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*Original Article*

# CYP3A4 gene expression discloses individual differences in postoperative pain susceptibility and drug treatment response in patients with lung cancer

Xiunan Jia[1*], Xi Nan[1*], Shiqi Diao[1], Dongxin Wang[1], Tongrao Wang[1], Dongmei Fu[1], Chunyan Ni[1], Ying Chang[1], Jixin Liu[1], Xitong Zhang[1], Hongling Cao[1], Xiaoyu Zhang[1], Dongxue Li[1], Qing Zu[1], Gang Liu[2], Zongming Liu[1]

*[1]Department of Anesthesiology, Jilin Province Cancer Hospital, Changchun 130021, Jilin, China; [2]Department of Thoracic Oncology, Jilin Province Cancer Hospital, Changchun 130021, Jilin, China. [*]Equal contributors.*

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**Abstract:** This study investigates the influence of CYP3A4 gene polymorphisms on postoperative pain sensitivity and analgesic response in lung cancer patients undergoing intercostal nerve block with local anesthetics. Sixty patients (ages 31-74) undergoing thoracoscopic lung cancer surgery were enrolled and divided into two groups based on CYP3A4 gene expression level: Group I (high CYP3A4) and Group II (low CYP3A4). Postoperative pain was assessed using the Visual Analogue Scale (VAS), and patient-controlled intravenous analgesia (PCIA) pump usage, ECG ST-T segment changes, complications, hospital stay, and costs were recorded. Results showed significantly higher VAS scores, PCIA usage, ST-T depression, complications, longer hospital stay, and higher costs in Group I compared to Group II ($P < 0.05$). These findings suggest that higher CYP3A4 expression is associated with increased postoperative pain, complications, and healthcare cost. According to CYP3A4 gene expression activity, which was determined before surgery, patients with low enzyme activity metabolized local anesthetics slowly, which resulted in better analgesic effect and a longer duration of intercostal nerve block anesthesia. Owing to the impact of CYP3A4 gene expression on local anesthetic metabolism, precise intercostal nerve block anesthesia and individualized pain treatment plans could be formulated for patients undergoing radical thoracoscopic surgery for lung cancer. This may accelerate postoperative recovery from lung cancer and reduce both the length of hospital stay and hospitalization costs.

**Keywords:** CYP3A4, gene polymorphism, lung cancer, pain, intercostal nerve block

## Introduction

Lung cancer remains one of the most prevalent malignancies worldwide and a leading cause of cancer-related mortality [1]. Surgical resection, which is often accompanied by significant postoperative pain, is the primary treatment modality for lung cancer [2]. Intercostal nerve block anesthesia is widely utilized in thoracic surgery because of its effectiveness and relatively low cost in managing postoperative pain [3-5]. However, individual differences in pain sensitivity and response to analgesic medications present challenges in achieving optimal pain control [6].

Cytochrome P450 (CYP) enzymes play critical roles in drug metabolism, including the metabolism of local anesthetics such as ropivacaine [7, 8]. The CYP3A4 enzyme, encoded by the CYP3A4 gene, primarily metabolizes ropivacaine [5]. Genetic polymorphisms in the CYP3A4 gene can lead to variations in enzyme activity, influencing the metabolism and pharmacokinetics of ropivacaine [9, 10].

While some studies have revealed the potential benefit of individualized adjustments to ropivacaine dosing, we were unable to provide a reference since it was published in 1987; and the relationship between postoperative analgesia in patients with lung cancer and the activity of this gene has not been reported. In our study, we aimed to explore the impact of CYP3A4 gene expression on the individualized response to ropivacaine-based intercostal nerve block

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anesthesia in patients who underwent thoracoscopic lung cancer surgery. The aim of this endeavor was to provide further insights into its evaluation in clinical practice, thus offering more practical implications for cancer patients.

## Materials and methods

### *General information*

This study was a prospective study. The clinical registration platform is: Jilin Provincial Health Commission, Changchun, Jilin, China. The registration number is: 2021LC133. Our study was approved by the Jilin Province Cancer Hospital Institutional Review Board (202108-024-01), and we obtained informed consent from patients and/or their families. All participants underwent preoperative blood sampling of 5 ml to assess CYP3A4 gene expression activity, and optical density (OD) values were recorded.

The inclusion criteria were as follows: underwent thoracoscopic lung cancer resection surgery at our institution between January 2022 and December 2023; were aged 31-74 years; had an ASA classification I-III; and randomly divided into two groups (30 patients per group) based on their OD values. Group I means patients with high CYP3A4; Group II means patients with low CYP3A4. The preoperative criteria included no myocardial ischemia, normal lung function, no history of local anesthetic allergy, and intercostal nerve block anesthesia.

The exclusion criteria were severe cardiac or pulmonary insufficiency (cardiac function > grade 3; hypertension > grade 3), severe liver or renal dysfunction, coagulation disorders, diabetes, hypothyroidism, or unsuccessful intercostal nerve block anesthesia.

