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Thoracic paravertebral nerve block combined laryngeal mask airway with preservation of spontaneous breathing can accelerate postoperative recovery

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Abstract. – OBJECTIVE: This study aimed to examine the potential benefits of Thoracic Paravertebral Nerve Block (TPVB) coupled with Laryngeal Mask Airway (LMA) and the maintenance of spontaneous breathing anesthesia, in contrast to general anesthesia utilizing double-lumen endobronchial intubation, on promoting recovery following thoracoscopic surgery.

PATIENTS AND METHODS: A randomized controlled trial was carried out involving sixty patients set for Video-Assisted Thoracoscopic Surgery (VATS) at the Affiliated People's Hospital of Jiangsu University from February 2021 to January 2022. Patients were randomized to either the TPVB and LMA with spontaneous breathing anesthesia group (non-intubation group, NI group) or the general anesthesia with double-lumen endobronchial intubation group (Intubation group, I group). The primary outcome measured was the duration of hospitalization. Secondary outcomes included early postoperative rehabilitation indicators, postoperative complications, Visual Analogue Score (VAS), and inflammatory response markers.

RESULTS: Patients in the NI group experienced significantly shorter hospital stays than those in the I group ($p < 0.05$). Early postoperative recovery, assessed by metrics including the first exhaust time, food intake time, first ambulation time, and duration of chest-tube placement, was superior in the NI group ($p < 0.05$). Postoperative complications such as nausea and vomiting, pulmonary infection, atelectasis, sore throat, and hoarseness, along with cortisol and C-reactive protein (CRP) levels at the end of the operation and 24 h post-operation, and VAS values within the first 12 h post-operation, were significantly lower in the NI group ($p < 0.05$). However, blood loss, operation time, and VAS values at 24 h and 48 h post-surgery showed no significant differences between the two groups.

CONCLUSIONS: Our findings suggest that TPVB, in conjunction with LMA and spontaneous breathing anesthesia, may expedite postoperative recovery in patients undergoing VATS.

Key Words:
Enhanced recovery after surgery, Laryngeal mask airway, Nerve block, Spontaneous breathing anesthesia, Video-assisted thoracic surgery.

Introduction

Enhanced recovery after surgery (ERAS) in thoracic procedures involves not only minimally invasive surgery (MIS)[1], but also minimally invasive anesthesia (MIA)[2]. MIS is one of the accepted treatment approaches for pleural or peripheral lung diseases worldwide[3]. VATS as MIS is widely used nowadays[4]. However, an equally significant factor is the MIA method, which, in the context of ERAS, often involves

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the preservation of spontaneous breathing anesthesia without endotracheal intubation, allowing patients to maintain self-ventilation under sedation during surgery[5].

Conventionally, general anesthesia with double-lumen endotracheal intubation is employed for VATS, providing safe and reliable surgical conditions[6]. However, it also introduces potential complications, such as intubation-related airway trauma, ventilation-induced lung injury[7], upper respiratory tract obstruction, reflux aspiration due to residual neuromuscular relaxants, and postoperative pulmonary infections[8]. These complications can significantly impede a patient's rapid recovery. Recent studies[9-11] have indicated that preserved spontaneous breathing anesthesia without endotracheal intubation can be safely and feasibly used for VATS, potentially avoiding these issues. Previous studies[12] have demonstrated that LMA can avoid complications by intubation, thereby promoting early patient rehabilitation and aligning with the ERAS concept.

ERAS was first proposed by the Danish physicians in the 1990s[13]. It utilizes improved clinical approaches throughout the perioperative period to mitigate surgical and anesthesia stress responses. This approach helps to reduce postoperative complications and promote rapid recovery for patients[14]. Central goals of ERAS[15,16] include shortened hospital stay duration, adequate postoperative analgesia, early food intake, early ambulation, and control of perioperative stress and inflammation.

