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Comparison of postoperative analgesia by thoracoscopic-guided thoracic paravertebral block and thoracoscopic-guided intercostal nerve block in uniportal video-asssited thoracic surgery: a prospective randomized controlled trial

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Abstract

Background Thoracoscopic-guided thoracic paravertebral nerve block (TG-TPVB) and thoracoscopic-guided intercostal nerve block (TG-INB) are two postoperative analgesia technology for thoracic surgery. This study aims to compared the analgesic effect of TG-TPVB and TG-INB after uniportal video-asssited thoracic surgery (UniVATS).

Methods Fifty-eight patients were randomly allocated to the TG-TPVB group and the TG-INB group. The surgical time of nerve block, the visual analog scale (VAS) scores, the consumption of sufentanil and the number of patient-controlled intravenous analgesic (PCIA) presses within 24 h after surgery, the incidence of adverse reactions were compared between the two groups.

Results The VAS scores were significantly lower during rest and coughing at 2, 6, 12, and 24 h in the TG-TPVB group than in the TG-INB group ($P < 0.05$). The consumption of sufentanil and the number of PCIA presses within 24 h after surgery were significantly lower in the TG-TPVB group than in the TG-INB group ($P < 0.001$).The surgical time of nerve block was significantly shorter in the TG-TPVB group than in the TG-INB group ($P < 0.001$). The incidence of bleeding at the puncture point was lower in the TG-TPVB group than that in the TG-INB group ($P < 0.05$).

Conclusion TG-TPVB demonstrated superior acute pain relieve after uniVATS, shorter surgical time and non-inferior adverse effects than TG-INB.

Keywords Thoracic paravertebral nerve block, Intercostal nerve block, Thoracoscopic-guided, Uniportal video-asssited thoracic surgery, Postoperative analgesia

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Introduction

In recent years, thoracoscopic minimally invasive surgery has become the main surgical method of thoracic surgery [1]. Migliore first reported the application of uniportal video-asssited thoracic surgery (UniVATS) in the diagnosis and treatment of thoracic diseases in 2000–2001 [2, 3]. In 2011, Forster et al. reported the first case of uniportal thoracoscopic lobectomy combined with mediastinal lymph node dissection [4]. From then on, uniportal thoracoscopic radical surgery for lung cancer gradually replaced multi hole thoracoscopic surgery due to its advantages of fewer incisions, less pain, and faster recovery [5]. However, the incision for uniportal thoracoscopic surgery is relatively large, and postoperative pain remains severe, which affects postoperative recovery [6]. Postoperative pain in thoracic surgery is mainly caused by chest wall incision and catheter stimulation.

Studies have found that peripheral nerve blocks such as ultrasound guided thoracic paravertebral block (TPVB), erector spinae plane block, and intercostal nerve block (INB) can block the transmission of pain stimuli from the corresponding intercostal nerve innervation area to the central nervous system, thereby reducing postoperative pain in thoracic surgery [7–11]. Thoracoscopic-guided thoracic paravertebral block (TG-TPVB) is a new peripheral nerve block method. And thoracoscopic- guided intercostal nerve block (TG-INB) is a relatively simple and effective peripheral nerve block technique favored by thoracic surgeons. Under the guidance of thoracoscopy, local anesthetics are injected into the paravertebral or intercostal space through an intrathoracic approach by a surgeon. In previous studies, researchers have found that TG-TPVB is a simple and convenient procedure, which can effectively reduce postoperative pain in thoracic surgery and promote postoperative recovery [12, 13]. Researches have found that TG-INB can alleviate chest wall pain during thoracic surgery, especially suitable for UniVATS [14, 15]. However, there have been no reports of comparative studies on postoperative pain between TG-TPVB and TG-INB in thoracic surgery. Therefore, this study aims to compare the analgesic effects of TG-TPVB and TG-INB after UniVATS.

Methods

Subjects

This study was a single-center, prospective, randomized, controlled, single-blind trial, approved by the Ethics Committee of the Lihuili Hospital Affiliated of Ningbo University (Approval No. KY2020PJ015), and registered with the Chinese Clinical Trial Registry (Approval No. ChiCTR2300072005, The date of first registration is 31st May 2023). Sixty patients undergoing uniportal thoracoscopic radical resection of lung cancer were enrolled between July 2023 and September 2023 at the affiliated Lihuili Hospital of Ningbo University. All patients signed informed consent form. Inclusion criteria: aged between 25 and 75 years; American Society of Anesthesiologists physical status grade(ASA) I~III; and scheduled to undergo uniportal thoracoscopic radical resection of lung cancer. Exclusion criteria: anticoagulant administration; coagulopathy; refuse uniportal thoracoscopic radical resection of lung cancer; allergies to local anesthetics; severe pleural adhesions; unplanned second surgery after surgery; intraoperative pathological examination during surgery confirms benign or in situ tumor; the procedure is changed to multi hole thoracoscopy or open chest surgery; or requested withdrawal during the research.

