days 0, 1, and 2. When the pain score was cut off at 5, a significantly higher proportion of patients with VAS ≥ 5 was found in the CSINB group than in the TEB group on day 0 (25.8% vs 2.4%, $p = 0.004$) (Table 2).

Table 2 Morphine Use and VAS Score on Day 0, 1 and 2 After Ablation

	Total (n=72)	CSINB (n=31)	TEB (n=41)	p-value
Additional morphine use, within 48 hours after ablation	34 (47.2)	24 (77.4)	10 (24.4)	**< 0.001**
VAS, continuous				
Day 0	1 (0–10)	1 (0–10)	1 (0–5)	0.267
Day 1	1 (0–9)	1 (0–9)	1 (0–8)	0.331
Day 2	0 (0–5)	0 (0–5)	0 (0–5)	0.626

(*Continued*)

Table 2 (Continued).

	Total (n=72)	CSINB (n=31)	TEB (n=41)	p-value
VAS ≥ 5				
Day 0	9 (12.5)	8 (25.8)	1 (2.4)	**0.004**[a]
Day 1	8 (11.1)	5 (16.1)	3 (7.3)	0.278[a]
Day 2	2 (2.8)	1 (3.2)	1 (2.4)	1.000[a]

Notes: [a]Fisher's exact test. Statistical significances (p-values <0.05) are shown in bold.
Abbreviations: VAS, visual analogue scale; TEB, thoracic epidural block; CSINB, conscious sedation with intercostal nerve block.

Table 3 Univariate and Multivariable Analysis of the Association Between Anesthesia Type and Pain (Baseline VAS ≥ 5) After Heat-Based Ablation

Characteristics	Univariate		Multivariable	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Group				
TEB	0.07 (0.01–0.61)	**0.016**	0.04 (0.003–0.47)	**0.011**
CSINB	Ref		Ref	
Age, years	1.02 (0.96–1.09)	0.497	0.97 (0.89–1.06)	0.543
Sex				
Female	Ref		Ref	
Male	0.77 (0.19–3.15)	0.715	0.34 (0.05–2.19)	0.254
Tumor status				
Primary early	Ref		Ref	
Primary advance	0.32 (0.06–1.78)	0.194	0.26 (0.03–2.05)	0.199
Secondary metastasis	0.17 (0.02–1.24)	0.061	0.08 (0.004–1.45)	0.087
Tumor number				
1	Ref		–	
2	NA		–	
Total tumor size	1.2 (0.73–1.96)	0.470	1 (0.55–1.81)	0.996

Notes: NA: No event occurred in a level group. Statistical significances (p-values <0.05) are shown in bold.
Abbreviations: VAS, visual analogue scale; OR, odds ratio; CI, confident interval; Ref, reference; TEB, thoracic epidural block; CSINB, conscious sedation with intercostal nerve block.

Table 3 shows the association between type of anesthesia and post-procedural pain (baseline VAS ≥ 5) after procedure in univariate and multivariable analysis. The risk of post-procedural VAS ≥ 5 was reduced by 93% in the TEB group compared to the CSINB group (OR: 0.07, 95% CI: 0.01–0.61, p = 0.016). After adjustment for related variables, the results were similar to those in the univariate model (adjusted OR [aOR], 0.04; 95% CI, 0.003–0.47; p = 0.011).

Table 4 shows the association between the type of anesthesia and post-procedural morphine use in univariate and multivariable analyses. In univariate analysis, the risk of post-procedural morphine use was reduced by 91% in the TEB group compared with the CSINB group (OR: 0.09, 95% CI: 0.03–0.28, p < 0.001), while age increased the risk of morphine use (OR: 1.05, 95% CI: 1.002–1.09, p = 0.039). After adjustment for related variables, TEB was still significantly associated with reduced risk of post-procedural morphine use (aOR: 0.08, 95% CI: 0.02–0.28, p < 0.001).

