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Assessment of intercostal nerve block analgesia and local anesthetic infiltration for thoracoscopic pulmonary bullae resection: a comparative study

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Abstract

Objective The purpose of this study was to compare the analgesic effects of intercostal nerve block (ICNB) and local anesthetic infiltration (LAI) on postoperative pain and recovery following thoracoscopic resection of pulmonary bullae.

Methods A total of 160 patients undergoing thoracoscopic pulmonary bullae resection were randomly assigned to receive either ICNB ($n=80$) or LAI ($n=80$). An experienced anesthesiologist administered ultrasound guided ICNB at the T4 and T7 levels with 5 mL of 0.375% ropivacaine hydrochloride for the ICNB group. Instead, the LAI group received 10 mL of the same concentration of ropivacaine hydrochloride at the same concentration used for ICNB for infiltration anesthesia at the incision sites. Out of the initial cohort, 146 patients completed the study (ICNB group, $n=71$; LAI group, $n=75$). The collected data included preoperative clinical characteristics, visual analog scale (VAS) scores for pain at various time points post-surgery (6, 12, 24, 48, and 72 h). Additionally, the Quality of Recovery-15 (QoR-15) questionnaire was administered 24 h after surgery, and sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI).

Results No significant differences were found in drainage volume, use of additional analgesics, duration of chest tube placement, or hospital stay between the two groups. However, the ICNB group had significantly lower VAS scores and QoR-15 scores 24 h postoperatively ($p<0.05$), indicating better pain management and recovery. The ICNB group also reported better sleep quality, as reflected by lower PSQI scores.

Conclusion ICNB provides superior analgesia compared to LAI after thoracoscopic resection of pulmonary bullae, significantly improving postoperative recovery.

Keywords Thoracoscopic pulmonary bullae resection, Intercostal nerve block, Local anesthetic infiltration

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Introduction

A bulla is radiologically defined as an expansion of the alveolar space with a diameter greater than 1 cm and a wall thickness of less than 1 mm. Giant pulmonary bullae (GPB) are defined as bullae of the lung occupying more than one-third of the hemithorax. A previous study has shown that GPB account for most of the adverse changes in lung function in up to one-third of the chest cavity [1, 2]. Video-assisted thoracoscopic surgery (VATS), which has been extensively used in the diagnosis and treatment of lung cancer, bullae, and mediastinal tumors [3]. However, patients still experience moderate to severe pain after thoracoscopic surgery, and effectively controlling the pain and improving postoperative recovery are challenging [4]. Thus, it is crucial for smooth recovery for VATS bullectomy with adequate analgesia.

Acute pain after thoracic surgery is common and severe and can lead to increased morbidity [5]. In the thorax, nociception travels primarily through the intercostal nerves. Increasing post-operative pain depends on various factors: surgical (procedure type, length and approach), patient response to pain and surgery and pre/peri-operative analgesic methods. Thus, to meet early patient discharge criteria, post-operative pain and side effects (nausea, vomiting and ileus) should be controlled [6]. Intercostal nerve blocks (ICNBs) are a common component of multimodal analgesia for thoracic surgery [7, 8]. Previous studies have found that ICNBs were superior to systemic analgesia and were associated with reductions in opioid consumption in postoperative surgical patients [9].

Despite the abundant research on the role of ICNB in flank incision analgesia for renal surgery [10], its impact on pain management and recovery after thoracoscopic surgery has not yet been investigated. This study aims to address this research gap by comparing the analgesic efficacy and postoperative recovery of ICNB *versus* local anesthetic infiltration (LAI) in patients undergoing thoracoscopic surgery, potentially providing novel insights into postoperative pain management.

Materials and methods

Study design

This study was approved by the Ethics Committee of Huaihai Hospital and approved this study (NO. 2018-009) and was registered on clinicaltrials.gov (Registration No: HHYY2018-KL080-02). All the patients signed an informed consent form, with all participants providing informed consent. This study was conducted in accordance with the Declaration of Helsinki. The investigation involved 160 patients from Huaihai Hospital, Xuzhou Medical University, admitted for treatment between January 2019 and December 2023, who met specific inclusion criteria. Patients were randomly assigned to one of two groups: the intercostal nerve block group (INB group, $n=80$) and the local infiltration anesthesia group (LAs group, $n=80$). Randomization was carried out using a computer-generated random number table. The allocation was concealed using sealed, opaque envelopes, which were opened only after the participant had been enrolled in the study.

This study was single-blind, meaning that the patients were unaware of the group allocation. The healthcare providers, including the surgeons and anesthetists, were not blinded due to the nature of the interventions. The patients were informed that they would receive one of two types of anesthesia for postoperative pain management but were not informed which specific method they would receive. The outcomes assessors were also blinded to the group assignments to reduce bias in data collection.

