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# The effect of interscalene block on ipsilateral shoulder pain and pulmonary function in patients undergoing lung lobectomy
## A randomized controlled trial

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## Abstract

**Background:** Postoperative ipsilateral shoulder pain occurs in 37% to 68% of patients undergoing a thoracotomy. We examined whether interscalene brachial plexus block using a lower concentration of local anesthetic would reduce the incidence of post-thoracotomy ipsilateral shoulder pain with assessment of pulmonary function in patients who underwent a lung lobectomy.

**Methods:** Forty-four patients who underwent a lung lobectomy were randomly assigned to either the control or the interscalene block group. Single-shot interscalene block on the surgical site side was performed using ropivacaine 0.25% 10 mL including dexamethasone 5 mg under ultrasound guidance in the interscalene block group. Lobectomy and continuous paravertebral block were performed under general anesthesia. The presence of ipsilateral shoulder pain and postoperative adverse events were assessed. Pulmonary function tests were performed preoperatively, the day after surgery, and the day after removing the chest tube.

**Results:** The incidence of ipsilateral shoulder pain was significantly lower in the interscalene block group than in the control group (54.5% vs 14.3%, $P = .006$) with an overall incidence of 34.9%. Postoperative adverse events were similar between the groups, with no patients presenting symptoms of respiratory difficulty. Significant reductions in pulmonary function were observed in all patients after lobectomy; however, no significant difference in any of the pulmonary function test variables was observed postoperatively between the groups.

**Conclusions:** Interscalene block using 10 mL of 0.25% ropivacaine including dexamethasone 5 mg reduced the incidence of post-thoracotomy ipsilateral shoulder pain and did not result in additional impairment of pulmonary function.

**Abbreviations:** $FEV_1$ = forced expiratory volume in 1 second, FVC = forced vital capacity, IQR = interquartile ranges, ISB = interscalene block, ISP = ipsilateral shoulder pain, MV = mechanical ventilation, NSAIDs = nonsteroidal anti-inflammatory drugs, PEFR = peak expiratory flow rate, PFTs = pulmonary function tests, US = ultrasound, VATS = video-assisted thoracoscopic surgery.

**Keywords:** interscalene block, local anesthetic, pain management, pulmonary function

## 1. Introduction

The incidence of postoperative ipsilateral shoulder pain (ISP) varies from 37% to 85% in patients undergoing thoracotomy.[1–4] It is often unresponsive to epidural or paravertebral analgesia, which is effective for alleviating surgical site pain after a thoracotomy.[1] Several methods have been investigated to treat ISP, including nonsteroidal anti-inflammatory drugs (NSAIDs),[5] suprascapular nerve block,[2] intrapleural local anesthetic,[6] and phrenic nerve block.[7] Two case reports described that interscalene block (ISB) relieved post-thoracotomy ISP immediately for 6 to 10 hours.[8,9] ISB using a high concentration of local anesthetic (0.5% 10 mL bupivacaine) showed superior efficacy for post-thoracotomy shoulder pain compared with NSAIDs in a prospective non-randomized study.[3] However, that study did not evaluate pulmonary function and used a high concentration of local anesthetic.

The etiology for the considerable decrease in pulmonary function after a lung lobectomy is multifactorial, including the lobectomy itself, post-thoracotomy surgical site pain, and the presence of chest drainage. Additional diaphragmatic paresis due to motor blockade of the phrenic nerve by ISB may harm patients undergoing lobectomy, although diaphragmatic paresis itself is not usually associated with adverse clinical symptoms in healthy patients.[10]

In this prospective randomized study, we examined whether ISB using a lower concentration of local anesthetic would reduce the incidence of post-thoracotomy ISP. We also performed pulmonary function test in patients who underwent a lung lobectomy.

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## 2. Materials and methods

After approval by the ethics committee of Ewha Womans University Mokdong Hospital (EUMC 2015-03-007), this trial was registered with the Clinical Trial Registry of Korea (KCT0001726), and written informed consent was obtained from all patients. Patients with ASA physical status I to III lung cancer scheduled for lung lobectomy and continuous paravertebral block for postoperative analgesia were enrolled from December 2015 to February 2017. Exclusion criteria were age <19 years, respiratory difficulty at rest, pre-existing contralateral diaphragmatic paralysis, ISP and chronic pain, coagulopathy, severe chronic obstructive pulmonary disease, neurological deficit, infection at the site of ISB, drug or alcohol abuse, peptic ulcer disease, uncontrolled diabetes mellitus, known allergy to local anesthetic, any physical or mental illness rendering the patient unable to perform spirometry, previous thoracic surgery, and patient refusal.