In thoracic surgery, local anesthetic techniques such as local wound infiltration, nerve blockade, and thoracic epidural analgesia (TEA) are often employed[17]. Though TEA is the "gold standard" for postoperative analgesia in thoracic surgery[18], it has some drawbacks, including difficult puncture, high failure rate, block of bilateral spinal nerve roots, and high requirement of coagulation function[18,19]. Recent research[20-22] suggests that ultrasound-guided TPVB could be superior to TEA in terms of safety and feasibility as it avoids epidural-related side effects.

In this study, we sought to gain a deeper understanding of how different anesthesia techniques influence ERAS. Specifically, we hypothesized that combining TPVB with LMA general anesthesia while preserving spontaneous breathing would reduce the duration of hospital stays and expedite postoperative recovery in VATS procedures.

Patients and Methods

General Data

A total of 86 patients scheduled for elective video-assisted thoracoscopic surgery (VATS) at the Department of Thoracic Surgery, Affiliated People's Hospital of Jiangsu University, were enrolled from February 2021 to January 2022. Based on the established criteria, patients were randomly assigned to either the Non-Intubation (NI, n = 30) or Intubation (I, n = 30) groups. Ethical approval for the study was secured from the hospital's Ethics Committee (LLYW20190004), and written informed consent was obtained from all participants. The trial was registered at Clinical Trials PRS (NCT05595096).

Inclusion Criteria and Exclusion Criteria

Inclusion criteria: patients undergoing VATS aged 18-69 years with a Body Mass Index (BMI) of 18-24 kg/m^2 and falling under American Society of Anesthesiologists' physical classification class I-II.

Exclusion criteria: patients with severe cardiopulmonary complications, spinal or thoracic deformity, respiratory obstruction, neuromuscular disorder, foreseeable difficult airway, known allergy to local anesthetics, infection at the injection site, coagulopathy, estimated operative time exceeding 3 hours, high-risk of massive intraoperative bleeding, or conversion to thoracotomy.

Group Allocation and Management

Patients were assigned to either the NI or I group *via* a computer-generated randomization scheme. The resulting assignments were kept in sealed envelopes by an investigator not involved in anesthesia, intraoperative management, or postoperative patient follow-up.

Anesthesia Procedure

Upon entry into the operating room, intravenous access was established in patients, and continuous monitoring of vital signs such as electrocardiogram (ECG), heart rate (HR), blood pressure (BP), oxygen saturation (SpO_2), respiratory rate (RR), and bispectral index (BIS) was initiated. Invasive blood pressure (IBP) was also monitored following radial artery puncture under local anesthesia.

For the NI group, TPVB was conducted after pre-anesthesia induction according to the methods in the literature[23]. The patient was placed in the lateral position with the affected side upward. The

area was disinfected, and the towel was spread. The ultrasonic probe was placed in the spinous process of the thoracic five vertebrae, perpendicular to the midline of the spine, then moved to the affected side 3 cm in the middle; the screen showed the transverse process, the supra-costal process ligament, the pleura. The needle was inserted from the outside of the probe, and the tip of the needle broke through the ligament of the transverse process and entered between the pleura and the articular process. When no blood, no air, and no cerebrospinal fluid were drawn back, 20 ml of 0.25% ropivacaine was injected. The I group did not receive TPVB.

Anesthesia Induction

Dexmedetomidine was administered to patients in the NI group at 1.0 μg/kg within 15 min, followed by intravenous target-controlled infusion (TCI) of propofol (2-3.5 ug/mL) and sufentanil (0.2 μg/kg). The Laryngeal Mask Airway (LMA) was placed and connected to the respiratory circuit once the BIS value dropped to between 40 and 60. If spontaneous breathing was absent, manual assisted ventilation or synchronized intermittent mechanical ventilation (SIMV) was initiated. For the I group, after vital signs monitoring, dexmedetomidine (1.0 μg/kg) was administered within 15 min, followed by sedation, analgesia, muscle relaxants, and then tracheal intubation for mechanical ventilation.