Table 5 shows the complications and adverse events during and after the procedure. The incidence of dural puncture was 8.3% and dural puncture with symptoms was 1.4% in the TEB group (Figure 1).

During the procedure, the first five patients in the TEB group reported nausea, which was relieved after administration of antiemetics, therefore antiemetics were regularly given before the procedure to prevent nausea; 35 patients had hypotension,

Table 4 Univariate and Multivariable Analysis of the Association Between Anesthesia Type and Additional Opioid Use After Heat-Based Ablation

Characteristics	Univariate		Multivariable	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Group				
TEB	0.09 (0.03–0.28)	**<0.001**	0.08 (0.02–0.28)	**<0.001**
CSINB	Ref		Ref	
Age, years	1.05 (1.002–1.09)	**0.039**	1.02 (0.96–1.08)	0.476
Sex				
Female	Ref		Ref	
Male	2.16 (0.82–5.72)	0.121	2.14 (0.59–7.77)	0.248
Tumor status				
Primary early	Ref		Ref	
Primary advance	0.46 (0.10–2.07)	0.309	0.77 (0.10–6.00)	0.804
Secondary metastasis	0.23 (0.05–1.07)	0.061	0.20 (0.02–1.94)	0.167
Tumor number				
1	Ref		Ref	
2	0.73 (0.11–4.65)	0.738	0.39 (0.02–6.13)	0.500
Total tumor size	1.36 (0.94–1.97)	0.104	1.02 (0.63–1.66)	0.936

Note: Statistical significances (p-values <0.05) are shown in bold.
Abbreviations: VAS, visual analogue scale; OR, odds ratio; CI, confident interval; Ref, reference; TEB, thoracic epidural block; CSINB, conscious sedation with intercostal nerve block.

Table 5 Complications and Adverse Events

	Total (n=72)	CSINB (n=31)	TEB (n=41)	p-value
Complication				
Fever	15 (20.8)	6 (19.4)	9 (22.0)	0.788
Pneumothorax	21 (29.2)	7 (22.6)	14 (34.1)	0.285
Pleural effusion	11 (15.3)	4 (12.9)	7 (17.1)	0.747[a]
Pigtail drainage tube insertion[b]	15 (20.8)	4 (12.9)	11 (26.8)	0.150
TEB-related complication				
Dural puncture	6 (8.3)	–	6 (8.3)	
Dural puncture with symptom	1 (1.4)	–	1 (1.4)	
Adverse events				
During surgery				
Nausea	5 (6.9)	0 (0.0)	5 (12.2)	0.066[a]
Respiratory depression	0 (0.0)	–	–	
Hypotension	35 (48.6)	0 (0.0)	35 (85.4)	**<0.001**
After surgery				
Nausea	7 (9.7)	3 (9.7)	4 (9.8)	1.000[a]
Respiratory depression	0 (0.0)	–	–	
Hypotension	0 (0.0)	–	–	

Notes: [a]Fisher's exact test. [b]Drainage tube insertion due to severe pneumothorax or pleural effusion. Statistical significances (p-values <0.05) are shown in bold. Categorical data are presented as n (%).
Abbreviations: TEB, thoracic epidural block; CSINB, conscious sedation with intercostal nerve block.

so ephedrine or norepinephrine was administered to maintain stable blood pressure. After the procedure, three patients in the TEB group and four patients in the CSINB group reported nausea (9.7% vs 9.8%). Comparable rates of complications including fever, pneumothorax, pleural effusion, and drainage tube insertion were observed in both groups.

 https://doi.org/10.2147/JPR.S515314

Discussion

The present study shows that TEB provides better pain relief than CSINB in patients undergoing thermal lung ablation. Compared with CSINB, TEB reduces the risk of post-procedural pain and morphine use. Rates of postprocedural complications were comparable between the two groups. There were no significant differences between the groups in the incidence of fever, pneumothorax, pleural effusion, or pigtail drainage tube insertion. In the TEB group, hypotension occurred in 35 patients and nausea was reported in 5 patients during the early phase of the study; both were effectively managed with vasopressors and antiemetics, respectively.