Routine monitors were applied and midazolam 1 to 3 mg was given intravenously for sedation upon arrival in the operating room. Patients were assigned randomly to either the control or the ISB group using a computer-generated randomization table. Patients assigned to the ISB group received single-shot ISB under ultrasound (US) guidance on the surgical site side before inducing anesthesia by one experienced anesthesiologist. Using a 5- to 12-MHz linear probe, the point where the C5, C6, and C7 roots were most visible was selected in the short-axis view. After sterile skin preparation, the tip of a 50-mm, 22-gauge insulated needle (UniPlex NanoLine, PAJUNKGmbH Medizintechnologie, Geisingen, Germany) was advanced towards the target point using the in-plane method. A total volume of 10 mL of 0.25% ropivacaine (2.5 mg) including dexamethasone 5 mg was administered immediately posterior to or between the C5 and the C6 nerve roots.

General anesthesia was induced using glycopyrrolate 0.2 mg, propofol 1.5 to 2 mg/kg, fentanyl 1 to 2 μg/kg, and rocuronium 0.6 mg/kg. The patients were intubated with a left-sided 35 or 37 Fr double-lumen tube, as appropriate, and positioned in the lateral decubitus position for surgery. Lobectomies were performed by video-assisted thoracoscopic surgery (VATS) and posterolateral thoracotomy at the surgeon's discretion. Intraoperative conversion from VATS to open thoracotomy was classified as open surgery for analysis. In patients with multiple tumors, metastasectomy of coexistent lesions was performed by wedge resection or lobectomy. Mediastinal lymph node dissection was performed in all patients. At the end of the lung resection and before closing the chest, a paravertebral catheter (On-Q SilverSoaker, Halyard Health, GA) was inserted using an introducer needle percutaneously by a surgeon, checking the parietal pleura under direct vision or using a camera. It was advanced beneath the parietal pleura longitudinally along the paravertebral space, and a tip of a catheter was placed at the level of the surgical incision (T5, T6, or T7). A bolus of 5 mL of 0.5% ropivacaine was injected followed by continuous infusion of 0.5% ropivacaine at a rate of 5 mL/h using an elastomeric pump (ON-Q Pain Relief System, Halyard Health, GA).[11,12] All surgeries and paravertebral blocks were performed by the same team of thoracic surgeons. At the end of each operation, a single chest tube was placed apically or with the tip positioned mid-posteriorly on waterseal. Patients were extubated in the operating room after reversing residual muscle relaxation, if possible.

Postoperative analgesia consisted of a paravertebral infusion of analgesia for 3 days and ketorolac 30 mg intravenously every 8 hours for the first 24 hours and after then oral ketorolac 10 mg every 8 hour. The patients were treated with tramadol 50 mg (up to 300 mg/d) intravenously when they requested an additional analgesic. If ISP or any complication existed after 48 hours, the patient was followed up at discharge.

Sensory blockade by paravertebral block in all patients and ISB in the ISB group was assessed by the attending anesthesiologist in the post-anesthesia care unit. The loss of cold sensation was regarded as a successful block. The adverse events such as respiratory difficulties and Horner syndrome were assessed. A doctor blinded to the groups assessed the presence and degree of pain using a numerical rating scale (0=no pain, 10=the worst imaginable pain) at the surgical site and the ipsilateral shoulder up for 48 hours postoperatively. Patients were asked if they had any ISP, and they were asked to be able to differentiate ISP from surgical site pain. A plain chest radiograph was taken to assess possible complications and the position of the tip of the chest tube within 1 hour postoperatively.