Anesthesia Maintenance

Local infiltration of the surgical incision was performed in the NI group with lidocaine before the skin incision. Thoracic vagus nerve blockade was performed after lung collapse with artificial pneumothorax. Propofol, remifentanil, and dexmedetomidine were administered to maintain BIS values between 40 and 60. In the I group, continuous propofol and remifentanil infusion were used, with intermittent cisatracurium injections for muscle relaxation maintenance.

Anesthesia Termination

Dexmedetomidine infusion stopped when the thoracic cavity was closed. Propofol and remifentanil infusion stopped at the end of the operation. After the operation, the patients in the two groups were both given patient-controlled intravenous analgesia (PCIA). The formula was the following:

2 μg/kg sufentanil + 10 mg dexamethasone + 6 mg granisetron + normal saline configured to 100 ml.

The background infusion flow rate was set at 2 ml/h and a 2 ml bolus with a lockout interval of 15 minutes.

Outcome Measures

Primary outcomes

All data were recorded and collected by the same senior resident. The primary outcome was the duration of the hospital stay for both groups. Criteria for discharge were standardized as follows: a) A chest X-rays showed whole re-expansion of the lung; b) No fever and PONV; c) Diet nearly normal; d) Motor and sensory functions returned to normal; e) Pain fully controlled (VAS $\leq$ 3).

Secondary Outcomes

Secondary outcomes encompassed early postoperative rehabilitation indicators (the first exhaust time, food intake time, first ambulation time, the duration of chest-tube placement), postoperative complications (PONV, pulmonary infection, atelectasis, sore throat, hoarseness), Visual Analogue Scale (VAS) pain scores at various times after surgery, and serum cortisol and CRP levels at the end of the operation and 24 hours post-operation.

Assessment of pulmonary infection and atelectasis was diagnosed by chest X-rays. It was performed after surgery to evaluate the pulmonary infection and atelectasis and assess the re-expansion of the lung before discharge. Pain scores were assessed by using a visual analogue score. The pain scale from 0 to 10 was chosen according to self-perception: 0 indicates painless, and 10 for the most severe pain. Pain intensity was scored: a) Mild pain: 1-3; b) Moderate pain: 4-6; c) Severe pain: 7-10.

Statistical Analysis

We calculated the sample size prior to the implementation of the study using a power and sample size program, according to the existing literature[24]. The significance level was set at α= 0.05, and the required sample size in each group was 27 with a power of 80%. Taking into account a loss-to-follow-up rate of about 10%, our study recruited 30 patients in each group to meet the sample size requirement.

SPSS 25.0 (IBM Corp., Armonk, NY, USA) was used for relevant statistical analysis. Measurement data meeting normal distribution were presented as mean (standard deviation, SD), and *t*-test or repeated analysis of measurement vari-

ance was used for comparison as appropriate. The analysis of variance with repeated measures was used to assess differences in VAS values and inflammatory response indicators between or within groups. If Mauchly's sphericity test was not met, the Greenhouse-Geisser modification was used. At first, the time by group interaction term was tested. If the main effect was significant, pairwise post-hoc multiple comparisons were performed using Bonferroni's correction; if the main effect was not significant, the main effect was examined next. The adjusted p-value by Bonferroni correction was calculated by dividing the default p-value ≤ 0.05 by the total number of comparisons. Enumeration data were presented as a rate, and the Chi-square test was used for comparison. $p < 0.05$ indicated statistical significance.

Results

Participant Characteristics

From February 2021 to January 2022, 60 patients were recruited for this study (Figure 1). However, one patient in the NI group underwent conversion from VATS to thoracotomy due to unanticipated substantial intraoperative bleeding, resulting in the exclusion of this patient from the data analysis. Consequently, participant demographics and baseline characteristics were compiled for 29 patients in the NI group and 30 in the I group, as outlined in Table I. The NI group included 4 cases of pleural lesions, 12 cases of pulmonary wedge resection, and 13 cases of lobectomy, while the I group had 3 cases of pleural lesions, 13 cases of pulmonary wedge resection, and 14 cases of lobectomy. There were no statistically significant differences between the two groups in terms of age, gender, body mass index, ASA classification of anesthesia, type of surgery, blood loss, and operation time ($p > 0.05$).