Randomization and blinding

Participants who met the inclusion criteria were randomly allocated to the TG-TPVB group and TG-INB group with a ratio of 1:1. Random allocation sequences were generated by a computer, and hidden in opaque sealed envelopes by a non-blinded special nurse. The nurse informed the anesthesiologist and surgeon of the grouping results before nerve block. Surgeon performed TG-TPVB or TG-INB based on the grouping. The surgeons, nurse, and anesthesiologists did not participate in the next research. Patients and other researchers are unaware of the grouping situation. The surgery and anesthesia management were performed by the same surgical team.

Anesthesia and Surgical management

All patients fasted for solid food for 8 h and clear liquids for 4 h before surgery. All patients received total intravenous general anesthesia. A double lumen bronchial tube was inserted after rapid intravenous induction. The ventilator was connected to the bronchial tube for mechanically controlled ventilation, with tidal volumes of 6 mL/kg and 8 ~ 10 times/min.

This surgical team included 3 thoracic surgeons. Patients underwent UniVATS. A incision was made at the fifth intercostal space of the midaxillary line. When body mass index (BMI) < 18.5 or thin patients (including female patients), the length of surgical incision was set to 3 cm. If 18.5 ≤ BMI ≤ 24.9, the length of surgical incision was set to 4 cm. If BMI ≥ 24.9 or obese patients, the length of surgical incision was set to 5 ~ 6 cm. The length of surgical incision was not fixed, which could be adjusted according to the BMI, body shape and surgical needs of patients [16, 17].Sterile incision sleeve used to protect surgical incision. The surgeon, according to the preoperative computer tomography imaging, the size and location of the tumor, actual anatomy of the artery, vein, and bronchus of the lobe or segment under the thoracoscopic view, decided whether to perform lobectomy or segment resection. Following the pathological

confirmation of a malignant tumor during surgery, lymph node dissection was performed on the hilum of the lung and mediastinal lymph nodes. A 26Fr drainage tube was placed at the incision.

At the end of the surgery, all patients were connected with a patient-controlled intravenous analgesia (PCIA) pump with sufentanil 1.5 ug·kg^{-1}, diluted to 100 ml with normal saline. The parameters were set as a continuous dose of 2 ml/h, a bolus dose of 1.5 ml, and a locking time of 15 min.

Nerve block procedure

Before closing the chest wall incision, a 24G needle with an extension tube was insert the into the chest cavity through the surgical incision with a needle holder. The injection needle was vertically inserted into the parietal pleura at the fifth intercostal and 0.2 cm lateral to the sympathetic chain through an intrathoracic approach under the direct vision guidance of thoracoscopy, with a depth of about 0.5 cm under parietal leura in the TG-TPVB group [12, 13]. Then, 15 ml of 0.375% ropivacaine was injected(Fig. 1).The surgery of TG-TPVB was performed by the thoracic surgeon.

Before closing the chest wall incision, a 24G injection needle with an extension tube was insert the into the chest cavity through the surgical incision with a needle holder. Under the guidance of thoracoscopy, the injection needle was vertically inserted into the parietal pleura at a depth of 0.5 cm, located 2 cm lateral to the sympathetic chain at the fourth, fifth, and sixth intercostal space. After no blood was drawn, 5 ml of 0.375% ropivacaine was injected at each intercostal space, totaling 15 ml. Then the parietal pleura was elevated (Fig. 2). The TG-INB surgery was performed by the thoracic surgeon.

Data collection

Primary outcomes: The primary outcomes were VAS scores (while rest and coughing) at 2, 6, 12, 24, and 48 h postoperative, and the consumption of sufentanil within 24 h after surgery. The assessment of postoperative VAS score was assessed by a dedicated anesthesiologist.

Secondary outcomes: The surgical time of nerver block of TG-TPVB and TG-INB were recorded. The surgical time of nerve block for TG-TPVB and TG-INB group started when the needle holder entered the thoracic cavity and the injection of local anesthetics was completed. The number of PCIA presses within 24 h after surgery, and the incidence of adverse reactions such as local anesthetics poisoning, bleeding at puncture point, postoperative nausea and vomiting were recorded. When the