Pulmonary function tests (PFTs) were performed preoperatively, the day after surgery and the day after removing the chest tube using a spirometer (Cosmed, Pony Fx; Cosmed Srl, Rome, Italy). Chest tubes can cause pain and impair mobility, and removing the chest tube improves forced expiratory volume in 1 second ($FEV_1$).[13] The chest tubes were removed when no air leakage was present and drainage was <200 mL and not chylous or bloody. FEV1, forced vital capacity (FVC), and peak expiratory flow rate (PEFR) were measured three times with the patient in a 45° upright position, and the best value was chosen. Based on the American Thoracic Society/European Respiratory Society guidelines,[14] obstructive disease was defined when $FEV_1$/FVC was <0.7 and a restrictive spirometric pattern was considered in nonobstructive patients if FVC was <80% of the predicted value.

### 2.1. Statistical analysis

SPSS software (ver. 18.0; SPSS Inc., Chicago, IL) was used for the statistical analysis. The primary endpoint was the incidence of ISP during the first 48 hours postoperatively. The results of a previous study evaluating the effect of phrenic nerve infiltration with lidocaine on post-thoracotomy ISP were used to calculate sample size because no study has reported the incidence of ISP when using ISB. A sample size of 20 patients (2-tailed $\alpha = 0.05$, power = 90%) per group was calculated to detect a reduction in the incidence of ISP from 0.85 to 0.33 after accepting two-tailed $\alpha$ error.[4] The correction for dropout would require 44 patients per group. Discrete variables were analyzed using the chi-square or Fisher exact tests. Continuous variables were analyzed by Student $t$ test or the Mann–Whitney $U$ test after the assessment for normality and are presented as the mean ± standard deviation or as medians with interquartile ranges (IQR) as appropriate. The spirometry results were analyzed by repeated-measures analysis of variance followed by Bonferroni correction. A 2-sided $P < .05$ was considered significant.

## 3. Results

Forty-six patients were assessed for eligibility, but 2 patients were ineligible because of the exclusion criteria or patient refusal; as such, 44 patients in total were included. One patient in the ISB group was excluded from the analysis because of a change in the operative plan to wedge resection (Fig. 1). The patient demographics and baseline characteristics were well balanced
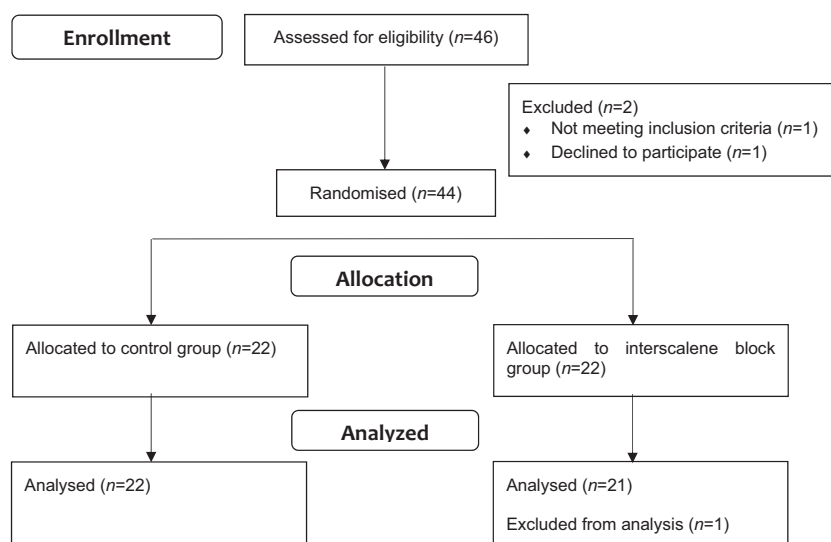
**Figure 1.** Flowchart of this study. ISB = interscalene brachial plexus block.

between the randomized groups (Table 1). Perioperative clinical details, such as the type and extent and method of surgery were also similar between the groups (Table 2).

The incidence of ISP was significantly lower in the ISB group than that in the control group (54.5% vs 14.3%, $P = .006$) with an overall incidence of 34.9% (Fig. 2). All patients who experienced ISP could distinguish shoulder pain from the surgical site pain. Fifteen patients (12 patients in the control group, 3 patients in the ISB group) experienced ISP during the study period with a median duration of 23 hours (IQR 6–48 hours). Three patients in the ISB group complained of ISP beginning 6, 7, or 12 hours after surgery, whereas patients in the control group had ISP from a median time of 1 hour (IQR 0.25–4.75 hours) after surgery. The use of rescue analgesic for the first 24 hours was higher in the control group compared with the ISB group ($P = .038$) (Table 2).

