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RESEARCH

Thoracoscopy-guided thoracic paravertebral block using dexmedetomidine in combination with ropivacaine for postoperative analgesia after thoracoscopic radical resection of lung cancer: a randomized controlled trial

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Abstract

Purpose The aim of this trial was to evaluate the analgesic effect of dexmedetomidine combined with ropivacaine for thoracoscopic-guided thoracic paravertebral block (TTPB) after thoracoscopic radical resection (TRR) of lung cancer.

Methods A total of 60 patients were enrolled from our hospital who underwent elective TRR of lung cancer and randomized into either a control group (group C) or a dexmedetomidine group (group D). Prior to incisional suturing, group C received ropivacaine alone for TTPB, while group D received dexmedetomidine combined with ropivacaine for TTPB. The primary outcome was the time to the first analgesic request (TFAR). The secondary outcomes included heart rate (HR), mean arterial pressure (MAP), Ramsay sedation score, and Numerical Rating Scale (NRS) scores (both at rest and during coughing) at the following time points: before the TTPB operation (T0), 1 h postoperatively (T1), 2 h postoperatively (T2), 6 h postoperatively (T3), 12 h postoperatively (T4), 24 h postoperatively (T5), as well as 48 h postoperatively (T6). Additional secondary outcomes included the patient-controlled intravenous analgesia (PCIA) sufentanil dosage at 48 h postoperatively, the incidence of adverse reactions, and postoperative recovery.

Results Compared to group C, group D showed a longer TFAR, lower total PCIA sufentanil dosage at 48 h postoperatively, and lower NRS scores at all time points; Group D also had lower MAP and HR, higher Ramsay sedation scores from T1 to T3 after surgery, a higher incidence of drowsiness, and better postoperative recovery.

Conclusions As an adjuvant in combination with ropivacaine, dexmedetomidine enhanced the analgesic effect of TTPB, prolonged the duration of analgesia, and reduced the time to first ambulation and hospital stay.

Clinical Trial Registration ChiCTR2400086347, Registered 28/06/2024.

Keywords Dexmedetomidine · Paravertebral Block · Postoperative Analgesia · Ropivacaine · Thoracoscopy

Introduction

The high incidence and mortality rates of lung cancer have become major concerns in the medical field due to their significant impact on the overall health and well-being of individuals (Zheng et al. 2024). For early to mid-stage thoracic tumors, surgical intervention is the preferred treatment Jedlicka (2021). Compared to traditional open thoracic surgery, minimally invasive thoracoscopic surgery offers several advantages, including reduced trauma, faster recovery, and a lower incidence of complications (Matthew et al. 2017; Smita et al. 2015). However, postoperative incision pain and chest drain irritation remain significant sources of stress (Dan and Xi 2024; Marzia et al. 2018), leading to postoperative anxiety related to coughing, sputum evacuation, and early activities. These factors may increase the incidence of postoperative complications, prolong hospitalization, and negatively the surgical outcomes and postoperative recovery, while also increasing the economic

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burden on patients (Kyle and Keleigh 2020; Xiaoyun et al. 2023). Therefore, identifying effective methods to enhance postoperative analgesia and promote recovery in patients undergoing TRR of lung cancer is crucial.

For patients undergoing thoracic surgery, thoracic paravertebral nerve block is a common approach of postoperative analgesia (Anindya et al. 2018; Jianghui et al. 2017), significantly reducing pain from surgical incisions. Thoracoscopic-guided thoracic paravertebral block (TTPB) is a novel, convenient, safe, and efficient method. Compared to ultrasound-guided thoracic paravertebral nerve block, TTPB has been shown to have a higher success rate and more precise blocking effects (Lihong et al. 2021a, b). Before suturing the surgical incision, local anesthetics are injected into the paraspinal area of the surgical vertebra under direct visualization via thoracoscopy. The anesthetics can be observed to diffuse effectively in the paravertebral interspace, spanning 2–4 vertebral segments around the site of injection (Lihong et al. 2021a, b). TTPB is a simple and effective procedure that alleviates postoperative pain in thoracic surgeries, including thoracoscopic minimally invasive radical surgery for lung cancer. It also minimizes adverse reactions (ARs) and facilitates postoperative recovery.