### *Methods*

*Anesthesia monitoring:* Upon entering the operating room, all patients underwent routine placement of two peripheral venous catheters in the lower extremities. The patients' vital signs were continuously monitored using the Deltex anesthesia system, including blood pressure monitoring with four-limb leads and one chest lead, heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygen saturation (SPO2), and the bispectral index (BIS) for depth of anesthesia. Inhalation and exhalation concentrations of sevoflurane were monitored in real time during surgery. Additionally, temperature and muscle relaxation were monitored throughout the procedure.

*Anesthesia method:* Preoperative stage: Both groups of patients received standard induction anesthesia by intravenous injection of midazolam (0.02-0.03 mg/kg), sufentanil (0.2-0.4 μg/kg), or propofol (1.0-1.5 mg/kg), etomidate (0.15-0.20 μg/kg), or cisatracurium (0.15-0.2 mg/kg) (3-4 times the ED95 dose). After a satisfactory depth of anesthesia was achieved (BIS value between 40 and 60), double-lumen endotracheal intubation was performed using a video laryngoscope. Fiber bronchoscopy was immediately conducted to confirm the correct placement of the double-lumen tube.

Intraoperative stage: Both groups of patients received intravenous combined general anesthesia with continuous target-controlled infusion (TCI) of remifentanil (0.05-0.15 ng/ml), along with inhalation of sevoflurane at 1.0-1.3 MAC to maintain sedation. Additional doses of sufentanil and cisatracurium were administered as needed on the basis of the bispectral index (BIS) and neuromuscular monitoring. Mechanical ventilation was used to control respiration, with the tidal volume set to 6-8 ml/kg and the respiratory rate adjusted to maintain the end-tidal $CO_2$ concentration between 35 and 45 mmHg, ensuring $SpO_2$ > 90%.

Postoperative stage: After the procedure, both groups of patients were monitored until consciousness and reflexes fully recovered. The double-lumen endotracheal tube was removed after clearing secretions and confirming clear bilateral breath sounds without complications such as lung collapse. The patients were maintained at a spontaneous breathing rate of 10-12 breaths/min and a tidal volume of 6-8 ml/kg without pain at the surgical site or drainage site. The vital signs remained stable, and the patients were safely transferred back to the recovery room.

*Analgesic methods:* Intercostal nerve block anesthesia: Prior to chest closure, all patients received intercostal nerve block anesthesia at two sites, namely, the surgical incision site and the drainage tube insertion site, under direct

**Table 1.** Comparison of general data of patients ($\bar{X}$±SD)

| | Group I (n=30) | Group II (n=30) | t-value | *p*-value |
|---|---|---|---|---|
| Age (years) | 58.67±8.03 | 59.20±7.27 | 0.270 | 0.788 |
| Weight (kg) | 66.50±11.66 | 69.67±9.90 | 1.134 | 0.262 |
| Height (cm) | 165.07±7.55 | 167.37±7.33 | 1.197 | 0.236 |
| BMI | 24.35±3.60 | 24.82±2.89 | 0.562 | 0.577 |
| Surgery duration (min) | 158.07±73.37 | 130.40±64.12 | 1.555 | 0.125 |

**Table 2.** CYP3A4 gene expression in the two groups of patients ($\bar{X}$±SD)

| Group | N | Level of CYP3A4 expression |
|---|---|---|
| Group I | 30 | 1.383±0.390 |
| Group II | 30 | 0.865±0.168 |
| t-value | - | 7.006 |
| *p*-value | - | 0.001 |

visualization via thoracoscopy. Method: A 5 cm long 22G needle was used for vertical penetration slightly above the lower edge of the rib, reaching the lateral aspect of the latter. The needle tip was then gently moved to the lower edge of the rib and advanced approximately 0.3 cm. After confirming the absence of blood or air aspiration, 10 ml of 0.375% ropivacaine local anesthetic solution was injected at each site.

Postoperative patient-controlled intravenous analgesia (PCIA): Patient-controlled analgesia was initiated 2 hours postoperatively using a drug combination comprising 200 mg of flurbiprofen ester, 100 μg of sufentanil, and 100 ml of normal saline [11-14].

*Observed indicators*

*CYP3A4 gene expression activity:* All patients underwent preoperative blood collection (5 ml) for the detection of CYP3A4 gene expression activity, and the enzyme content was recorded for comparison.

*Pain conditions:* We observed and recorded the resting incisional pain levels for both groups of patients 2 ($T_1$), 4 ($T_2$), 6 ($T_3$), 8 ($T_4$), and 12 hours ($T_5$) postoperatively by the visual analog scale (VAS). The VAS score ranges from 0 (no pain) to 10 (unbearable, severe pain). Additionally, we recorded the number of times the PCIA pump button was pressed 2, 4, 6, 8, and 12 hours postoperatively and compared them by considering the postoperative intervals of 0-2, 0-4, 0-6, 0-8, and 0-12 hours.