Satisfactory paravertebral blockade was achieved in all patients, and there was no patient who had sensory blockade above T3 dermatome. Satisfactory ISB was also observed in the ISB group. Figure 3 shows that the degree of surgical site pain was similar between the groups. Two patients in the ISB group did not complain of surgical site pain (4.7%), and the others presented with surgical site pain with various characteristics, such as dull

(37.2%), sharp (44.2%), or burning (14%) pain. On the other hand, all patients experiencing ISP expressed the pain as a dull ache, not a sharp pain.

Postoperative adverse events were similar between the groups (Table 3). There was no patient who had a symptom of respiratory difficulties and Horner syndrome. One patient in the control group received postoperative mechanical ventilation

### Table 1

**Demographic data. Values are number (%) or mean ± SD.**

| Characteristics | Control (n=22) | ISB (n=21) |
|---|---|---|
| Gender; men | 11 | 8 |
| Age; yr | 65.41 ± 8.69 | 63.48 ± 13.73 |
| Height; cm | 160.23 ± 7.84 | 159.95 ± 8.03 |
| Weight; kg | 61.57 ± 10.72 | 58.35 ± 11.16 |
| ASA physical status; I/II | 1/21 | 2/19 |
| smoking | 10 (45.5%) | 9 (40.9%) |
| Pulmonary function test: | | |
| Normal | 14 (63.6%) | 14 (66.7%) |
| Restrictive | 0 | 1 (4.8%) |
| Obstructive | 5 (22.7%) | 4 (19%) |
| Mixed | 3 (13.6%) | 2 (9.5%) |

ISB = interscalene brachial plexus block.

### Table 2

**Perioperative data. Values are number (%), mean ± SD or median (interquartile ranges).**

| Characteristics | Control (n=22) | ISB (n=21) |
|---|---|---|
| Extent of operation: | | |
| Lobectomy | 15 (68.2%) | 17 (81.0%) |
| Lobectomy + wedge resection | 5 (22.7%) | 4 (19.0%) |
| Bilobectomy | 2 (9.1%) | 0 (0%) |
| Method of surgery: | | |
| VATS | 9 (40.9%) | 7 (33.3%) |
| Open thoracotomy | 13 (59.1%) | 14 (66.3%) |
| Resected lobe (double checked for bilobectomy): | | |
| RUL | 11 | 6 |
| RML | 2 | 1 |
| RLL | 3 | 8 |
| LUL | 5 | 2 |
| LLL | 3 | 4 |
| The location of paravertebral catheter tip | | |
| 5th intercostal space | 6 | 2 |
| 6th intercostal space | 14 | 19 |
| 7th intercostal space | 2 | 0 |
| Chest tube location: | | |
| Apex | 11 (50%) | 11 (52.4%) |
| Dependent | 11 (50%) | 10 (47.6%) |
| Duration of surgery; min | 214.09 ± 67.18 | 204.76 ± 49.91 |
| Duration of anesthesia; min | 274.32 ± 70.31 | 277.38 ± 54.92 |
| Estimated blood loss; mL | 631.67 ± 633.10 | 558.33 ± 813.46 |
| Duration of chest tube; d | 8.70 ± 3.68 | 7.40 ± 1.88 |
| Rescue analgesic, 0–24 hours[*] | 1 (0–1) | 0 (0–1) |
| Rescue analgesic, 24–48 h | 0 (0–0.25) | 0 (0–0) |