At present, clinical thoracic paravertebral block often uses the long-lasting local anesthetic agent ropivacaine to achieve the extended analgesic effect. However, the analgesic effect typically lasts for only approximately six hours (Nagalingeswaran et al. 2021), which is insufficient for postoperative analgesia in thoracic surgery. Dexmedetomidine has been shown to enhance the analgesic effect of ropivacaine, prolonging the duration of the block (Fangzhou et al. 2023). To date, no studies have assessed the efficacy of combining dexmedetomidine with ropivacaine for TTPB in the context of postoperative analgesia for TRR of lung cancer. The objective of this trial was to investigate whether combining dexmedetomidine and ropivacaine in TTPB can improve analgesic effectiveness, extend the duration of analgesia, reduce the need for intravenous opioid analgesics, minimize ARs, and promote postoperative recovery, thereby achieving the optimal block effect with the fewest ARs, facilitating better postoperative recovery.

Methods

Ethics

This trial was reviewed and approved by our Ethics Committee (Ethics Approval No. KY2023SL340-01) and registered with the China Clinical Trial Registry under the number ChiCTR2400086347. A total of 60 patients undergoing TRR of lung cancer were enrolled, and all patients provided written informed consent prior to inclusion.

Inclusion and exclusion criteria

Patients between the ages of 20 and 70 years, with a BMI ranging from 18 to 32 kg/m^2, and classified under an American Society of Anesthesiologists (ASA) grade of I/II were included in this study.

Exclusion criteria were as follows: (1) Individuals with coagulation dysfunction; (2) Individuals with a history of spinal deformities, fractures, injuries, or surgeries; (3) Individuals who convert to thoracotomy during surgery; (4) Individuals with severe thoracic adhesions; and (5) Patients who were transferred to ICU postoperatively.

Randomization and blinding

Patients were allocated to the respective groups in a randomized manner using computer-generated randomization software. Group assignment information was placed in opaque envelopes. Each envelope contained the information necessary for determining the patient's group assignment. Group C received ropivacaine alone for TTPB, while group D received a combination of dexmedetomidine and ropivacaine for TTPB. The drugs for TTPB were prepared by non-blinded nurses according to group allocation. Both the participants and the researchers, including those involved in patient management and data collection, anesthesiology, and thoracic surgery, were unaware of the group allocation.

Monitoring and surgical procedures

Upon admission to the operating room, routine monitoring procedures for the patients were initiated, including pulse oximetry (SpO_2), electrocardiogram, non-invasive blood pressure measurement, end-tidal carbon dioxide partial pressure ($P_{ET}CO_2$) measurement, and bispectral index (BIS) monitoring. Under local anesthesia, internal jugular vein and radial artery punctures were performed for pressure measurement. Anesthesia was induced using rapid total intravenous induction with midazolam at a dose of 0.05 mg/kg, propofol at 2.0 mg/kg, sufentanil at 0.5 μg/kg, alongside rocuronium at 0.8 mg/kg. Proper positioning was confirmed using a fiberoptic bronchoscope, and intermittent positive pressure ventilation was initiated following oral double-lumen endotracheal intubation. The tidal volume was set at 8 ml/kg for bilateral lung ventilation and 6 ml/kg for unilateral lung ventilation, while the respiratory rate was kept within the range of 10 to 14 breaths/min. Throughout the surgery, $P_{ET}CO_2$ was maintained between 35 and 40 mmHg. During the maintenance of anesthesia, a propofol

infusion was administered at 6–8 mg/(kg·h), alongside a remifentanil infusion at a dosage of 0.1–0.3 μg/(kg·min). Additionally, rocuronium was given as a single intravenous dose at a dosage of 0.2 mg/kg every 0.5 h. Adjustments to anesthetic dosages were made intraoperatively to stabilize the BIS value between 40 and 60, ensuring adequate anesthesia depth.

The surgical procedure involved a two-port thoracoscopic lobectomy. The incisions were made at the seventh intercostal space along the mid-axillary line and at the fourth intercostal space between the mid-clavicular line and the anterior axillary line. After the malignancy was confirmed by intraoperative pathology, radical lung cancer surgery was performed. A 26-size thoracic drainage tube was positioned prior to the closure of the incisions.