*ST-T segment depression on electrocardiogram (ECG):* We recorded the presence of ST-T segment depression on the ECG at various time points postoperatively for both groups of patients.

*Adverse reactions postoperatively:* We recorded the incidence of complications, including respiratory depression, circulatory depression, mucus plug formation, and the occurrence of lung collapse (atelectasis), within 12 hours postoperatively for both groups of patients and compared the occurrence rates of complication between the two groups. Finally, we calculated the incidence rates of these complications.

*Statistical analysis*

The data in this study were analyzed using SPSS 21.0 software for statistical processing. Descriptive statistics for normally distributed continuous data are presented as the mean ± standard deviation ($\bar{X}$±SD), and the independent samples T-test was used for comparison. Categorical data were analyzed by the chi-square test. A *p* value lower than 0.05 ($P < 0.05$) was considered significant.

## Results

*Comparison of baseline characteristics between groups reveals no significant differences*

First, general data of the patients (**Table 1**) disclosed no significant differences ($P > 0.05$).

*Comparison of CYP3A4 gene expression activity in blood between groups*

In this comparison, the optical density (OD) value, which reflects the level of CYP3A4 gene expression in the blood, was measured for both groups of patients. The results (**Table 2**; **Figure 1**) revealed that the OD value was higher in Group I than in Group II, indicating greater CYP3A4 gene expression activity in Group I. This difference was significant (**P < 0.01),

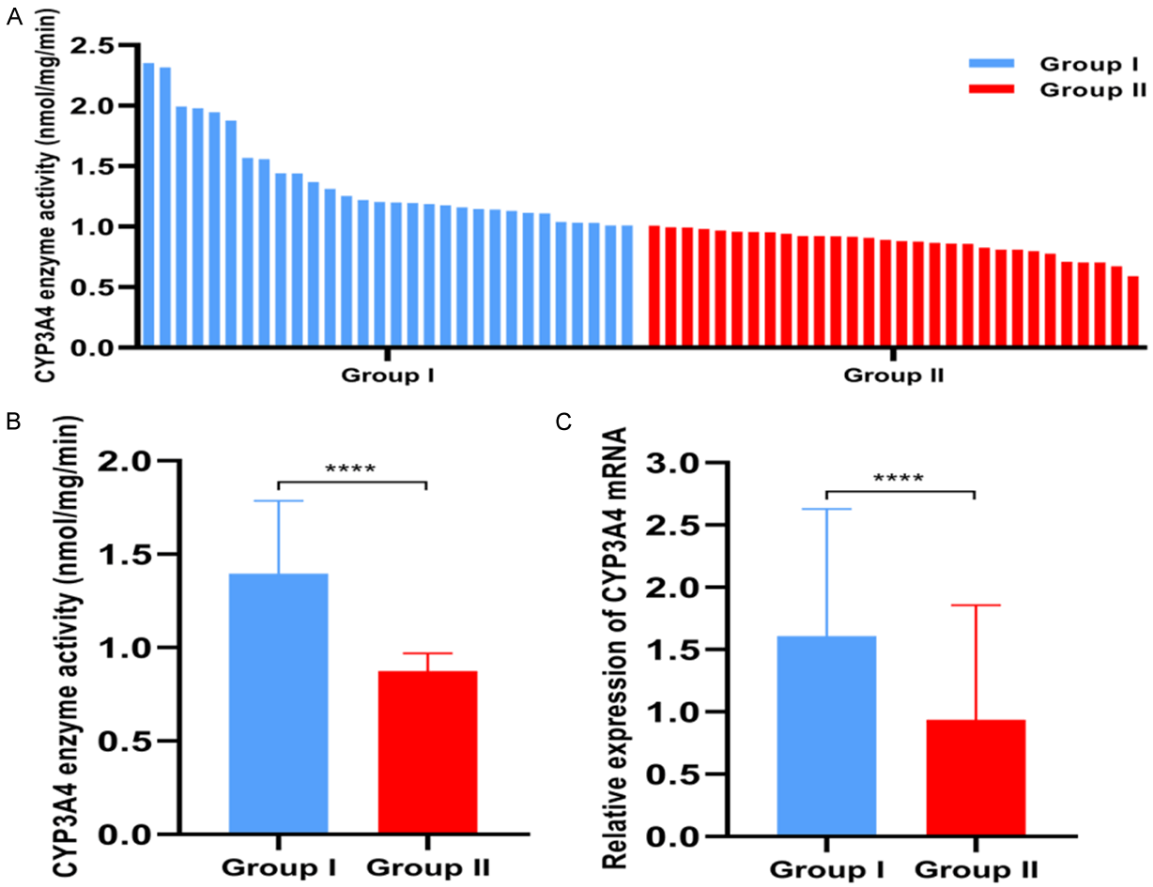


**Figure 1.** Comparison of CYP3A4 gene expression activity in blood between groups. A: CYP3A4 enzyme activity in all patients. B: CYP3A4 enzyme activity in the groups. Group I was higher than Group II (***P < 0.001). C: Relative expression of CYP3A4 mRNA in two groups. Group I is higher than Group II (***P < 0.001).