Inclusion criteria were as follows: (1) Computed tomography (CT) images suggest pulmonary bullae, include those with GPB; (2) Those with surgical indications for thoracoscopic bullectomy; (3) Strong compliance, and patients can cooperate in completing relevant work; (4) the patient's clinical data had to be complete and accurate. Exclusion criteria were as follows: (1) open thoracotomy; (2) Operation lasted more than 4 h; (3) the patient presented with one or more surgical contraindications (e.g., having a coagulation disorder, severe dysfunction of another organ or organ system, etc.). Patients were randomly assigned to receive either ICNB or LAI. Comprehensive clinical data were collected, and a follow-up was conducted until the third postoperative day.

All clinical data were recorded, including demographic information, history of present illness, medical history, CT images, size and location of bullae, postoperative complications, length of stay, symptoms, and pulmonary function. The follow-up period of each patient was from the day of surgery, post-operatively in the recovery room after the patient became fully conscious, until the end of the third post-operative day.

Initially, 160 patients were assessed for eligibility in this study and were randomly divided into the ICNB group ($n=80$) and LAI group ($n=80$). Subsequently, in the ICNB group nine patients were excluded as five of them were converted to thoracotomy and four were operated on for more than 4 h. Additionally, in the LAI group, five patients were excluded as three of them were converted to thoracotomy and two were operated on for more than 4 h, as shown in Fig. 1. Ultimately, 146 patients were enrolled according to the inclusion criteria and were randomly divided into ICNB group ($n=71$) and LAI group ($n=75$).

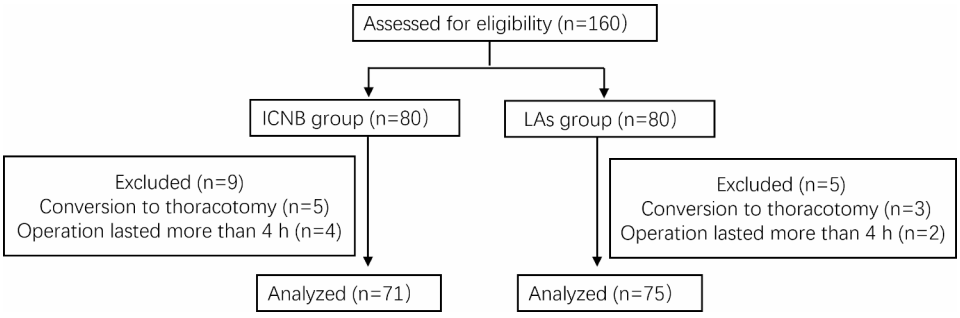

Fig. 1 Consort flow chart of patient enrollment

Table 1 Comparison of demographic data between groups

Group	*n*	Age (years)	BMI (kg/cm^2)	Surgical time(min)	Anesthesia time(min)	Intraoperative bleeding(ml)	Incision length (cm)
ICNB group	71	31.2 ± 12.9	23.7 ± 2.3	71.5 ± 17.3	145.5 ± 11.5	18.3 ± 6.8	4.3 ± 0.4
LAI group	75	29.1 ± 9.6	22.9 ± 3.0	69.6 ± 19.2	141.6 ± 13.6	21.2 ± 8.2	4.2 ± 0.7
p		0.35	0.19	0.64	0.27	0.17	0.36

Surgical techniques

All patients underwent single-port thoracoscopic lung bullectomy, which involved a single surgical incision. In the INB group, patients received a preemptive intercostal nerve block. Specifically, 5 ml of 0.375% ropivacaine hydrochloride was injected both at the T4 and T7 levels intercostal spaces along the paravertebral line, and each intercostal nerve was injected for 5 s. In the LAs group, patients received local infiltration anesthesia, where 10 ml of 0.375% ropivacaine hydrochloride was infiltrated around the incision site. Both anesthesia techniques were administered according to standardized protocols to ensure consistency across all procedures.

The VAS was used to assess pain levels. In addition, patients were subjected to preoperative fasting and water deprivation. After patients entered the operating room, VAS scores at rest and during coughing, preoperative quality of recovery-15 (QoR-15) score [11], as well as lung function parameters were recorded in a sitting position.

Participants completed the Pittsburgh Sleep Quality Index (PSQI) questionnaire. The PSQI questionnaire is a self-report assessment tool that evaluates sleep quality over a one-month period [12]. A global score and seven component scores can be derived from the scale. The component scores are the following: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medications and daytime dysfunction. Each component is scored on a scale from 0 to 3, with the total score ranging from 0 to 21; where a higher score indicates poorer sleep quality [13].