In contrast, INB is a single-shot peripheral block targeting individual nerves, with a shorter duration of effect and potentially incomplete dermatomal coverage. These factors likely contribute to the superior post-procedural pain control and reduced opioid requirement observed in the TEB group.

Significantly lower risks of additional morphine use and postprocedural VAS≧5 were observed in the TEB group compared with the CSINB group. Opioid analgesia was administered during the procedure in both groups, with direct administration through an epidural catheter resulting in a better and longer analgesic effect than intravenous administration, leading to improved pain control after the procedure. Studies have reported the safety and analgesic effects of radiofrequency ablation under TEB for hepatocellular carcinoma and lung tumors.[16,17] Choi et al[18] reported that TEB provided a more effective analgesic effect than intravenous general anesthesia in patients with primary hepatocellular tumors who undergoing radiofrequency ablation. TEB acts directly at the spinal nerve roots, providing segmental and more comprehensive analgesia.[19] It also allows for continuous titration of local anesthetics via an indwelling catheter, enabling longer and more controlled pain relief.[20] In contrast, INB is a single-shot peripheral technique with a shorter duration and potentially incomplete dermatomal coverage. This mechanistic difference may help explain the lower post-procedural pain scores and reduced opioid use observed in the TEB group.

Since that TEB does not affect respiration, it was used for ablation in patients with lower pulmonary function. In the present study, 10 patients (13.9%) had a history of lobectomy and therefore had worse pulmonary function; however, respiratory depression did not occur in any patient during or after the procedure. Meanwhile, nausea occurred in the first five patients during ablation under TEB; therefore, antiemetics were regularly administered before ablation in the TEB group afterward, and nausea was no longer reported. In our experience, many patients undergoing thoracic tumor ablation experience nausea and vomiting after starting ablation. We propose that this is caused by the parasympathetic stimulation of ablation rather than anesthesia. In the TEB group, the analgesic agent was administered from the beginning of needle insertion, and the patients experienced a pain-relief effect, but no nausea occurred at the beginning of ablation. Furthermore, hypotension is a sign of successful TEB; therefore, ephedrine or norepinephrine was administered to maintain a stable blood pressure. Although the incidence of intra-procedural adverse events, including nausea and hypotension, was higher in the TEB group compared to the CSINB group, these were effectively managed with antiemetics and vasopressors. Notably, in recent clinical practice, the concentration has been reduced from 0.5% to 0.3% while maintaining the same volume, which has significantly decreased the occurrence of hypotension without compromising anesthetic coverage. Given the favorable analgesic outcomes and manageable side effect profile, TEB may be a particularly suitable option for patients with impaired pulmonary function undergoing thermal lung tumor ablation.

The frequency of dural puncture in the present study was 15% (6/40); however, dural puncture with symptoms occurred in only one patient. This implies an underestimation of dural puncture when performing epidural block. However, this also indicates that even when images show a dural puncture, management is still focused on the patient's symptoms. Overreactions to imaging findings should be avoided.

Thermal ablation can be performed under TEB, CSINB, or inhalation general anesthesia. The reasons for choosing TEB are as follows. First, the possible negative effects of inhalation general anesthesia include 1) increased the risk of air embolism, and 2) patients with poor cardiopulmonary function may not be able to successfully remove the breathing tube after intubation and need to be transferred to the intensive care unit after surgery. Second, in our study population, even 10 minutes of conscious sedation during ablation causes a decrease in tidal volume, leading to partial atelectasis of the lung parenchyma. After partial lung collapse, the ablation area can be changed and the ablation area can be cauterized to areas other than those originally intended. Lung collapse blurs the tumor image and the ablation zone, making it difficult for the operator to determine if the expected ablation area has been achieved. In the study population, there are more patients with FEV1% < 60% since 2018 (70%, 7/10). These patients have poor lung function. They are susceptible to hypoxia during the procedure, even if they underwent conscious sedation with intravenous general anesthesia, and they may adopt the prone position during ablation. The prone position makes it difficult to protect the airway and to perform emergency ambu-bagging to maintain blood oxygen, which may increase the risk during anesthesia. Therefore, since 2018, TEB has almost become the first choice for ablation. However, the placement of an epidural catheter has higher technical requirements for the anesthesiologists. If the anesthesiologist cannot place an epidural catheter effectively, we performed thermal ablation under CSINB.