**Table 3.** CYP3A4 Primer sequence

| Primer | Sequence (5' to 3') |
|---|---|
| Forward P450 | TTCAACAGATGATCGACTCCCA |
| Reverse P450 | TTGTGTCATAGGCAGCAAAAATG |

suggesting a meaningful variation in CYP3A4 gene activity between the two groups. The CYP3A4 primer sequence in **Table 3**.

*Postoperative VAS score comparison between groups over time*

Visual analog scale (VAS) scores, which measure pain intensity, were compared between the two groups at various time points after surgery. At the initial time point ($T_1$), there was no significant difference in the VAS score between Group I and Group II (P > 0.05), indicating similar pain levels shortly after surgery. However, from $T_2$ to $T_5$, Group I consistently reported significantly higher (**P < 0.01) VAS scores than did Group II. This significant difference suggests that patients in Group I experienced more intense postoperative pain during these later time points (**Table 4**; **Figure 2**). Moreover, The VAS score $T_2$ of patients in group I was higher than $T_1$. This was because the metabolic half-life of local anesthetic ropivacaine is about 4 hours, so the patient's pain began to worsen 4 hours after surgery ($T_2$). At the same time, patients in Group I have higher expression of CYP3A4 enzyme activity and metabolize the local anesthetic ropivacaine faster. Since ropivacaine is gradually and completely metabolized, the pain levels at $T_3$, $T_4$, and $T_5$ are significantly higher than those at $T_1$. The pain of patients in group II also began to worsen at $T_2$; that is, the VAS score of $T_2$ was higher than that of $T_1$, but the pain level at the $T_2$ time point was significantly lower than that of group I, because the enzyme content of patients in group II was

**Table 4.** VAS scores of patients in the two groups at each time point ($\bar{X}$±SD)

| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ |
|---|---|---|---|---|---|
| Group I (n=30) | 1.467±0.507 | 3.767±0.679 | 5.033±0.718 | 5.467±0.681 | 6.233±0.728 |
| Group II (n=30) | 1.333±0.479 | 2.433±0.504 | 3.667±0.661 | 4.433±0.679 | 5.667±0.661 |
| t-value | 1.046 | 8.637 | 7.668 | 5.884 | 8.070 |
| *p*-value | 0.300 | 0.001 | 0.001 | 0.001 | 0.003 |

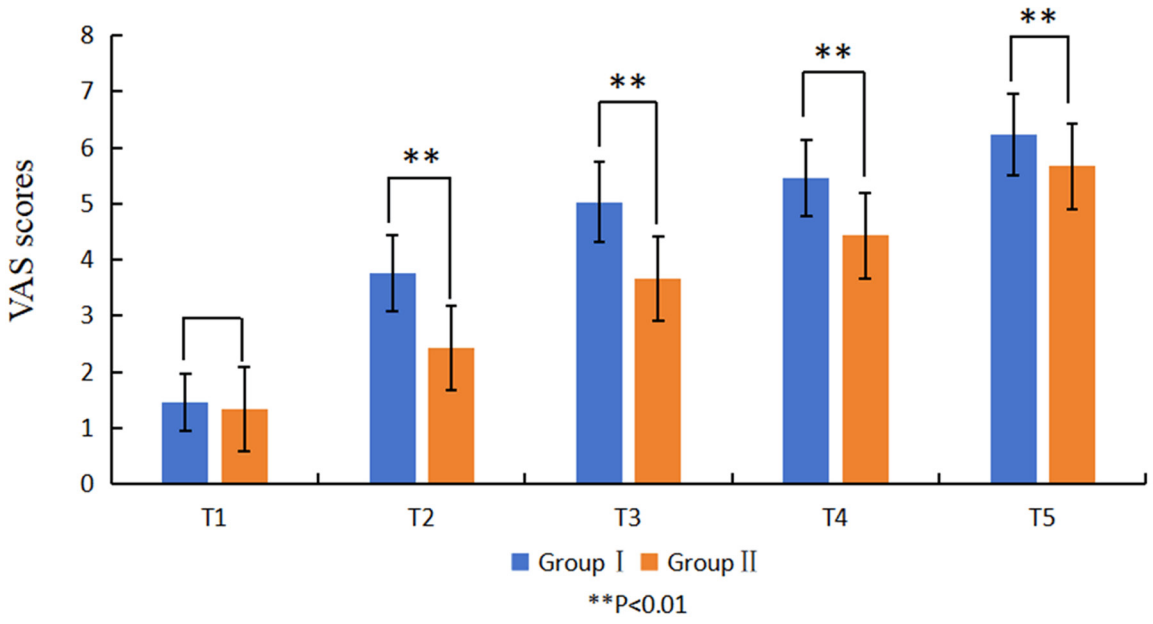


**Figure 2.** Quantitative analysis of **Table 4**.

low. This prolonged the half-life of ropivacaine metabolism. The analgesic effect was significantly better than that of patients in group I. Although the VAS scores of group II at $T_3$, $T_4$, and $T_5$ time points were also higher than those at $T_1$ time point, this was due to the low expression of CYP3A4 enzyme activity in the patients and the slow metabolism of ropivacaine. The VAS score at each time point was also significantly lower than that of group I (Supplementary Table 1).