Statistical analysis

Statistical analysis was performed using the SPSS (version 22.0) software (IBM Corporation, Armonk, NY, USA), and graphs were drawn using the GraphPad Prism (version 9.0.) software (GraphPad Software Inc., San Diego, CA, USA). Continuous variables were assessed for normality using the Shapiro-Wilk test. Normally distributed data were expressed as the mean ± SEM and compared between groups using the independent samples t-test. Non-normally distributed data were expressed as the median (M) and interquartile range (IQR) and compared between groups using the Mann-Whitney U test. Categorical variables were expressed as n (percentage) and compared between groups using the χ [2] test or Fisher's exact test. $p<0.05$ was considered statistically significant.

Results

Comparison of preoperative clinical data between groups

Of 160 records screened, 14 were excluded based on the prespecified exclusion criteria discussed in Methods (Fig. 1). A comparison of the preoperative clinical data, encompassing clinical characteristics and surgical specifics, is summarized in Table 1. There were no significant differences in clinical characteristics, operative details, intraoperative blood loss, or incision length between the intercostal nerve block (ICNB) and local anesthetics (LAI) groups ($p>0.05$).

Comparison of consumption of postoperative analgesics between groups

Regarding postoperative analgesia, a minority of patients reported dizziness, nausea, and vomiting, with no significant difference in the incidence of these symptoms between groups ($p>0.05$). There were no cases of respiratory depression, constipation, skin pruritus, urinary retention, or nerve block-related complications in either group. The Quality of Recovery-15 (QoR-15) scores were notably lower in the ICNB group at 24 h postoperatively

Table 2 Comparison of postoperative recovery and occurrence of adverse events

Variables	ICNB group (*n* = 71)	LAI group (*n* = 75)	*p*
Channel traffic(*ml*)	143.5 ± 18.4[b]	196.6 ± 32.3	0.00
Analgesia(%)	6.8[b]	46.7	0.00
Residence(*day*)	2.1 ± 0.6[a]	2.8 ± 0.6	0.03
Hospitalization time(*day*)	3.5 ± 0.5[b]	4.4 ± 1.0	0.00
Postoperative QoR-15 score	123 ± 9[a]	122 ± 6	0.002
Nausea and vomiting	12 (16.9%)	14 (18.7%)	0.413
Dizziness	21 (29.6%)	23 (30.7%)	0.287

[a]$p<0.05$ vs. the LAI group;[b]$p<0.01$ vs. the LAI group

compared to the LAI group ($p<0.05$). Additionally, the duration of chest tube drainage and hospital stay was significantly reduced in the ICNB group ($p<0.05$), as shown in Table 2.

Comparison of VAS scores between groups

The VAS scores for pain at rest and during coughing were significantly lower in the ICNB group at 12 and 24 h postoperatively compared to the LAI group ($p<0.05$), as detailed in Table 3. However, differences were not statistically significant at 12, 24 h after surgery.

Comparison of PSQI between groups

The Pittsburgh Sleep Quality Index (PSQI) parameters, including duration of light, deep, and REM sleep, were significantly enhanced in the ICNB group in contrast to the LAI group ($p<0.05$), as presented in Table 4. The PSQI score was significantly lower for the ICNB group (3.9 ± 1.4) than the LAI group (6.9 ± 2.3) ($p<0.01$).

Discussion

This study demonstrated that ICNB significantly reduces the duration of chest tube drainage and hospital stay following thoracoscopic procedures compared to LAI. Additionally, the QoR-15 scores were lower for patients receiving ICNB. However, we found no significant difference in the incidence of dizziness, nausea, or vomiting.

GPB are defined as bullae of the lung occupying more than one-third of the hemithorax [14]. Treatment is necessary for patients with GPB with complications, such as progressive respiratory insufficiency, pneumothorax, and intrafoveal infection [15]. The pain after thoracoscopy is associated with a combination of factors. Specifically, acute pain is caused by surgical incisions and lung parenchymal injury. Persistent pain stimulation may lead to peripheral or central sensitization, increasing the incidence of chronic pain [16]. The role of local analgesic agents in decreasing post-operative pain and prolonging the duration of analgesia post-operatively has been widely studied. Nirmala et al.. studied the role of a bupivacaine and buprenorphine combination and found that this combination was effective in reducing the total analgesic requirements and in increasing the duration of the post-operative analgesic time [17]. Meanwhile, Singh et al.. compared wound infiltration to the ICNB method and found that wound infiltration was superior in decreasing the total analgesic requirements and post-operative pain, as well as prolonging the first analgesic demand, which is inconsistent with the results of our study. On the other hand, Nirmala et al.. showed that ropivacaine, when used in an ICNB, had superior analgesic efficacy to peritubal infiltration post percutaneous nephrolithotomy, as evidenced by the reduction in the number of analgesic demands and consumption, as well as in the longer time