Primary Outcome

The duration of hospital stay was comparatively shorter for patients in the NI group than those in the I group, indicating a significant difference ($p < 0.05$, Table II).

Secondary Outcome

Secondary outcomes post-surgery for both groups are delineated in Tables II, III, IV, and V. The I group exhibited longer times for first exhaust, food intake, first ambulation, and duration of chest-tube placement compared to the NI group ($p < 0.05$, Table II). The incidence of postoperative complications such as postoperative nausea and vomiting

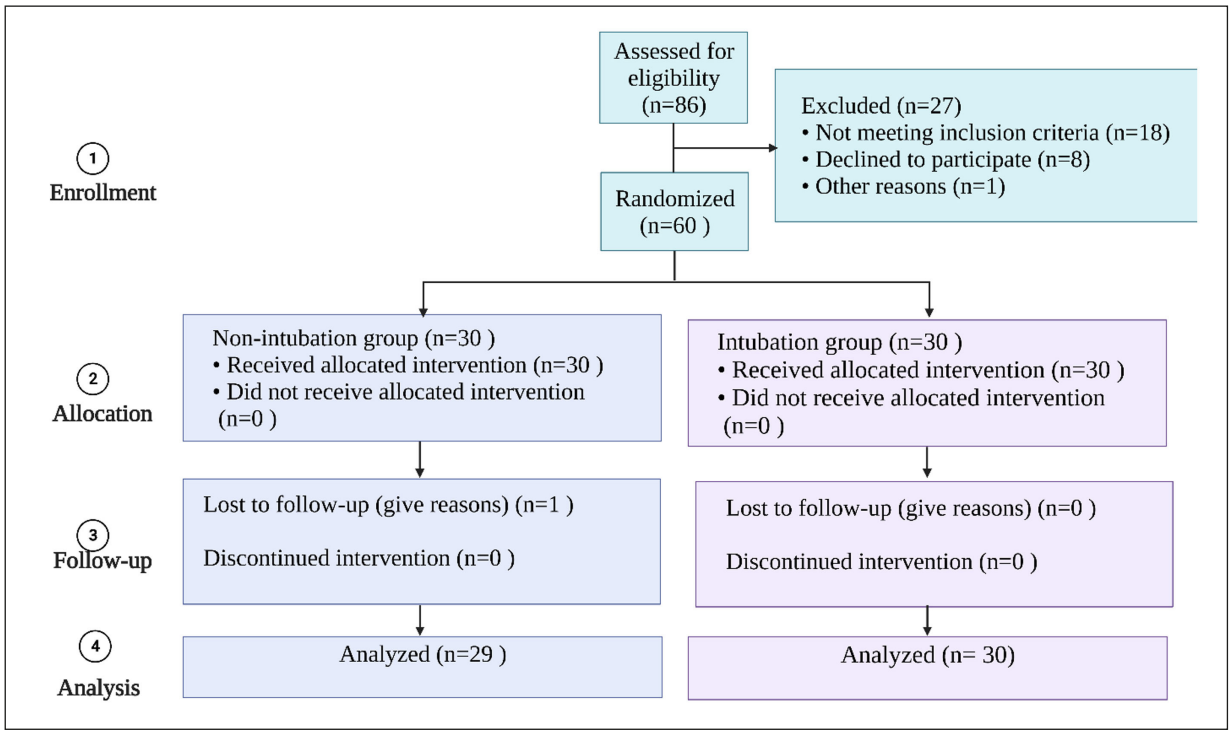

Figure 1. Flow diagram of the study.

Table I. Patients' general information.