ISB = interscalene brachial plexus block, LLL = left lower lobe, LUL = left upper lobe, RLL = right lower lobe, RML = right middle lobe, RUL = right upper lobe, VATS = video-assisted thoracoscopic surgery.
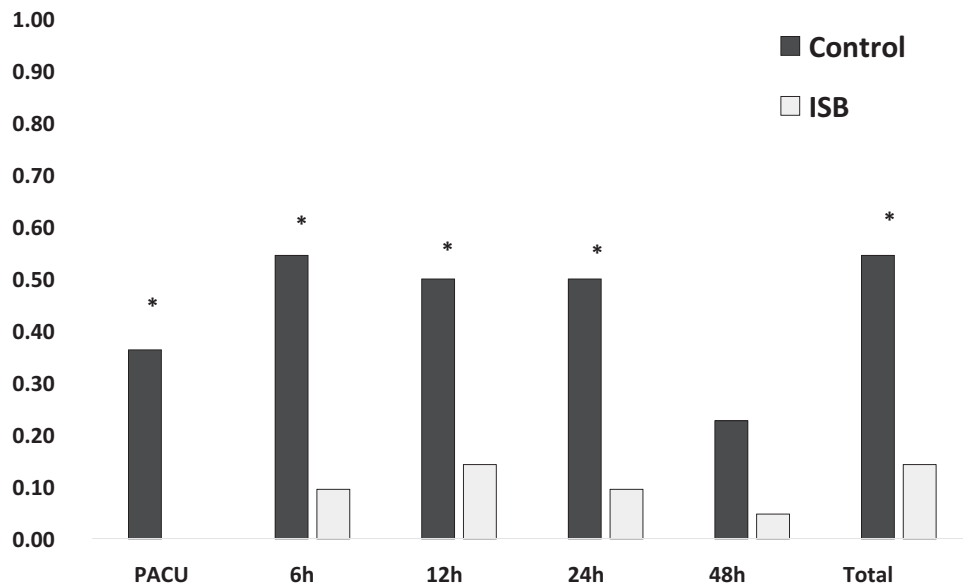[*] $P = .038$.

**Figure 2.** Proportion of patients who experienced ipsilateral shoulder pain. The incidence of ISP was significantly lower in the ISB group than that in the control group. ISB = interscalene brachial plexus block, PACU = post-anesthesia care unit.
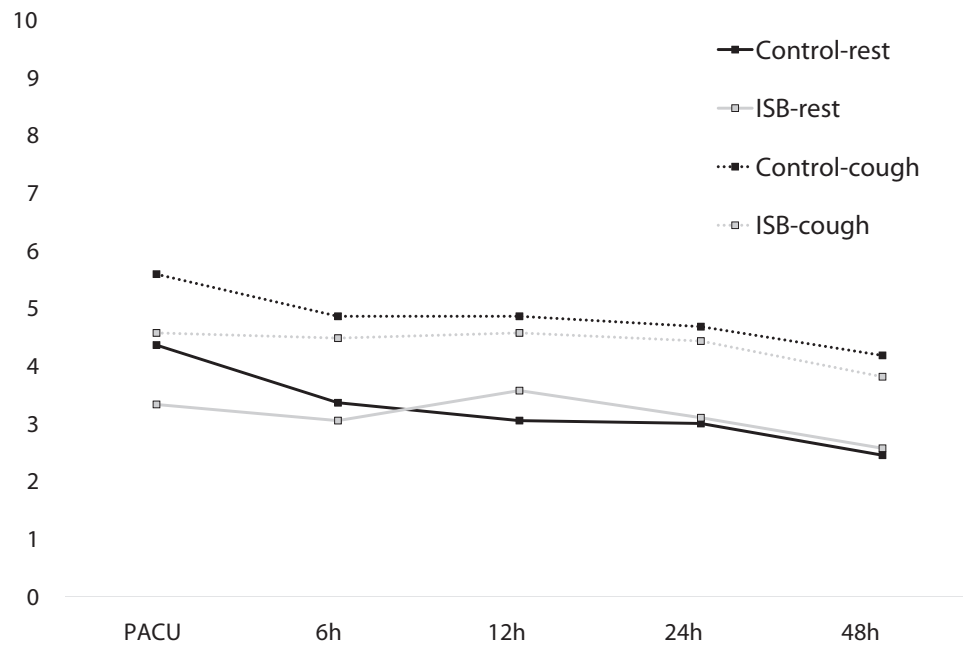


**Figure 3.** Numerical rating scale (0–10) for the surgical site pain. The degree of surgical site pain was similar between the groups. ISB = interscalene brachial plexus block.

**Table 3**

**Adverse events in the postoperative period.**

|  | Control ($n=22$) | ISB ($n=21$) |
|---|---|---|
| Mechanical ventilation | 1 | 1 |
| Nausea and vomiting | 3 | 2 |
| Horner syndrome | 0 | 0 |
| Dyspnea | 0 | 0 |

ISB = interscalene brachial plexus block.