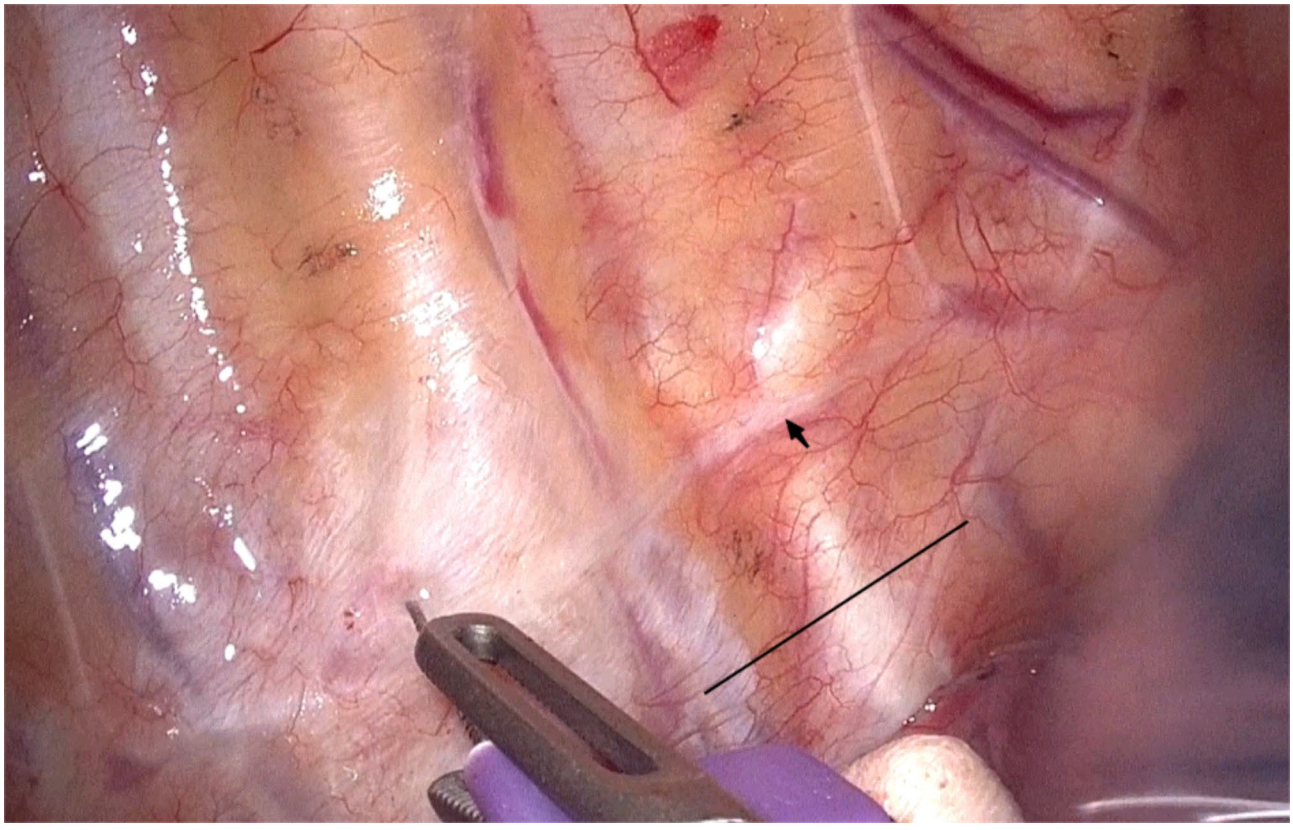

Fig. 1 TG-TPVB at the fifth thoracic paravertebral space. The black line indicates the thoracic vertebral body, and the arrow indicates the sympathetic chain