Limitations

This study had several limitations. First, this was a single-center study with a limited sample size; therefore, selection bias could not be excluded. Second, this study had inherent limitations owing to its retrospective nature. Third, CSINB was primarily used before 2018, whereas TEB was used from 2018 because 70% (7/10) of patients with FEV1< 60% were admitted from 2018. Whether the accumulated experience in lung tumor ablation leads to better pain control remains unknown. Another limitation of our study is the lack of stratification based on body mass index (BMI) or history of obstructive sleep apnea, which may influence opioid sensitivity and the risk of respiratory depression during conscious sedation. Although no patients had a known diagnosis of sleep apnea, the possibility of undiagnosed cases cannot be excluded, particularly in obese individuals. Future studies should consider BMI and sleep apnea risk in the anesthesia decision-making process.

Conclusions

Thermal ablation of lung tumors performed under TEB provides superior pain control and is associated with reduced morphine requirements compared to CSINB. Although our study did not specifically evaluate a defined subgroup of patients with impaired pulmonary function, the absence of respiratory depression in the TEB group—which included patients with prior lobectomy and presumed reduced pulmonary reserve—suggests potential applicability in this population. However, adverse events such as hypotension and incidental dural puncture were observed, underscoring the importance of careful patient selection and experienced anesthetic management. Further prospective studies are warranted to confirm the safety and efficacy of this approach in patients with compromised respiratory function.

Data Sharing Statement

The datasets analysed during the current study are available from the corresponding author (Chao-Chun Chang) on reasonable request.

Ethics Approval and Informed Consent

The study protocol was reviewed and approved by the Institutional Review Board of National Cheng Kung University Hospital, and the requirement for signed informed consent was waived due to the nature of the study. All patient data were anonymized and de-identified prior to analysis to protect confidentiality. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and conformed to the applicable laws and local regulations.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the National Cheng Kung University Hospital of Taiwan (NCKUH-11403001 and NCKUH-11403003) and the Ministry of Science and Technology of Taiwan (MOST 113-2314-B-006-064 and MOST 113-2314-B-006-078-MY2).

Disclosure

The authors have declared that no competing interests exist for this work.