(MV) to minimize any adverse effects of increased work-of-breathing in the immediate postoperative period because he had a 7-hour-long surgery due to severe adhesions and intraoperative difficulties, but was weaned from MV only 3 hours later. One patient in the ISB group received MV postoperatively due to 2400-mL blood loss and hemodynamic instability during the operation and was also weaned from MV only 3 hours later. Significant reductions in $FEV_1$, FVC, and PEFR were observed in all patients after the lobectomy (Table 4). However, no significant differences were observed between the 2 groups in any of the PFT variables measured postoperatively. The reduction in $FEV_1$

**Table 4**

Pulmonary function test. No significant difference between groups. Values are mean±SD.

| Parameter | Control (n=22) | | | ISB (n=21) | | |
| | Baseline | Postoperative day 1 (% change from baseline) | After chest tube removal (% change from baseline) | Baseline | Postoperative day 1 (% change from baseline) | After chest tube removal (% change from baseline) |
|---|---|---|---|---|---|---|
| FEV$_1$; L | 2.45±0.67 | 1.11±0.46* (−54.12±16.04) | 1.36±0.57*,† (−43.66±16.79) | 2.42±0.71 | 1.05±0.39* (−55.66±13.04) | 1.22±0.49* (−48.28±16.79) |
| FVC; L | 3.35±0.84 | 1.62±0.68* (−51.30±15.18) | 1.95±0.83*,† (−42.61±17.25) | 3.26±0.99 | 1.40±0.48* (−56.56±10.57) | 1.65±0.68*,† (−49.17±15.29) |
| PEFR; L/min | 6.90±1.90 | 2.62±1.41* (−62.33±18.05) | 3.12±1.74* (−54.65±24.15) | 6.36±2.25 | 2.00±1.02* (−64.33±20.29) | 2.66±1.61* (−54.47±23.95) |
| FEV$_1$/FVC | 73.68±9.13 | 73.23±19.01 | 73.82±18.84 | 74.05±8.97 | 74.05±11.48 | 74.38±10.64 |

FEV$_1$ = forced expiratory volume in 1 second, FVC = forced vital capacity, ISB = interscalene brachial plexus block, PEFR = peak expiratory flow rate.

* $P < .05$ from baseline value.

† $P < .05$ vs postoperative day 1.

measured on postoperative day 1 was 54.12±16.04% in the control group versus 55.66±13.04% in the ISB group. The reduction in FVC was 43.66±51.30% in the control group versus 48.28±16.79% in the ISB group.

## 4. Discussion

To our knowledge, this is the first randomized study to demonstrate the effect of single shot ISB using low concentration and volume of ropivacaine to prevent post-thoracotomy ISP and describes pulmonary functions and the character of ISP in the immediate postoperative period. We have shown that ISB using ropivacaine 0.25% 10 mL significantly reduced the incidence of post-thoracotomy ISP and no significant differences in FEV$_1$, FVC, or PEFR between the control and ISB groups postoperatively.

The characteristics of the pain at the surgical site and shoulder were different, suggesting a different mechanism. Suggested etiologies for ISP include referred phrenic nerve pain by the diaphragm and pleural irritation caused by the surgical process and the chest drain, and causes directly related to the shoulder region, such as an upward retracted scapula and distraction of the acromioclavicular and coracoclavicular joints due to inadequate lateral decubitus positioning.[4,15] Theoretically, ISB is supposed to prevent these 2 possible mechanisms because it causes a phrenic nerve block due to nerve proximity with anatomical brachial plexus analgesia of the shoulder region. Local anesthetic in a patient who received ISB can spread to the cervical sympathetic nerve chain,[16] which can also play a role in reducing ISP as visceral pain, as a sympathetic block is one of the methods to treat sympathetic-mediated pain of the upper limbs.[17] Despite this theoretical background, ISB has generally not been used because of the drawback of diaphragmatic paresis. ISB is often associated with blockade of the phrenic nerve, which supplies motor fibers to the diaphragm, causing diaphragmatic paresis and sensory fibers to the fibrous pericardium, mediastinal pleura and diaphragmatic peritoneum.[18] In our study, we used a low concentration of ropivacaine, which preferentially blocks sensory nerve fibers while sparing motor nerve fibers compared with bupivacaine.[19] To avoid motor blockade of the phrenic nerve leading to diaphragmatic paresis, previous investigations used various combinations of reduced volume, concentration, and dose of local anesthetic in non-thoracic surgical populations.[3,20] Riazi et al[21] assessed diaphragmatic excursion by real-time United States in patients who received an ISB, followed by general anesthesia for shoulder surgery. They found a 33% incidence of paralyzed diaphragm 60 minutes after surgery when using ropivacaine 0.5% 5 mL (2.5 mg) for ISB. Another study by al-Kaisy et al[20] used bupivacaine 0.25% 10 mL (2.5 mg) for an