*Comparison of the number of postoperative PCIA pump presses between group over time*

The number of presses of the patient-controlled intravenous analgesia (PCIA) pump, which indicates the frequency of patient-requested pain relief, was compared between the two groups at different time points after surgery. At the initial time point ($T_1$), there was no significant difference between Group I and Group II ($P > 0.05$), suggesting similar immediate postoperative pain management needs. However, from $T_2$ to $T_5$, Group I presented a significantly greater number of PCIA pump presses than did Group II (**$P < 0.01$). This need of Group I for more frequent analgesia indicated greater pain or discomfort during these later postoperative periods (**Table 5**; **Figure 3**). Moreover, due to the worsening of postoperative pain, patients began to increase the number of compressions of the PCIA pump. Group I metabolized ropivacaine quickly, and the pain appeared early and severe. The number of compressions of the PCIA pump at $T_2$ was higher than that at $T_1$. As the pain worsened, the number of PCIA pump compressions at $T_3$, $T_4$, and $T_5$ time points was significantly higher than that at $T_1$; patients in group II also increased the number of PCIA pump compressions at $T_2$, but the pain level was lower than that of group I, and the number of compressions was less than that of group I. Due to the half-life of the drug, long-term, the

**Table 5.** Pressing times of PCIA pump in the two groups at each time point ($\bar{X}$±SD)

| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ |
|---|---|---|---|---|---|
| Group I (n=30) | 0.60±0.50 | 4.50±0.86 | 5.80±0.96 | 7.93±0.98 | 10.63±1.30 |
| Group II (n=30) | 0.53±0.51 | 2.80±0.76 | 3.47±0.90 | 5.03±0.93 | 9.70±1.02 |
| t-value | 0.513 | 8.102 | 9.520 | 8.518 | 10.978 |
| *p*-value | 0.610 | 0.001 | 0.001 | 0.001 | 0.003 |

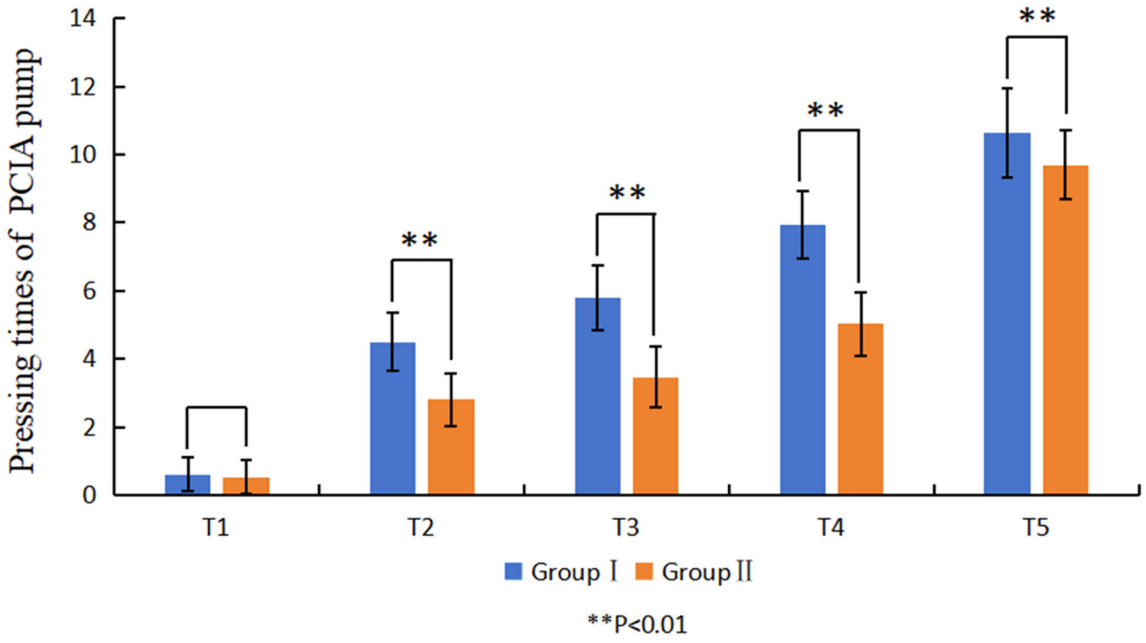


**Figure 3.** Quantitative analysis of **Table 5**.

number of PCIA pump compressions at $T_3$, $T_4$, and $T_5$ time points were significantly lower than that of group I (Supplementary Table 2).