Before closing the thoracic incision, thoracoscopic guidance was used to inject a No. 5 needle with an extension tube at the thoracic paravertebral block site. The needle was positioned 1 cm to the left of the T5-T6 vertebral interspace and advanced vertically to a depth of 0.5 cm below the parietal pleura. Aspiration was performed to ensure no blood or cerebrospinal fluid was aspirated. Group C received a paravertebral injection of 0.375% ropivacaine solution (20 ml), while group D received a paravertebral injection of a mixture of 0.375% ropivacaine and 1.0 μg/kg dexmedetomidine (20 ml). Following a 5-min observation period for no bleeding or hematoma formation. The operation process is shown in Fig. 1. After the surgical procedure, patient-controlled intravenous analgesia (PCIA) was initiated. The analgesic pump was prepared with a solution comprising diluted sufentanil (1.5 μg/kg) and tropisetron (5.0 mg) in 100 ml of 0.9% saline. Specifically, the pump settings were as follows: a loading dose of 2 ml, a background dose of 1 ml/h, an additional PCIA dose of 1 ml, as well as a lockout time of 15 min. Pain status of patients was assessed using the Numeric Rating Scale (NRS).

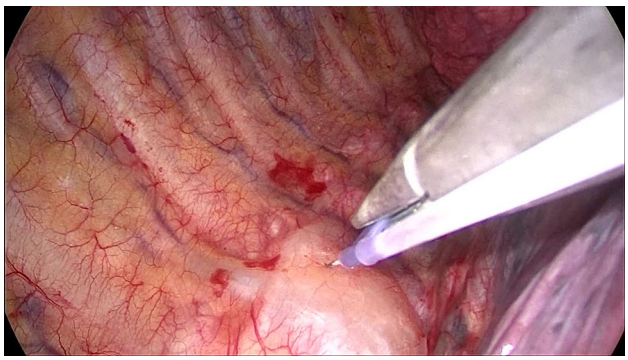

Fig. 1 The TTPB is located in the fifth and sixth thoracic paravertebral spaces. The white raised area indicates the spread of local anaesthetic in the paravertebral space

When the NRS score reached ≥ 4, additional analgesia was administered in the form of 50 mg of flurbiprofen axetil.

Data collection

The primary outcome was the time to the first analgesic request (TFAR). The secondary outcomes measured in this trial included the PCIA sufentanil dosage at 48 h postoperatively, mean arterial pressure (MAP), heart rate (HR) at time points including before the TTPB operation (T0), 1 h postoperatively (T1), 2 h postoperatively (T2), 6 h postoperatively (T3), 12 h postoperatively (T4), 24 h postoperatively (T5), as well as 48 h postoperatively (T6), NRS score (both at rest and during coughing), as well as Ramsay sedation score at each time point from T1 to T6. Additionally, the occurrence of postoperative adverse reactions (ARs) was monitored. Hypotension, referring to a decrease in systolic blood pressure of 30% from baseline or below 80 mmHg, was administered with an intravenous injection of 6 mg ephedrine. Bradycardia, defined as a HR < 55 beats/min, was treated with an intravenous injection of 0.5 mg atropine. Other postoperative recovery secondary outcomes included the time to first ambulation, the interval until chest drain removal, and the length of postoperative hospital stay.

Sample size and statistical analysis

Based on previous studies by Wang et al. (2021) and Sayed Kaoud et al. (2019), the trial was designed with a sample size of 60 patients, randomized into two groups, each consisting of 30 patients. All data were analyzed using SPSS version 26.0 statistical software. For normally distributed quantitative data, results were presented as mean ± standard deviation (SD) and analyzed using the Student's *t*-test. For variables with skewed distributions, data were described using medians and interquartile ranges. Besides, comparisons of these data were performed based on the Mann–Whitney *U*-test. Categorical variables were presented in terms of frequencies and percentages, and analyzed using either the chi-square test or Fisher's exact test, depending on the data distribution. A *p*-value of less than 0.05 was considered to indicate statistical significance.

Results

Sixty patients were enrolled into the trial and randomized to group C or group D. All patients successfully completed both the monitoring and surgical procedures, as shown in the flowchart in Fig. 2. No significant differences were observed in the baseline characteristics or surgical parameters between the two groups ($P > 0.05$, Table 1).