	NI group (n=29)	I group (n=30)	p
Age (years)	47.24±11.72	46.17±10.25	0.709
Gender (male/female)	15/14	14/16	0.902
BMI	22.82±1.18	22.62±1.40	0.555
ASA (I/II)	6/23	5/25	0.692
Type of surgery (%)			0.903
Pleural lesions	4 (13.8%)	3 (10.0%)	
Pulmonary wedge resection	12 (41.4%)	13 (43.3%)	
Lobectomy	13 (44.8%)	14 (46.7%)	
Surgery duration (min)	103.97±31.01	101.17±31.83	0.734
Intraoperative blood loss (mL)	82.07±57.36	82.50±57.55	0.977

Data were presented as mean (SD), number (percentage). BMI = Body Mass Index; ASA = American Society of Anesthesiology physical status.

Table II. Postoperative recovery indicators.

	NI group (n=29)	I group (n=30)	χ^2	p
Duration of hospital stay (days)	5.07±1.19	6.87±0.97	-6.352	< 0.001
First exhaust time (h)	8.31±1.75	14.83±1.98	-13.360	< 0.001
Food intake time (h)	9.72±1.96	15.92±2.31	-11.180	< 0.001
First ambulation time (h)	15.97±1.99	23.47±2.62	-12.343	< 0.001
Chest-tube dwell time (days)	2.79±0.94	3.80±0.76	-4.528	< 0.001

Data were presented as mean (SD).

(PONV), pulmonary infection, atelectasis, sore throat, and hoarseness were significantly higher in the NI group ($p < 0.05$, Table III). VAS values at 2 h, 6 h, and 12 h post-operation were substantially lower in the NI group ($p < 0.05$, Table IV). An increase in the levels of cortisol and CRP was observed in both groups at the end of the operation and 24 hours post-operation, compared to pre-anesthesia values. Notably, these increases were more pronounced in the I group at every time point post-operation ($p < 0.05$, Table V and VI). Data were presented as mean (standard deviation, SD).

Discussion

Our study indicates that combining spontaneous breathing anesthesia with a thoracic paravertebral block can potentially shorten hospital stays for patients undergoing VATS. Patients treated with this approach also experienced several positive outcomes, such as faster post-surgery recovery, reduced postoperative complications, diminished pain intensity within 12 hours following the procedure, and decreased perioperative stress and inflammatory responses.

Table III. Postoperative complications.

	NI group (n=29)	I group (n=30)	χ^2	p
PONV (%)	4 (13.8%)	12 (40.0%)	3.484	0.024
Pulmonary infection (%)	0	4 (13.3%)	2.306	0.042
Atelectasis (%)	0	5 (16.7%)	3.351	0.022
Sore throat (%)	2 (6.9%)	15 (50%)	13.357	< 0.001
Hoarseness (%)	0	5 (16.7%)	3.351	0.022

Data were presented as numbers (percentage). PONV = Postoperative nausea and vomiting.

Table IV. Postoperative pain intensity (VAS).

	NI group (n=29)	I group (n=30)	F	p
Postoperative pain intensity (score)				
2 h	2.07±0.65	3.13±0.82	30.394	< 0.001
6 h	2.86±0.74	4.17±0.91	36.111	< 0.001
12 h	2.79±0.73	4.33±0.92	50.575	< 0.001
24 h	2.34±0.81	2.43±0.63	0.220	< 0.641
48 h	2.10±0.82	2.37±0.61	1.964	0.167

Data were presented as mean (SD). F_{group}=26.608, F_{time}=97.499, $F_{time*group}$=25.153, $p < 0.001$.

Table V. The levels of serum cortisol.

	NI group (n=29)	I group (n=30)	F	p
Before anesthesia	218.03±16.40	219.53±19.65	0.101	0.752
At the end of operation	225.14±14.83	235.37±17.71	5.762	0.02
24 h after operation	243.07±15.69	263.90±20.30	19.352	< 0.001

Data were presented as mean (SD). F_{group}=5.609, F_{time}=2,369.969, $F_{time*group}$=6.688, $p < 0.05$.