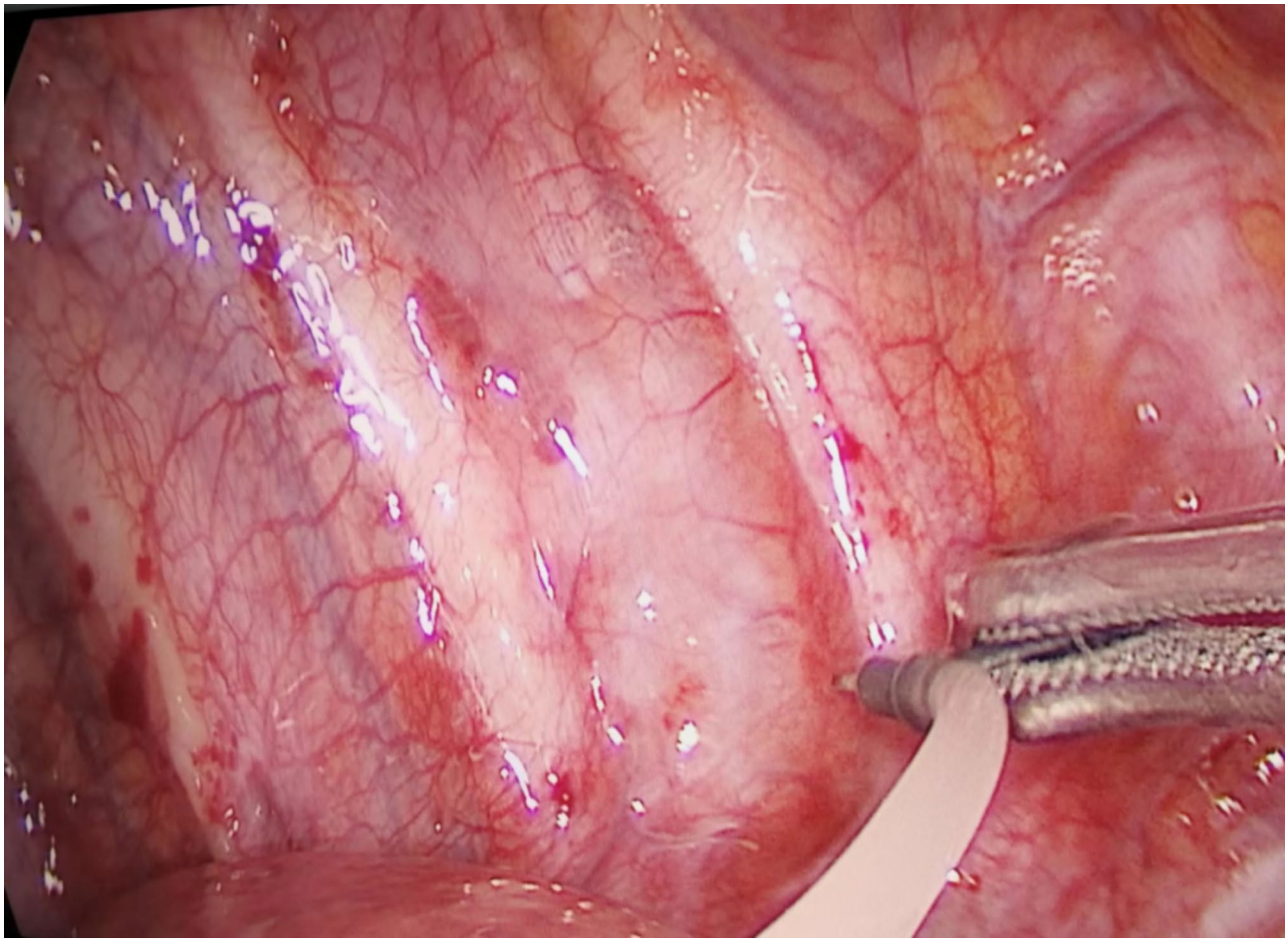

Fig. 2 TG-INB at the fifth intercostal space.The puncture point is 2 cm outside the sympathetic chain

injection needle was removed after the local anesthetic was injected, if there was blood exudation at the puncture point, it means bleeding.

Sample size

A pilot study was conducted including 20 patients to calculate the minimum sample size. Pilot testing showed a mean [standard deviation] the VAS score at 2 h postoperative of 2.2 [0.3] in the TG-TPVB group and 2.5 [0.4] in the TG-INB group. The requirement was 21 in each group, which was calculated by the MedSci Sample Size Tools at a power of 0.8 with 0.05 alpha. Therefore, considering a potential 20% rate of missing data or dropouts and greater test efficiency, 30 patients were included in each group.

Statistical analysis

Data were analyzed using the SPSS version 24.0 software (IBM Corp, USA). Continuous variables with a normal distribution are expressed as mean ± standard deviation. The differences between the two groups were determined using the student's *t*-test. Non-normally distributed variables are presented as medians (interquartile range) and were analyzed with the Mann–Whitney U-test. Categorical variables are presented as numbers (percentages). Differences in the categorical data between the two groups were determined using Fisher's exact test or the chi-square (χ^2) test. *P*-value of <0.05 was considered statistically significant.

Result

The baseline data and intraoperative data of patients

A total of 60 patients were recruited for the study. They were randomly divided into the TG-TPVB and TG-INB groups. One patient in the TG-TPVB group was confirmed with tumor in situ via rapid intraoperative pathology, and one patient in the TG-INB group was changed to thoracotomy during operation. Therefore, these two patients were excluded from the study. Thus, 58 patients were finally included in the study, and the research process were successfully performed. The CONSORT flow diagram is shown in Fig. 3. There were no significant differences of the baseline data and intraoperative data between the two groups ($P>0.05$, Table 1).