*Comparison of postoperative ST-T depression on electrocardiograms between groups over time*

The degree of ST-T depression on electrocardiograms (ECGs), which can indicate cardiac stress or ischemia, was compared between the two groups at various time points after surgery. At the initial time point ($T_1$), there was no significant difference in ST-T depression between Group I and Group II ($P > 0.05$), suggesting similar cardiac conditions immediately after surgery. However, from $T_2$ to $T_5$, Group I presented a significantly greater magnitude of ST-T depression than Group II did (**$P < 0.01$). This difference indicates that patients in Group I experienced more pronounced cardiac stress or ischemia during these later postoperative periods (**Table 6**; **Figure 4**). Moreover, postoperative pain increased the patient's myocardial oxygen consumption, and the electrocardiogram showed a downward shift of ST-T, inducing myocardial ischemia. Patients in group I had increased pain due to rapid drug metabolism, with ST-T at $T_2$, $T_3$, $T_4$, and $T_5$ time points. The downward movement amplitude for these time points was significantly greater than that of $T_1$. Due to the different time and degree of pain onset in the two groups of patients, the ST-T downward movement amplitude of patients in group II at each time point of $T_2$, $T_3$, $T_4$, and $T_5$ was significantly lower than that of group I (Supplementary Table 3).

*Comparison of postoperative complication incidence rates between groups*

The incidence rates of several postoperative complications - respiratory depression, circulatory depression, sputum plug, and pulmonary

**Table 6.** Variations in the ST-T segment of the electrocardiogram in the two groups at each time point ($\bar{X}$±SD)

| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ |
|---|---|---|---|---|---|
| Group I (n=30) | 0.032±0.008 | 0.088±0.019 | 0.120±0.017 | 0.147±0.018 | 0.150±0.016 |
| Group II (n=30) | 0.029±0.005 | 0.041±0.005 | 0.043±0.008 | 0.044±0.007 | 0.134±0.021 |
| t-value | 1.300 | 12.926 | 22.618 | 29.459 | 32.737 |
| *p*-value | 0.199 | 0.001 | 0.001 | 0.001 | 0.002 |

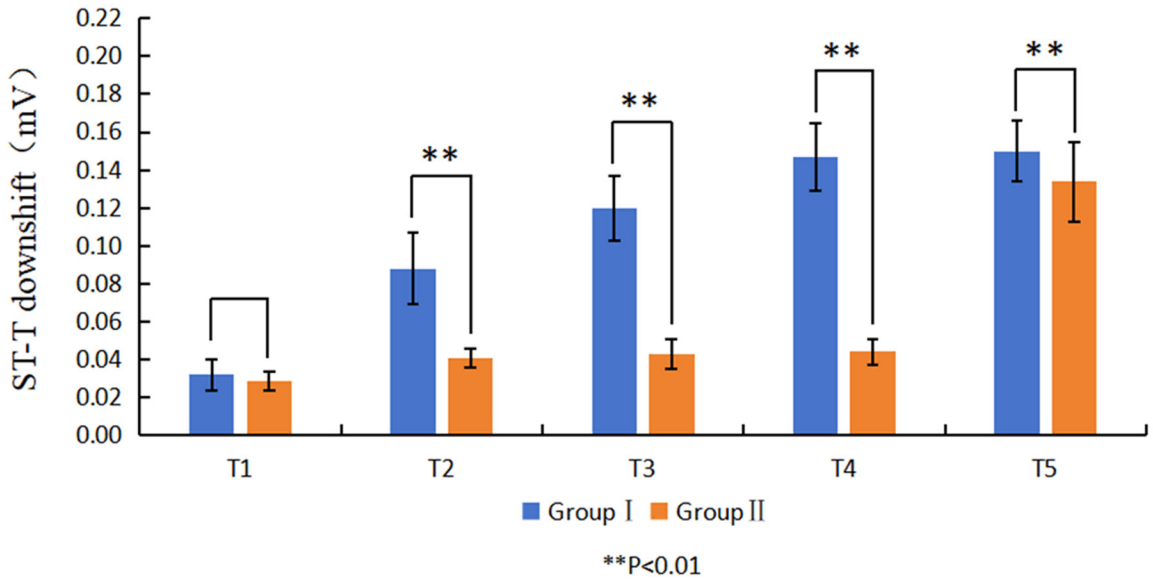


**Figure 4.** Quantitative analysis of **Table 6**.

atelectasis - were compared between the two groups. The results revealed that Group I had significantly higher (*P < 0.05) incidence rates of these complications than did Group II. Specifically, the rates of respiratory depression and circulatory depression were notably higher in Group I, indicating more frequent occurrence of impaired breathing and circulatory function after surgery. Additionally, Group I experienced higher rates of sputum plug formation and pulmonary atelectasis, suggesting more issues with airway obstruction and lung collapse, respectively. These differences were significant, highlighting a greater overall burden of postoperative complications in Group I (**Table 7**; **Figure 5**).