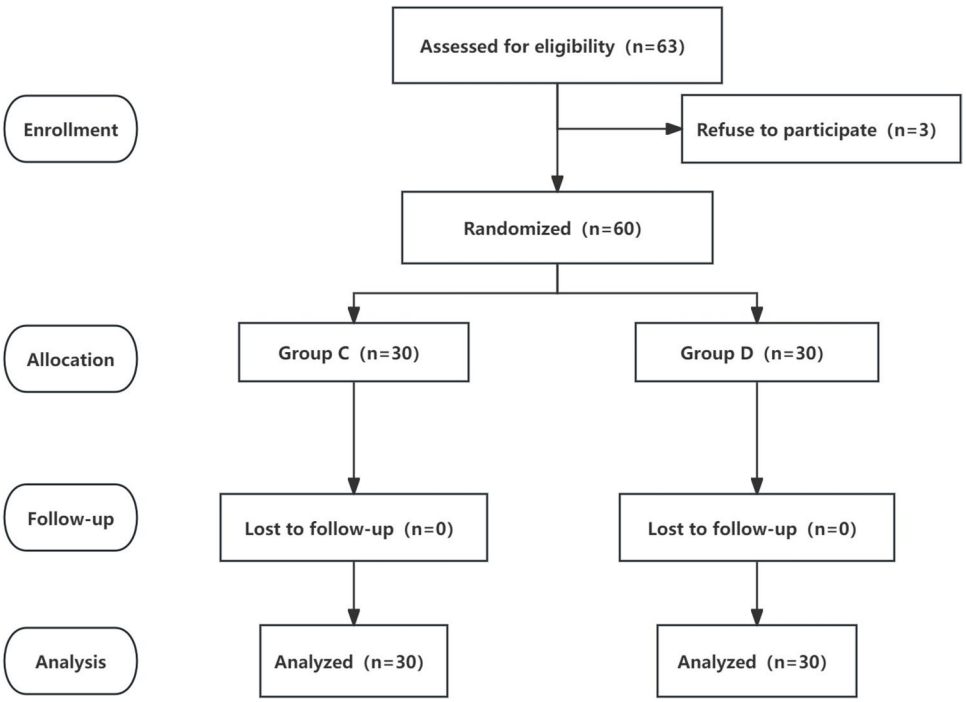

Fig. 2 Flow chart of this study

Table 1 Characteristics of the patients and surgery

Items	C group (n = 30)	D group (n = 30)	*P* value
Age (years) M (P_{25}, P_{75})	60.0 (51.3,65.3)	60.0 (52.0,65.3)	0.935
Gender (Female/Male)	12/18	14/16	0.602
ASA (I/II)	9/21	8/22	0.774
BMI (kg/m^2)	22.4 ± 2.5	23.2 ± 2.8	0.284
Operating time (min)	122.7 ± 10.3	124.4 ± 11.7	0.553
Anesthesia time (min)	162.6 ± 8.4	160.2 ± 9.6	0.294

Primary outcome

TFAR was longer in group D in contrast with group C with statistical significance (22.6 ± 2.7 vs. 6.0 ± 1.2, $t = -31.046$, $P < 0.001$, Table 2).

Secondary outcomes

In contrast with group C, group D required a lower PCIA sufentanil dosage at 48 h postoperatively (51.4 ± 3.6 vs. 67.3 ± 7.4, $t = 10.580$, $P < 0.001$, Table 2), and showed lower MAP and HR from T1 to T3 following surgery ($P < 0.05$), as shown in Fig. 3. Group D also had lower NRS scores (both at rest and during coughing) at various time points from T1 to T6 after surgery ($P < 0.05$), as shown in Fig. 4, and higher Ramsay sedation scores from T1 to T3 following surgery ($P < 0.05$), as shown in Fig. 5. Additionally, group D had a shorter time to first ambulation and postoperative hospital stay ($P < 0.05$) (Table 2) and a higher incidence of postoperative drowsiness ($P < 0.05$). Other postoperative ARs were not significantly different (Table 3).

Table 2 Comparison of analgesic effects and postoperative recovery status between two groups

Items	C group (n = 30)	D group (n = 30)	*P* value
First analgesic request time (h)	6.0 ± 1.2	22.6 ± 2.7	< 0.001
48 h postoperative sufentanil dosage (μg)	67.3 ± 7.4	51.4 ± 3.6	< 0.001
First ambulation time (h)	9.2 ± 1.1	8.6 ± 0.8	0.017
Chest tube removal time (d)	3.8 ± 0.8	3.6 ± 0.9	0.343
Postoperative hospital stay time (d)	6.1 ± 0.8	5.6 ± 0.8	0.009