Table 3 Comparison of VAS between groups

Variables	Group	Time after surgery (h)				
		6	12	24	48	72
Resting	ICNB	1.6 ± 0.4[NS]	1.9 ± 0.3[a]	2.1 ± 0.6[a]	2.0 ± 0.4[NS]	1.7 ± 0.4[NS]
	LAI	1.9 ± 0.6	2.5 ± 0.4	3.0 ± 0.7	2.3 ± 0.6	1.8 ± 0.6
p		0.09	0.04	0.01	0.13	0.36
Cough	ICNB	1.8 ± 0.5[NS]	2.6 ± 0.4[a]	2.9 ± 0.6[b]	2.5 ± 0.6[NS]	1.9 ± 0.8[NS]
	LAI	2.2 ± 0.5	3.5 ± 0.8	4.1 ± 0.5	2.9 ± 0.8	2.0 ± 0.6
p		0.13	0.01	0.00	0.20	0.24

[a]$p<0.05$, [b]$p<0.01$, [NS]$p>0.05$ vs. the corresponding LAI group

Table 4 Comparison of PSQI score between groups

Group	Quality of sleep				WAS (Min)	PSQI score
	Light Sleep (%)	Deep Sleep (%)	REM Sleep (%)	Sleep Onset Latency (Min)		
ICNB	46.2 ± 6.4[b]	7.3 ± 3.2	21.4 ± 3.2[b]	29.1 ± 16.3[a]	33.4 ± 11.5[a]	3.9 ± 1.4[b]
LAI	61.3 ± 5.8	9.3 ± 2.2	28.2 ± 4.7	33.5 ± 26.8	45.7 ± 23.4	6.9 ± 2.3
p	0.00	0.00	0.00	0.03	0.02	0.00

[b]$p<0.01$, [a]$p<0.05$ vs. the corresponding LAI group

to first analgesic rescue, which is consistent with our results [18].

In this study, the postoperative QoR-15 score was significantly lower in the ICNB group than in the LAI group. The results of our study indicated that VAS scores at rest and during coughing were similar at the observation times between both groups. Postoperative pulmonary function parameters objectively reflected the analgesic effect, and there was also no statistical difference in pulmonary function parameters at 1, 4, and 24 h postoperatively between the two groups. Due to the residual anesthesia, initial recovery and patient's activity ability and other factors, often due to the residual anesthesia and the small amount of activity, do not need to actively cough, pain is not obvious at the 6th hour after surgery, so there is no obvious difference between the two groups, 12 h and 24 h after surgery anesthesia has basically been completely metabolized, the need for patients to take the initiative to cough, coughing to prevent and control lung infections and take the initiative to get out of bed, which is the most obvious time of postoperative pain, the intercostal nerve tissue and local anesthesia for analgesia. The intercostal nerve tissue and local anesthesia have obvious differences for analgesia, 48 h and 72 h after the operation, the patients have found suitable coughing and getting out of bed activities, and the pain has been reduced, we observed that there is no obvious difference between the two groups at this time.

Our research found that compared to the LAI group, ICBN group has the following advantages: (1)Superior Analgesic Effect: ICNB provides more effective pain relief compared to LAI. This enhanced pain control likely allows patients to engage more actively in postoperative activities, such as coughing and breathing exercises. Effective pain management is crucial for promoting lung expansion and mobilization of secretions, which can help prevent complications such as pneumothorax recurrence and reduce the need for prolonged chest tube drainage. (2) Improved Patient Compliance: With better pain control, patients in the ICNB group are likely to participate more actively in postoperative rehabilitation exercises and respiratory therapy. This increased participation can contribute to faster recovery, shorter chest tube duration, and reduced hospital stay. (3) Reduced Postoperative Complications: Effective pain management with ICNB may also reduce the incidence of postoperative complications that can prolong hospital stay. For example, better pain control can decrease the risk of complications related to inadequate respiratory effort, such as atelectasis or infection, which can otherwise lead to prolonged chest tube use and extended hospitalization.

This study has the limitation that it did not measure the time to perform ultrasound-guided nerve blocks, so it did not compare the time cost of the two nerve blocks.

In conclusion, ICNB is better than LAI in terms of VAS scores, QoR-15 scores, PSQI scores and recovery. This method prevents damage by ensuring that there is enough distance from the spinal cord, blood vessels, and pleura, which is safer and easier for beginners to operate, thus providing a new analgesic method for thoracic anesthesia.

Author contributions

Bing Huang and Yujing Zhang had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Jing Shi, Yingtong Feng and Jianfu Zhu revised the manuscript for important intellectual content acquisition, analysis, or interpretation of data. Sen Li and Ning Shan collected data. All authors drafted of the manuscript and statistical analysis.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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