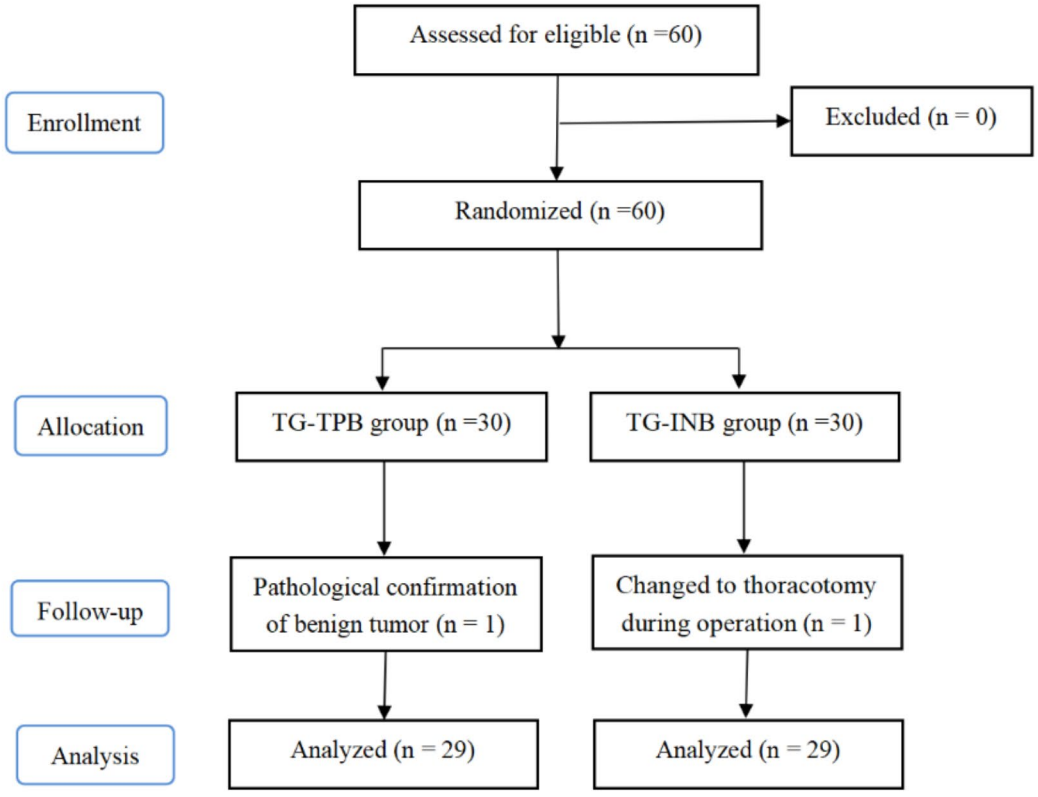

Fig. 3 CONSORT flow diagram for the trial

Primary outcomes

The VAS scores (while rest and coughing) at 2 h, 6 h, 12 h, and 24 h after surgery in the TG-TPVB group were lower than that in the TG-INB group ($P<0.05$). But there was no significant difference at 48 h between TG-TPVB group and TG-INB group ($P>0.05$, Table 2).

The consumption of sufentanil within 24 h after surgery was significantly lower in the TG-TPVB group than that in the TG-INB group (51.4±1.1 vs. 57.2±2.2 ug, $t=12.610$, $P<0.001$).

Secondary outcomes

The surgical time of nerve block in the TG-TPVB group was significantly shorter than that in the TG-INB group (1.4±0.2 vs. 2.0±0.3 min, $t=-7.656$, $P<0.001$).

The number of PCIA presses within 24 h after surgery in the TG-TPVB group were lower than that in the TG-INB group (2 [1, 2] vs. 6 [6, 7], z = -6.575, $P<0.001$).

The incidence of bleeding at puncture point in the TG-TPVB group were lower than that in the TG-INB group (17.2% vs. 41.4%, $\chi^2=4.077$, $P<0.05$). There were no significant differences of adverse reactions such as local anesthesia poisoning,, postoperative nausea and vomiting.between the two groups ($P>0.05$, Table 3).

Discussion

UniVATS integrates the manipulation and video holes into one incision, so the incision is larger than conventional multi hole thoracoscopic surgery, resulting in postoperative pain is still severe and seriously affecting postoperative recovery. Given its minimally invasive nature, postoperative pain is often overlooked. Intrathoracic surgery and different degrees of lung tissue resection lead to the decline of postoperative pulmonary function reserve. The severe postoperative pain makes patients dare not take deep breath and cough, prone to postoperative pulmonary complications such as

Table 1 Comparison of baseline characteristics and perioperative details between two groups

	TG-TPVB group (*n* = 29)	TG-INB group (*n* = 29)	*P* value
Male (%)	17(58.6%)	16(55.2%)	0.791
Age (years)	53.0 ± 9.3	53.7 ± 12.6	0.807
Weight (kg)	64.3 ± 8.7	63.3 ± 10.5	0.772
ASA			0.853
I	16(55.2%)	18(62.1%)	
II	11(37.9%)	19(31.0%)	
III	2(6.9%)	2(6.9%)	
BMI (kg/m^2)	22.2 ± 2.1	22.7 ± 4.4	0.381
Surgical type			0.599
Lobectomy	16(55.2%)	14(48.3%)	
Segment resection	13(44.8%)	15(51.7%)	
Surgical site			0.791
left	17(58.6%)	16(55.2%)	
right	12(41.4%)	13(44.8%)	
Surgery time (min)	119.5 ± 10.7	114.8 ± 16.0	0.188

Data are presented as mean±standard deviation or number (%). TG-TPVB- Thoracoscopic-guided thoracic paravertebral nerve block, TG-INB - thoracoscopic-guided intercostal nerve block. ASA - American Society of Anesthesiologists, BMI - Body Mass Index

pneumonia and atelectasis [18]. Adequate postoperative analgesia can promote postoperative recovery.

The main cause of chest wall pain after thoracic surgery is the severe damage to the intercostal nerve caused by the incision. And the degree of pain is independent of the size of the surgical incision. Acute pain without timely and effective treatment can easily change into chronic pain, which affects the quality of life of patients after surgery. That's why acute pain control is a necessary condition for preventing complications and promoting postoperative recovery. Nerve block techniques, including TPVB and INB, are effective methods for treating acute pain caused by intercostal nerve injury.