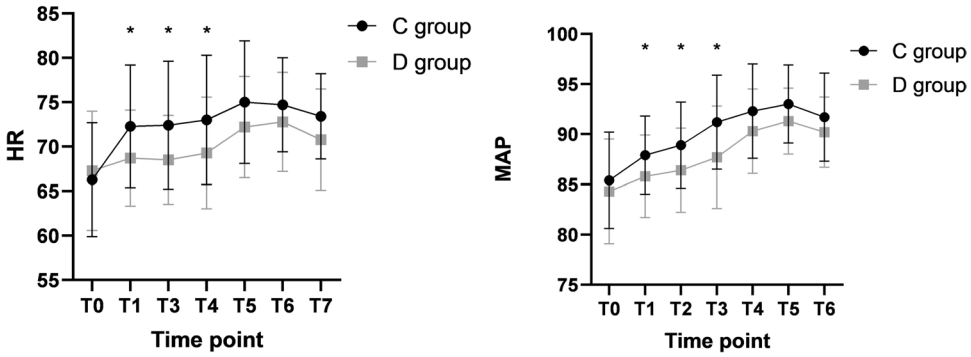

Fig. 3 Comparison of MAP and HR between two groups. Note: *Comparison between two groups, $P < 0.05$

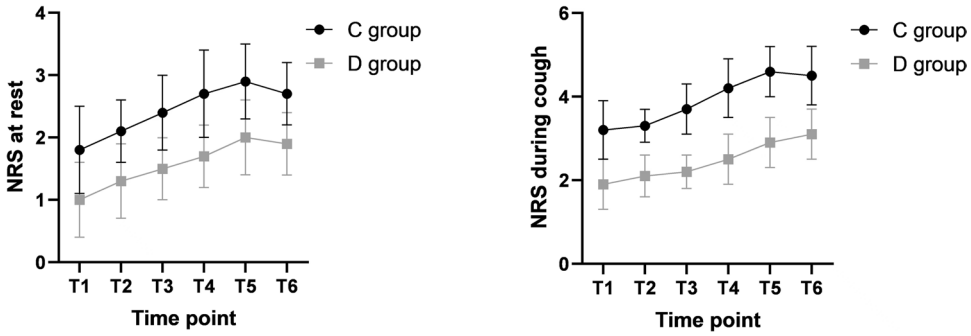

Fig. 4 Comparison of NRS scores between two groups

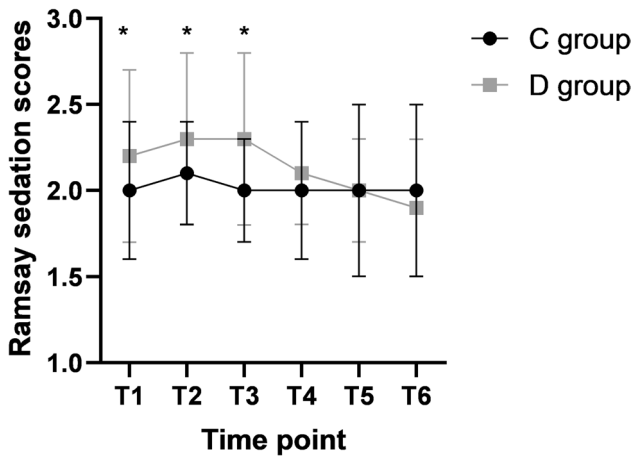

Fig. 5 Comparison of sedation scores between two groups. Note: *Comparison between two groups, $P < 0.05$

Table 3 Comparison of incidence of postoperative adverse reactions

Items	C group (n = 30)	D group (n = 30)	*P* value
drowsiness	2	9	0.042
Nausea	4	3	1.000
Vomiting	3	2	1.000
Hypotension	1	2	1.000
Bradycardia	1	3	1.000

Discussion

Clinical practice mainly relies on systemic intravenous analgesia (PCIA) with opioid-based analgesics, whose prolonged use can lead to ARs such as nausea, vomiting, and respiratory depression (Julio et al. 2022). To achieve effective analgesia while reducing the use of opioid analgesics and promoting early recovery, it is now generally recommended to use a multimodal analgesic protocol combining PCIA and regional nerve block techniques (Medha et al. 2015). TTPB is a highly effective method of analgesia in thoracic surgery. TTPB involves the administration of local anesthetics into the thoracic paravertebral space, which includes the intercostal nerves, posterior branches, communicating branches, and sympathetic nerve trunks. This technique effectively blocks ipsilateral sensory, motor, and sympathetic nerves (Pawa et al. 2019). Prior research has shown that TTPB provides an analgesic effect comparable to thoracic epidural analgesia while maintaining high hemodynamic stability. Compared to percutaneous ultrasound-guided thoracic paravertebral block, TTPB has been shown to enhance the efficacy of analgesia and reduce the incidence of puncture-related bleeding (Xia et al. 2024). There have been no reports on the use of dexmedetomidine and ropivacaine in combination with TTPB for postoperative analgesia in thoracic surgery.