*Comparison of postoperative hospitalization days and cost between groups*

The postoperative hospitalization duration and associated costs were compared between the two groups. The results indicated that patients in Group I had significantly longer (**P < 0.01) hospitalization days than did those in Group II. This extended hospital stay in Group I reflects a prolonged recovery period. Consequently, the hospitalization costs for Group I were also significantly higher than those for Group II. These differences suggest that the patients in Group I not only required more extended postoperative medical care but also had higher health care cost (**Table 8**; **Figure 6**).

## Discussion

Currently, surgical resection is the preferred treatment method for lung cancer [15], but postoperative pain remains a major clinical issue [16]. Studies have shown that postoperative pain can lead to a series of detrimental effects, primarily the exacerbation of cardiovascular workload and an increase in oxygen consumption, thereby resulting in an increased incidence of cardiovascular events, a delay in postoperative respiratory function recovery [17,

**Table 7.** Incidence of postoperative complications in the two groups

| | Respiratory depression | Circulatory depression | Phlegm embolism | Atelectasis |
|---|---|---|---|---|
| Group I (n=30) | 10 (33%) | 14 (47%) | 8 (27%) | 8 (27%) |
| Group II (n=30) | 2 (7%) | 3 (10%) | 1 (3%) | 1 (3%) |
| *p*-value | 0.01 | 0.002 | 0.011 | 0.011 |

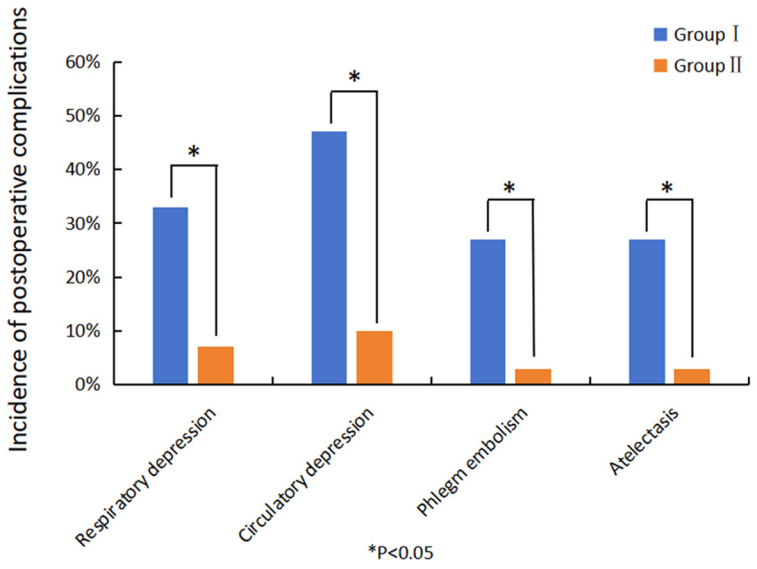


**Figure 5.** Quantitative analysis of **Table 7**.

**Table 8.** Duration and healthcare expense of hospitalization in the two groups ($\bar{X}$±SD)

| Group | Duration of hospitalization (Days) | Healthcare expenses of hospitalization (CNY) |
|---|---|---|
| Group I (n=30) | 9.43±2.86 | 48227.41±7725.56 |
| Group II (n=30) | 7.30±1.80 | 42602.56±8396.82 |
| t-value | 0.138 | 2.700 |
| *p*-value | 0.001 | 0.009 |

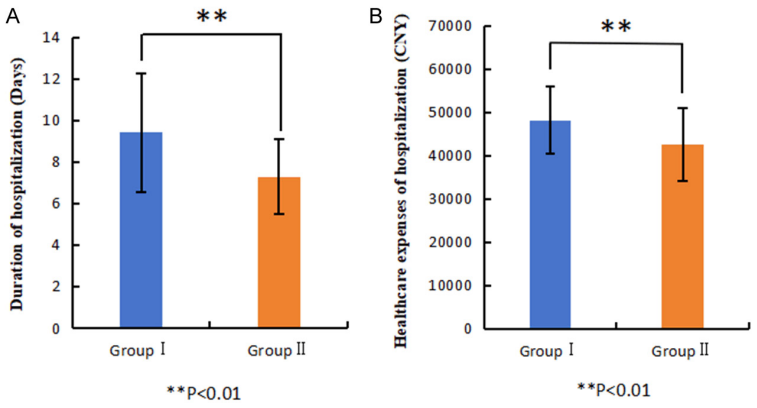


**Figure 6.** Quantitative analysis of **Table 8**. A. The duration of hospitalization, in Group I was higher than Group II (**P < 0.01). B. The healthcare expenses of hospitalization in Group I was higher than in Group II (**P < 0.01).

18], the induction of a hypercoagulable state postoperatively [19], a reduction in postoperative immune function [20], a delay in postoperative gastrointestinal function recovery [21], a transition to chronic pain [22], and an increase in hospitalization days and cost. Postoperative pain, particularly incisional and intercostal neuralgia, has become a primary concern for lung cancer patients [23], as it often leads to respiratory and circulatory depression, sputum plug formation, atelectasis, and other complications [24]. Research has indicated that intercostal nerve block analgesia offers advantages such as ease of operation and effectiveness [25]. It has been suggested that intercostal nerve block anesthesia can improve perioperative-related parameters, prevent central sensitization to pain, alleviate stress and pain stimuli, and thus protect immune function [26]. Currently, the single-dose intercostal nerve block method is widely used for postoperative analgesia after thoracoscopic surgery to maintain hemodynamic stability [27].