Table VI. The levels of CRP.

	NI group (n=29)	I group (n=30)	F	p
Before anesthesia	3.30±0.63	3.41±0.82	0.314	0.577
At the end of operation	12.13±1.47	13.41±2.75	4.870	0.031
24 h after operation	18.74±1.68	20.55±3.25	7.059	0.01

Data were presented as mean (SD). F_{group}=5.609, F_{time}=2,369.969, $F_{time*group}$=6.688, $p < 0.05$.

The reduced length of hospital stay observed in our study aligns with findings from a study by Liu et al[8]. This outcome is largely attributable to preserved spontaneous breathing techniques. In contrast to traditional anesthesia, the LMA was used as an alternative to endotracheal intubation, ensuring the preservation of spontaneous breathing and thereby mitigating the complications associated with intubation injury and muscle relaxant residue[25]. Previous studies[26] have reported that preserving spontaneous breathing can prevent lung injury resulting from excessive tidal volume or alveolar pressure, maintain basic lung function, and prevent atelectasis. Our study also revealed that LMA combined TPVB anesthesia technique mitigated postoperative stress responses and inflammation levels, further contributing to shortened hospital stays. Additionally, effective pain relief facilitates coughing and expectoration, while early ambulation aids in preventing pulmonary infection, both promoting a faster recovery for patients.

The use of TPVB was associated with lower VAS scores at 2-, 6-, and 12-hours post-operation, aligning with previous studies[27,28] which found TPVB to improve postoperative pain significantly. Furthermore, TPVB reduced opioid consumption[29,30], which likely led to a lower incidence of postoperative PONV in patients who received LMA combined with TPVB anesthesia[31,32]. The reduced PONV occurrence could also be related to less severe depression of the autonomic nervous system and faster recovery of gastrointestinal function.

Postoperative stress responses were found to be less severe in patients with preserved spontaneous breathing anesthesia, which aligns with findings by Sen et al[33]. Moreover, the effective, durable, and stable analgesic effect provided by TPVB appears to alleviate postoperative stress response[34].

Limitations

Our study does, however, have several limitations. First, the sample size was relatively small, although it was sufficient for the scope of our study. Second, the patients in our study were generally in good health, and the operation time was lower than 3 hours. As such, the LMA combined with the TPVB anesthesia method may only be suitable for a subset of patients, specifically those within ASA classes I-II. Third, our study only analyzed the short-term effects on patients; the long-term impact of this combined anesthesia technique remains unclear. Future research involving long-term follow-ups and larger, multi-center clinical studies will be required to further investigate the safety and efficacy of this anesthesia technique.

Conclusions

Our study suggests significant advantages for patients undergoing VATS with TPVB combined with LMA general anesthesia while preserving spontaneous breathing. Compared to traditional general anesthesia, this technique expedites patients' postoperative recovery.

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Authors' Contributions

Yong-Feng Zheng, Cai-Xia Sun, Ai-Zhong Shao, Jing-Feng Zhu: Conceived and designed the experiments; Performed the experiments; Wrote the paper. Yan-Shuang Jiang, Hai-Tong Liu, Yuan-Feng Chen: Contributed reagents, materials, analysis tools or data; Wrote the paper. Lian-Ping He, Fang-Zhou Chen, Xiao-Dong Ma: Analyzed and interpreted the data; Wrote the paper.

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Data Availability

Data will be made available on request.

Conflict of Interest

The authors report no conflicts of interest in this work.

Ethics Approval

Ethical approval for the study was secured from the Affiliated People's Hospital of Jiangsu University Ethics Committee (LLYW20190004).

Trial Registration

The trial was registered at Clinical Trials PRS (NCT05595096).

Informed Consent

Written informed consent was obtained from all participants.

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