In this trial, compared with group C, group D showed a longer TFAR. The research results indicate that the combination of dexmedetomidine and ropivacaine can prolong the analgesic time of TTPB. Since both dexmedetomidine and ropivacaine have analgesic effects, their combination can produce a synergistic effect, significantly enhancing pain relief and prolong analgesic time (Indu Mohini et al. 2021; Jing et al. 2022). Dexmedetomidine inhibits neuronal excitability, slows nerve conduction velocity, and prolongs the action of ropivacaine around nerves. Additionally, the vasoconstrictive properties of ropivacaine help reduce drug absorption and metabolism, further prolonging pain relief (Jianghui et al. 2017; Rong et al. 2022). Research has found that in peripheral nerve or plexus block trials, dexmedetomidine significantly prolonged sensory nerve block time, which aligned with the findings of the present trial (Mahzad et al. 2022).

Compared with group C, group D reduced sufentanil usage in PCIA 48 h post-surgery, this result indicates that the combination of dexmedetomidine and ropivacaine can enhance the analgesic effect and prolong the analgesic time of TTPB, reduce the use of postoperative opioids, and provide better postoperative analgesia. The findings of this trial demonstrated that at time points T1–T6, compared to group C, group D showed a lower NRS scores. The duration of analgesia of ropivacaine is approximately 6 h. Compared to group C, group D showed a lower NRS scores at time points T1, T2, and T3, this result indicates that the combination of dexmedetomidine and ropivacaine can enhance the analgesic effect. Compared to group C, group D showed a lower NRS scores at time points T4, T5, and T6, this result indicates that the combination of dexmedetomidine and ropivacaine can prolong the analgesic time. The findings of this trial demonstrated that at time points T1, T2, and T3, compared to group C, group D showed a higher Ramsay sedation score and lower HR and MAP. This can be attributed to the anxiolytic and sedative effects of dexmedetomidine, which reduce patient tension and improve the Ramsay sedation score (Killian et al. 2024). Dexmedetomidine can reduce sympathetic excitation and improves hemodynamic stability in patients (Zheping et al. 2023). The combination of dexmedetomidine and ropivacaine can enhance the analgesic effect of TTPB, thereby reducing the increase in HR and MAP caused by pain, stabilizing hemodynamics, and improving patient comfort and safety (Baoli et al. 2022). The above results also indicate that the combination of dexmedetomidine and ropivacaine for TTPB is safe. However, due to the enhanced sedative and analgesic effects, the incidence of postoperative drowsiness in group D was higher when compared to group C. Furthermore, we observed no obvious differences in the incidence of other ARs.

In contrast with group C, group D had shorter first ambulation time as well as postoperative hospital stay. This is because effective postoperative analgesia promotes early activity, early diaphragm movement, coughing, and sputum excretion, thereby reducing the occurrence of lung function impairment and lung infection (Xiaoyun et al. 2023), which facilitates postoperative recovery, reduces postoperative complications, and shortens hospitalization (Dong-Jian et al. 2016).

There were certain limitations to our trial. Firstly, different doses of dexmedetomidine in combination with ropivacaine for TTPB could be investigated in future to select the optimal analgesic dose. Secondly, in this study, TTPB was performed at only one segment. However, the analgesic effect of simultaneously blocking multiple segments was not assessed, highlighting the need for further in-depth research. Thirdly, we did not observe the effect of performing TTPB with dexmedetomidine alone for comparison. Fourth, we didn't observe the occurrence of postoperative pulmonary complications. Finally, the relatively small sample size of this trial might impact the precision of the reported incidence of postoperative ARs.

Conclusions

Dexmedetomidine combined with ropivacaine for TTPB enhanced the analgesic effects and prolonged pain relief after TRR of lung cancer. TTPB is simple to operate, with obvious analgesic effect and high practicality in clinical work. This new combination of nerve block and medication has shorted hospitalization time and accelerated postoperative recovery of patients.

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Author contributions Kewei Wu and Lihong Hu designed the study and submitted the manuscript. Shuyu Deng and Xufeng Zhang collected and analyzed the data. Dawei Zheng participated in the surgical operation. Kewei Wu drafted the manuscript. All authors reviewed the manuscript.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval and consent to participate This research project was approved by the Ethics Committee of the Lihuili Hospital, Affiliated

to Ningbo University (Approval number: KY2023SL340-01). All participants included in the study signed their informed consents.

Consent for publication Not applicable.

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