The thoracic paravertebral space has a triangular structure on the horizontal plane. And the adjacent paravertebral spaces are interconnected. Paravertebral space contains spinal nerve, intercostal nerve and sympathetic nerve chain from intervertebral foramen. At present, the commonly used thoracic paravertebral block is mainly through ultrasound-guided percutaneous puncture approach, and local anesthetics are injected into the paravertebral space. Local anesthetics spread in the paravertebral space of 2 ~ 4 segments above and below the injection site [19]. Therefore, TPVB can block the intercostal nerve and sympathetic nerve of multiple segments at the same time, which has the effect similar to unilateral epidural block, and then relieve the chest and abdominal wall incision pain and visceral pain after operation [8]. However, ultrasound-guided operation has high requirements for blocking technology, limited operation space and low success rate. In recent years, TG-TPVB has been recognized as an emerging TPVB technique. It is to puncture the blocking needle through the parietal pleura under the direct vision of thoracoscopy, and directly inject local anesthetics into the paravertebral space. In previous studies, researchers have confirmed that TG-TPVB can effectively reduce the pain after thoracic surgery [12, 13, 20]. The findings suggest that, in contrast to ultrasound-guided TPVB, TG-TPVB shows advantages, such as simpler and more convenient surgery, shorter surgical time, a higher success rate of the first puncture, wider block segments, and superior analgesic effect [20].

Table 3 Comparison of adverse reactions after surgery between two groups

	TG-TPVB group (*n* = 29)	TG-INB group (*n* = 29)	*P* value
Bleeding at puncture point	5(17.2%)	12 (41.4%)	0.043
Local anesthesia poisoning	0(0.0%)	0(0.0%)	1.000
Postoperative nausea	5 (17.2%)	4 (13.8%)	1.000
Postoperative vomiting	3 (10.3%)	4 (13.8%)	1.000

Data are presented as number (%). TG-TPVB- Thoracoscopic-guided thoracic paravertebral nerve block, TG-INB - thoracoscopic-guided intercostal nerve block

Table 2 Comparison of VAS scores between two groups

		TG-TPVB group (*n* = 29)	TG-INB group (*n* = 29)	t	*P* value
During rest	2 h after surgery	2.0 ± 0.2	2.5 ± 0.3	9.384	< 0.001
	6 h after surgery	2.1 ± 0.3	2.5 ± 0.3	5.274	< 0.001
	12 h after surgery	2.2 ± 0.3	2.6 ± 0.6	3.433	0.001
	24 h after surgery	2.2 ± 0.4	2.7 ± 0.4	4.540	< 0.001
	48 h after surgery	3.0 ± 0.5	3.2 ± 0.6	1.908	0.062
While coughing	2 h after surgery	3.1 ± 0.6	3.5 ± 0.6	2.539	0.014
	6 h after surgery	3.0 ± 0.6	3.6 ± 0.7	3.391	0.001
	12 h after surgery	3.0 ± 0.6	3.7 ± 0.7	3.477	0.001
	24 h after surgery	3.2 ± 0.6	3.7 ± 0.4	3.543	0.001
	48 h after surgery	3.8 ± 0.8	3.7 ± 0.7	-0.267	0.791

Data are presented as mean±standard deviation. TG-TPVB- Thoracoscopic-guided thoracic paravertebral nerve block, TG-INB - thoracoscopic-guided intercostal nerve block

INB is a relatively ancient and classic peripheral nerve block technique that can effectively alleviate acute and chronic pain in the corresponding intercostal nerve innervated area. Ultrasound guided INB is a simple procedure that can effectively alleviate chest wall incision pain and is widely used for postoperative analgesia in thoracic surgery [21]. Compared with the traditional blind puncture INB or Ultrasound guided INB, TG-INB, as a different approach INB technology, has emerged with the progress of thoracoscopic surgery. It only needs the surgeon to inject the local anesthetics under the parietal pleura between the ribs under the direct vision of thoracoscopy. At this time, the diffusion of local anesthetics in the intercostal space can be seen. The operation of TG-INB is simpler, the success rate is higher, the effect is exact, and it can effectively reduce the postoperative pain, which has been welcomed by the majority of thoracic surgeons [22].

Studies have shown that ultrasound-guided TPVB and ultrasound-guided INB have similar effects in reducing pain after thoracic surgery [23]. But other studies have suggested that ultrasound-guided TPVB has better analgesic effect than ultrasound-guided INB. TG-TPVB and TG-INB are two kinds of nerve block techniques through thoracic approach under thoracoscopy [24–26]. At present, there is no comparative study of TG-TPVB and TG-INB in reducing postoperative pain of thoracic surgery. Therefore, this study intends to compare the analgesic effect of TG-TPVB and TG-INB after uniportal thoracoscopic radical resection of lung cancer in terms of operation convenience, analgesic effect and adverse reactions.

In this study, the surgical time of nerve block in TG-TPVB group was significantly lower than that in TG-INB group, suggesting that the surgical of TG-TPVB is simpler. This is mainly because TG-TPVB only needs a single injection, and local anesthetics can diffuse in the paravertebral space of multiple segments above and below the injection site [12, 13, 20]. However, the local anesthetics of single TG-INB only diffused in the intercostal space of the injection, and could only block a single intercostal nerve. In order to expand the scope of block, it is necessary to block 1 ~ 2 intercostals above and below the incision for multiple times [22]. In this study, Uniportal thoracoscopic surgery was selected, so only three intercostal blocks were selected between the incision intercostals and the fourth and sixth intercostals. Therefore, compared with TG-TPVB, the surgical time of TG-INB is longer.