ISB, which induced no significant change in diaphragm excursion. On the other hand, bupivacaine 0.5% 10 mL (5 mg) abolished normal diaphragm movement completely 30 and 60 minutes after ISB. In another study, diaphragm movement was reduced by 54% compared with that at baseline by continuous ISB (5–9 mL/h of 0.125% bupivacaine).[22]

Diaphragmatic dysfunction can be assessed during the postoperative period by several methods such as chest radiographs, fluoroscopy, US and PFT by spirometry.[23] We performed PFT to assess the effects on respiration. In all patients, significant reductions in the value of FEV$_1$, FVC, and PEFR were observed postoperatively, which were consistent with previous study.[24] However, there was no difference between the 2 groups in PFT variables measured the day after surgery and after the chest tube had been removed.

ISP generally disappears within 1 to 2 days,[3,25] and our previous study showed that 5 mg of perineural dexamethasone prolonged the median time of sensory blockade by ISB using 0.5% ropivacaine from 11.0 to 24.2 hours.[26] Thus, in this study we used dexamethasone as an adjuvant to the ISB. It can be criticized that perineural dexamethasone might have its own systemic effect and contribute to our results. It has been described that perineural dexamethasone acts via a direct effect of the glucocorticoid on nerve conduction or a direct blockade of transmission in nociceptive C fibers, besides its systemic anti-inflammatory action.[27,28] We cannot determine how much perineural dexamethasone acts systemically, however, evidence that systemic dexamethasone relieves pain is limited to surgical site pain, which is related to the postoperative inflammatory response and pain related to bone metastasis, bone surgery, and local edema.[29–31] Referred pain, which has been suggested to be the main mechanism for ISP, does not mainly originate from either an inflammatory reaction or edema. In addition, no difference in surgical site pain was observed between the 2 groups, and ISP was not related to the degree of surgical site pain (not shown here). Therefore, we consider that perineural dexamethasone itself probably did not have a considerable systemic effect on the occurrence of ISP.

Several limitations of the present study should be mentioned. First, this was a single-center study with a relatively small sample size. Second, we performed ISB before induction of general anesthesia according to our study design to evaluate the incidence of ISP. Although there was no adverse effect related to ISB in our patients, our sample sizes are too small to conclude the risks of ISB in the thoracic surgical populations. Third, we did not inject saline at the same volume for the control group. All patients were sedated with midazolam but patients were not blinded to the group randomization. Fourth, radionuclide lung scanning to estimate the predicted postoperative FEV$_1$ is not assessed in all

patients at our institution; therefore, we could not calculate the change in pulmonary function due to the lobectomy itself. However, no differences were observed in the distribution of resected lobe and any of the PFT variables between groups. Lastly, as the etiology of ISP remains not fully understood, we cannot completely rule out the effect of dexamethasone on the occurrence of ISP despite our earlier explanation. Further study without dexamethasone is warranted to clarify an effect of ISB itself on post-thoracotomy ISP.

## 5. Conclusions

ISB using ropivacaine 0.25% 10 mL including dexamethasone 5 mg was effective for reducing the incidence of post-thoracotomy ISP without additional impairment of pulmonary function in the postoperative period. Further study is needed to clarify the benefit and safety profiles of ISB in a larger population of patients undergoing lung lobectomy.

## Author contributions

**Conceptualization:** Youn Jin Kim, Chi Hyo Kim.
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**Writing – original draft:** Jae Hee Woo.

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