Moreover, studies [28] have shown that the pharmacogenomics of local anesthetics may focus on relevant genes associated with $Na^+$ channels. Since neuronal excitability and conduction are related primarily to the opening and closing of membrane Na and $K^+$ channels, local anesthetics block $Na^+$ channels intracellularly, in-

hibiting the occurrence and conduction of action potentials and reversibly blocking the generation and conduction of sensory nerve impulses. For these reasons, we propose performing intercostal nerve block anesthesia at the incision and drainage tube sites before thoracotomy, followed by a multimodal analgesia regimen with patient-controlled analgesia (PCIA) postoperatively to alleviate postoperative pain, reduce the incidence of complications, and achieve individualized and precise anesthesia for patients.

To elucidate the relationship among drug metabolism, genetic polymorphisms of drug target molecules, and drug efficacy and to explore the role of CYP3A4 gene polymorphisms in individualized differences in postoperative pain susceptibility and drug treatment response in lung cancer patients receiving intercostal nerve block anesthesia, 5 ml blood samples were collected from all patients preoperatively to measure CYP3A4 enzyme activity and OD values. There were no significant differences in the general characteristics of the two groups of patients, such as age, weight, height, BMI, or surgical duration. The patients in Group I presented higher enzyme levels of CYP3A4 gene expression than those in Group II did.

The results revealed that within 2 hours postoperatively, there were no significant differences in the VAS score, number of times the PCIA pump button was pressed, or ST-T downslope between the two groups of patients. However, approximately 4 hours postoperatively, patients in Group I, those with higher enzyme activity, metabolized the local anesthetic ropivacaine faster than those in Group II did. Consequently, the onset of pain was earlier in Group I patients, and their VAS scores were significantly higher than those in Group II, indicating that the pain intensity, which was mostly located at the drainage tube insertion site, was also greater in Group I. As part of multimodal analgesia, patients began using PCIA at this time, and the results revealed that the number of times the PCIA pump button was pressed in Group I was significantly higher than that in Group II. Owing to the low enzyme activity of the CYP3A4 gene in Group II patients, the metabolism of ropivacaine slowed, thereby prolonging the duration of intercostal nerve block anesthesia and resulting in significantly better analgesic effects than in those in Group I, which significantly reduced the number of times the PCIA pump button was pressed.

Furthermore, the stress response to pain in Group I patients increased the heart rate and myocardial oxygen consumption, and the electrocardiogram revealed greater ST-T values downslope than those in Group II patients did, indicating myocardial ischemia and circulatory depression. The intercostal nerve block anesthesia used in this study not only treated the intercostal neuralgia caused by drainage tube insertion but also prevented respiratory depression caused by intercostal neuralgia, thus reducing the incidence of complications such as sputum plugs and atelectasis due to cough suppression. Another important result of this study is that the length of hospital stay and hospitalization cost of Group II patients were significantly lower than those of Group I patients. This may have been due to the CYP3A4 gene polymorphism in Group II patients, resulting in individual differences in postoperative pain susceptibility and drug treatment response, longer postoperative analgesia duration, less pain, and fewer complications, thus leading to faster postoperative recovery compared with Group I patients. On the basis of the characteristics of CYP3A4 gene polymorphisms, in this study, we independently developed a continuous injection device for intercostal nerve block anesthesia, which can be used for continuous quantitative injection of local anesthetics for patients with different enzyme levels, maintaining stable analgesic efficacy.

In summary, we performed thoracoscopic lung cancer radical surgery under general anesthesia and determined CYP3A4 gene expression activity preoperatively; patients with low enzyme activity metabolized drugs slowly, thereby prolonging the duration of intercostal nerve block anesthesia and achieving better analgesic effects. Based on the influence of CYP3A4 gene polymorphisms on local anesthetic metabolism, we developed an individualized intercostal nerve block anesthesia and multimodal analgesia regimen for patients undergoing thoracoscopic radical surgery for lung cancer that is safe and reliable; furthermore, it can relieve pain, reduce the incidence of complications, shorten the length of hospital stay, lower hospi-

talization costs, improve patient satisfaction, and achieve ERAS in lung cancer surgery patients. The results of this study may also guide individualized and precise anesthesia induction.

## Disclosure of conflict of interest

None.

**Address correspondence to:** Gang Liu, Department of Thoracic Oncology, Jilin Province Cancer Hospital, Changchun 130021, Jilin, China. E-mail: 135960-73953@163.com; Zongming Liu, Department of Anesthesiology, Jilin Province Cancer Hospital, Changchun 130021, Jilin, China. Tel: +86-181-43087567; E-mail: Zongmingliu7567@163.com

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