The VAS scores at 2, 6, 12, and 24 h after surgery, the consumption of sufentanil and the number of PCIA presses within 24 h after surgery were significantly lower in the TG-TPVB group than in the TG-INB group.These results suggest that the analgesic effect of TG-TPVB is better than that of TG-INB. There are two main reasons for this: Firstly, TPVB can block the intercostal nerve of multiple segments at the same time, while INB can only block the intercostal nerve of corresponding segments. Secondly, radical resection of lung cancer will also carry out hilar lymph node dissection at the same time of lobectomy, which may be accompanied by visceral pain. TG-TPVB can block the spinal nerve, intercostal nerve and sympathetic nerve chain in the paravertebral space at the same time, and then relieve the chest wall incision pain and visceral pain after operation. But TG-INB can only relieve the incision pain of chest wall.

The incidence of bleeding at puncture point was significantly lower in TG-TPVB group than that in TG-INB group. This may be because there is only one puncture point for TG-TPVB, and TG-INB needs to be punctured in three intercostals, resulting in the incidence of bleeding at puncture site in TG-INB group is higher than that in TG-TPVB group. In case of bleeding at the puncture point, it is only necessary to gently press with gauze to stop bleeding [20]. In addition, thoracoscopy has the amplification function, which can avoid blood vessels as much as possible during the blocking operation, and can also reduce the incidence of bleeding.

This study also has many limitations. Firstly, sensory planes were not observed in this study; Secondly, the removal time and pain of thoracic drainage tube were not recorded in this study; Thirdly, this study only observed the pain of 48 h after operation and the consumption of sufentanil within 24 h, and did not observe the analgesia for a longer time; They are also our future research focus.

Conclusion

In conclusion, both TG-INB and TG-TPVB can effectively reduce the pain after UniVATS. However, TG-TPVB demonstrated superior acute pain relieve after uniVATS, shorter surgical time and non-inferior adverse effects than TG-INB.

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Author contributions

Xia Xu, and Meng Zhang involved in the study's conceptualization, data collection, analysis, interpretation, and manuscript preparation. Meng Zhang, Yan Li, and Jian-hui Du participated in the data collection, research, and interpretation. Jin-xian He participated in the surgery and nerver block. The corresponding author, Li-hong Hu, supervised the entire research process, ensured the integrity of the work, and was the primary contact for correspondence related to the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval and consent to participate

This study was performed in accordance with the Helsinki Declaration of 1964 and its later amendments. This study has been approved by the Ethics Committee of the Lihuili Hospital Affiliated of Ningbo University (Approval No. KY2020PJ015). This study was registered with the Chinese Clinical Trial Registry (http://www.chictr.org.cn, ChiCTR2300072005). Written consent was provided by the patients for their information to be stored in the hospital database and used in research. Patient records were anonymized and de-identified before analysis.

Consent for publication

All the authors approved the manuscript for publication.

Competing interests

The authors declare no competing interests.