References

1. Ferlay J, Ervik M, Lam F, et al. *Global Cancer Observatory: Cancer Today*. Lyon: International Agency for Research on Cancer; 2020.
2. Herold CJ, Bankier AA, Fleischmann D. Lung metastases. *Eur Radiol*. 1996;6(5):596–606. doi:10.1007/BF00187656
3. Baisi A, De Simone M, Raveglia F, Cioffi U. Thermal ablation in the treatment of lung cancer: present and future. *Eur J Cardiothorac Surg*. 2013;43(4):683–686. doi:10.1093/ejcts/ezs558
4. Lin M, Eiken P, Blackmon S. Image guided thermal ablation in lung cancer treatment. *J Thorac Dis*. 2020;12(11):7039–7047. doi:10.21037/jtd-2019-cptn-08
5. Murphy MC, Wrobel MM, Fisher DA, Cahalane AM, Fintelmann FJ. Update on image-guided thermal lung ablation: society guidelines, therapeutic alternatives, and postablation imaging findings. *AJR Am J Roentgenol*. 2022;219(3):471–485. doi:10.2214/AJR.21.27099
6. Prud'homme C, Deschamps F, Moulin B, et al. Image-guided lung metastasis ablation: a literature review. *Int J Hyperthermia*. 2019;36(2):37–45. doi:10.1080/02656736.2019.1647358
7. Benzoni T, Agarwal A, Cascella M. Procedural Sedation. In *StatPearls*. Treasure Island (FL):StatPearls Publishing; 2025. https://www.ncbi.nlm.nih.gov/books/NBK551685/.
8. Clemente A, Carli F. The physiological effects of thoracic epidural anesthesia and analgesia on the cardiovascular, respiratory and gastrointestinal systems. *Minerva Anestesiol*. 2008;74(10):549–563.
9. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. *Ann Surg*. 2008;248(2):189–198. doi:10.1097/SLA.0b013e31817f2c1a
10. Manion SC, Brennan TJ, Riou B. Thoracic epidural analgesia and acute pain management. *Anesthesiology*. 2011;115(1):181–188. doi:10.1097/ALN.0b013e318220847c
11. Dales RE, Dionne G, Leech JA, Lunau M, Schweitzer I. Preoperative prediction of pulmonary complications following thoracic surgery. *Chest*. 1993;104(1):155–159. doi:10.1378/chest.104.1.155
12. Sekine Y, Behnia M, Fujisawa T. Impact of COPD on pulmonary complications and on long-term survival of patients undergoing surgery for NSCLC. *Lung Cancer*. 2002;37(1):95–101. doi:10.1016/S0169-5002(02)00014-4
13. Sudheshna KD, Gopinath R, Ayya SS, Kar P, Kumar RV. High vs mid thoracic epidural analgesia - A comparative study on the ease of insertion and effects on pain, hemodynamics, and oxygenation in patients undergoing thoracotomies. *Ann Card Anaesth*. 2019;22(4):383–387. doi:10.4103/aca.ACA_169_18
14. Pöpping DM, Elia N, Marret E, Remy C, Tramèr MR. Protective effects of epidural analgesia on pulmonary complications after abdominal and thoracic surgery: a meta-analysis. *Arch Surg*. 2008;143(10):990–999. doi:10.1001/archsurg.143.10.990
15. Kranz PG, Abbott M, Abbott D, Hoang JK. Optimal contrast concentration for CT-guided epidural steroid injections. *AJNR Am J Neuroradiol*. 2014;35(1):191–195. doi:10.3174/ajnr.A3626
16. Ke JD, Hou HJ, Wang M, Zhang YJ. The comparison of anesthesia effect of lung surgery through video-assisted thoracic surgery: a meta-analysis. *J Cancer Res Ther*. 2015;11(11 Suppl):C265–270. doi:10.4103/0973-1482.170534
17. Pouliquen C, Kabbani Y, Saignac P, Gékière JP, Palussière J. Radiofrequency ablation of lung tumours with the patient under thoracic epidural anaesthesia. *Cardiovasc Intervent Radiol*. 2011;34(Suppl 2):S178–181. doi:10.1007/s00270-010-9843-9
18. Choi EJ, Choi YM, Kim HJ, et al. The effects of thoracic epidural analgesia during percutaneous radiofrequency ablation for hepatocellular carcinoma. *Pain Res Manag*. 2018;2018(4354912):1–6. doi:10.1155/2018/4354912
19. Liu Y, Wang C, Ye Z, et al. Effects of epidural anesthesia and analgesia on the incidence of chronic pain after thoracoscopic lung surgery: a retrospective cohort study. *Heliyon*. 2024;10(15):e35436. doi:10.1016/j.heliyon.2024.e35436
20. Avila Hernandez AN, Hendrix JM. Epidural Anesthesia. In *StatPearls*. Treasure Island (FL):StatPearls Publishing; 2025. https://www.ncbi.nlm.nih.gov/books/NBK542219/.