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References

1. Leschber G. Video-assisted thoracic surgery: a global development. Chirurg. 2018;89(3):185–90.
2. Migliore M, Giuliano R, Deodato G. Video assisted thoracic surgery through a single port. Proceedings of Thoracic Surgery and Interdisciplinary Symposium on the Threshold of the Third Millennium. Naples, Italy. 2000, pp. 29–30. http://xoomer.virgilio.it/naples2000/index1.html.
3. Migliore M, Deodato G. A single-trocar technique for minimally invasive surgery of the chest. Surg Endosc. 2001;15:899–901.
4. Tosi D, Mazzucco A, Musso V, Bonitta G, Rosso L, Mendogni P, et al. Pulmonary lobectomy for early-stage Lung Cancer with Uniportal versus Three-Portal Video-assisted thoracic surgery: results from a single-centre Randomized Clinical Trial. J Clin Med. 2023;12(22):7167.
5. Forster, Céline. Gonzalez Michel,Uniportal video-assisted thoracic surgery segmentectomy: a promising new development for thoracic surgery. Transl Lung Cancer Res. 2023;12:1152–5.
6. Davide T. Pulmonary lobectomy for early-stage Lung Cancer with Uniportal versus Three-Portal Video-assisted thoracic surgery: results from a single-centre Randomized Clinical Trial. J Clin Med. 2023;12(22):7167.
7. Feray S, Lubach J, Joshi GP, et al. PROSPECT guidelines for video-assisted thoracoscopic surgery: a systematic review and procedure-specific postoperative pain management recommendations. Anaesthesia. 2022;77:311–25.
8. Zheng C, Wang J, Xie S. Ultrasound-guided thoracic paravertebral nerve Block on Postoperative Pain, Quality of Life, and recovery in patients with non-small-cell Lung Cancer. Biomed Res Int. 2021;2021:6692815.
9. Zhao H, Xin L, Feng Y. The effect of preoperative erector spinae plane vs. paravertebral blocks on patient-controlled oxycodone consumption after video-assisted thoracic surgery: a prospective randomized, blinded, non-inferiority study. J Clin Anesth. 2020;62:109737.
10. Mahmoudi K, Rashidi M, Soltani F, Savaie M, Hedayati E, Rashidi P. Comparison of intercostal nerve block with Ropivacaine and Ropivacaine-Dexmedetomidine for Postoperative Pain Control in patients undergoing thoracotomy: a Randomized Clinical Trial. Anesth Pain Med. 2021;11(6):e118667. https://doi.org/10.5812/aapm.118667. PMID: 35291405; PMCID: PMC8908443.
11. Li S, Feng J, Fan K, Fan X, Cao S, Zhang G. The effect of ultrasound-guided intercostal nerve block on postoperative analgesia in thoracoscopic surgery: a randomized, double-blinded, clinical trial. J Cardiothorac Surg. 2023;18(1):128. https://doi.org/10.1186/s13019-023-02210-8. PMID: 37041525; PMCID: PMC10091630.
12. Lihong Hu X, Xu W, Shen, et al. Feasibility and effectiveness of multi-injection thoracic paravertebral block via the intrathoracic approach for analgesia after thoracoscopic-laparoscopic esophagectomy. Esophagus. 2021;18:513–21.
13. Lihong H, Xu X, Tian H, et al. Effect of single-injection thoracic paravertebral Block via the Intrathoracic Approach for Analgesia after single-Port Video-assisted thoracoscopic lung wedge resection: a Randomized Controlled Trial. Pain Therapy. 2021;10(1):433–42.
14. Nachira D, Punzo G, Calabrese G, et al. The efficacy of continuous Serratus Anterior and Erector Spinae Plane blocks vs intercostal nerve block in Uniportal-Vats surgery: a propensity-matched prospective trial. J Clin Med. 2024;13(2):606.
15. Kang DK, Kang MK. A pilot study of intraoperative intercostal nerve block during uniportal thoracoscopic wedge resection of the lung. Ann Thorac Med. 2022 Jul-Sep;17(3):180–3.
16. Bertolaccini L, Batirel H, Brunelli A, Gonzalez-Rivas D, Ismail M, Ucar AM, et al. Uniportal video-assisted thoracic surgery lobectomy: a consensus report from the Uniportal VATS Interest Group (UVIG) of the European Society of thoracic surgeons (ESTS). Eur J Cardiothorac Surg. 2019;56:1075–80.
17. Migliore M, Hirai K, Uniportal VATS. Comment on the consensus report from the uniportal VATS interest group (UVIG) of the European society of thoracic surgeons. Eur J Cardiothorac Surg. 2020;57(3):612.
18. Marshall K, McLaughlin K. Pain management in thoracic surgery. Thorac Surg Clin. 2020;30(3):339–46.
19. Wu Z, Wang Q, Wu C, et al. Paravertebral vs epidural anesthesia for video-assisted thoracoscopic surgery: a Randomized Trial. Ann Thorac Surg. 2023;116:1006–12.
20. Xu X, Xie YX, Zhang M, Du JH, He JX, Hu LH. Comparison of Thoracoscopy-Guided Thoracic Paravertebral Block and Ultrasound-Guided Thoracic Paravertebral Block in Postoperative Analgesia of Thoracoscopic Lung Cancer Radical Surgery: A Randomized Controlled Trial. Pain Ther. 2024 Apr 9. https://doi.org/10.1007/s40122-024-00593-7
21. Nakai A, Nakada J, Takahashi Y, Sakakura N, Masago K, Okamoto S, Kuroda H. Divided method of intercostal nerve block reduces ropivacaine dose by half in thoracoscopic pulmonary resection while maintaining the postoperative pain score and 4-h mobilization: a retrospective study. J Anesth. 2023;37(5):749–54.
22. Wang T, Wang X, Yu Z, Li M. Programmed intermittent Bolus for Erector Spinae Plane Block Versus intercostal nerve Block with patient-controlled intravenous analgesia in video-assisted thoracoscopic surgery: a Randomized Controlled Noninferiority Trial. Clin J Pain. 2024;40(2):99–104.
23. Zhao X, Li X, Wang Y, Xiao W, Zhang B, Meng X, Sun X. Efficacy of intrathoracic intercostal nerve block on postoperative Acute and chronic pains of patients undergoing video-assisted thoracoscopic surgery. J Pain Res. 2022;15:2273–81.
24. Zheng Y, Wang H, Ma X, Cheng Z, Cao W, Shao D. Comparison of the effect of ultrasound-guided thoracic paravertebral nerve block and intercostal nerve block for video-assisted thoracic surgery under spontaneous-ventilating anesthesia. Rev Assoc Med Bras (1992). 2020;66(4):452–7.
25. Turhan Ö, Sivrikoz N, Sungur Z, Duman S, Özkan B, Şentürk M. Thoracic paravertebral Block achieves Better Pain Control Than Erector Spinae Plane Block and intercostal nerve block in thoracoscopic surgery: a randomized study. J Cardiothorac Vasc Anesth. 2021;35(10):2920–7.
26. Huan S, Deng Y, Wang J, Ji Y, Yin G. Efficacy and safety of paravertebral block versus intercostal nerve block in thoracic surgery and breast surgery: a systematic review and meta-analysis. PLoS ONE. 2020;15(10):e0237363. https://doi.org/10.1371/journal.pone.0237363. PMID: 33017425; PMCID: PMC7535861.

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