The effects of ultrasound-guided serratus plane block, in combination with general anesthesia, on intraoperative opioid consumption, emergence time, and hemodynamic stability during video-assisted thoracoscopic lobectomy

A randomized prospective study

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Abstract

Background: Thoracotomy is one of the most painful surgeries; therefore, video-assisted thoracoscopic surgery (VATS) was developed to reduce the surgical stress of thoracotomy. Although VATS results in reduced postoperative pain compared with thoracotomy, it is still painful. Serratus plane block (SPB) is a novel technique that provides lateral chest wall analgesia by blocking the lateral branch of the intercostal nerve.

Methods: We conducted a prospective study in 50 patients, aged 20 to 75 years, undergoing three-port VATS lobectomy. Group G (n = 25) received conventional general anesthesia and Group S (n = 25) received SPB before induction of general anesthesia. In Group S, 20 ml of 0.375% ropivacaine was injected between the serratus anterior and latissimus dorsi muscles. During surgery, anesthesia was maintained by adjusting the propofol dose to maintain a bispectral index of 40 to 60 and the remifentanil dose to maintain blood pressure and heart rate within 70 to 130% of baseline.

Results: Intraoperative remifentanil consumption was significantly lower in Group S compared to that in Group G (519.9 μg vs 1047.7 μg, P < .001). Moreover, emergence time was significantly shorter in Group S compared to Group G (10.8 minutes vs 14.9 minutes, P = .01). However, there were no significant differences in systolic blood pressure and heart rate (HR) between the groups at each time point. The doses of rescue drugs for the control of blood pressure and HR were not significantly different between the 2 groups.

Conclusions: Ultrasound-guided SPB could be a safe and effective regional anesthesia technique for VATS

Abbreviations: HR = Heart rate, SBP = Systolic blood pressure, SPB = Serratus plane block, VATS = Video-assisted thoracoscopic surgery.

Keywords: anesthesia, opioid, pain management, perioperative care, vital signs

1. Introduction

Thoracotomy is known as one of the most painful surgeries.[11] Thus, video-assisted thoracoscopic surgery (VATS) has been developed to reduce surgical stress in terms of operation technique. Although it has reduced postoperative pain and complications compared with thoracotomy, VATS is still quite a painful operation.[2,3]

Opioids are essential part of balanced general and total intravenous anesthesia. However, reducing opioid consumption has become important because its side effects, such as delayed recovery from general anesthesia, opioid-induced hyperalgesia, sedation, nausea, and respiratory depression.[4–6] Several modalities to reduce intraoperative opioid use have been suggested, including medications and nerve blocks.[7–10]

Serratus plane block (SPB) is a novel technique which provide analgesic effect against lateral chest wall pain by blocking the lateral branch of the intercostal nerve.[11] It has been reported to be used for pain management, including the pain of rib fractures and herpes zoster, and postoperative pain.[12–14] The block has become a popular analgesic modality because it is easy to perform and relatively safe.

However, the effects of SPB during intraoperative period have not yet been studied. Therefore, we investigated the effects of SPB on intraoperative opioid consumption, emergence time, and hemodynamic stability in patients undergoing VATS.
2. Methods

The present study was approved by hospital ethics committee (KNUH 2018-06-006-002) and informed written consent for participating in the study was obtained from all patients. This study was registered at https://clinicaltrials.gov (NCT03718377).

Fifty patients with American Society of Anesthesiologists physical status class I or II, aged 20 to 73 years, undergoing three-port VATS lobectomy under general anesthesia were enrolled in this study. Exclusion criteria were: a history of allergic reaction to local anesthetics, coagulopathy, local infection at the injection site, and systemic infection.

Enrolled patients were divided into 2 groups in a 1:1 allocation ratio by computer-generated block randomization using block sizes of 2, 4, and 6. Opaque sealed envelopes were used to conceal the allocation sequence by unrelated assistant to this study. Group G (n = 25) received conventional general anesthesia care, and Group S (n = 25) received SPB in the regional-anesthesia unit outside operation room before induction of general anesthesia. Data were collected by the attending anesthesiologist, who was blind to the group assignment.

All SPBs were performed by a single practitioner. After sterilization of the injection site on the lateral chest wall, a high-frequency linear transducer was used to identify the fifth rib at the mid-axillary line. The serratus anterior and latissimus dorsi muscles were then easily identified above the rib. A 20-gauge Tuohy needle was introduced in the interfascial space between the serratus anterior and latissimus dorsi muscles using an in-plane technique. After confirming the interfascial space using hydrodissection with normal saline, 20 ml of 0.375% ropivacaine was injected. Loss of pinprick sensation was checked using a blunt needle for confirming success of the block.

No premedication was administered. Using standard monitoring protocols in the operating room, anesthesia was induced with propofol (2mg/kg), remifentanil (0.3–1.0μg/kg/minutes), and rocuronium (0.8mg/kg). Intubation was performed using a double-lumen tube. A radial artery catheter was used for continuous blood pressure monitoring.

During surgery, anesthesia was maintained by adjusting propofol concentration for a bispectral index of 40 to 60 and remifentanil concentration for blood pressure and heart rate within 70% to 130% of the baselines. Rocuronium (0.2mg/kg) was administered every 30 minutes. If abrupt hypotension, bradycardia, or tachycardia developed beyond the 70% to 130% of the baselines. Rocuronium (0.2mg/kg) was administered every 30 minutes. If abrupt hypotension, bradycardia, or tachycardia developed beyond the 70% to 130% of the baselines. Rocuronium (0.8mg/kg). Intubation was performed using a double-lumen tube. A radial artery catheter was used for continuous blood pressure monitoring.

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Secondary outcomes were emergence time, systolic blood pressure (SBP), heart rate (HR), and doses of rescue drugs used to control blood pressure and HR. The recording time of SBP and HR was set for 1 hour because mean surgery time (107.2 minutes) was shorter than 2 hours during a pilot study. The SBP and HR were recorded before induction, immediately after incision, and subsequently, at 5, 15, 30, and 60 minutes during the surgery.

The sample size was calculated based on a pilot study comparing remifentanil consumption in 8 patients: group receiving general anesthesia care, 869.8 ± 117.7 μg; and group receiving SPB before general anesthesia, 693.3 ± 245.0 μg. The present study required 22 patients in each group for alpha = 0.05 and statistical power = 0.9. Considering a 10% dropout rate, 25 patients would be required per group.

The IBM SPSS software (version 20; IBM Corp., Armonk, NY, USA) was used for statistical analysis. For continuous variables, after assessment of normality using Shapiro–Wilk test, Student’s t test and Mann–Whitney U test were used to compare normally and non-normally distributed continuous data, respectively. Categorical variables were compared by using Fisher’s exact test. P values < .05 were considered statistically significant.

3. Results

Fifty patients were included in the present trial. Among them, 4 patients were excluded because of conversion to open thoracotomy (2 from Group G and 1 from Group S) and closure without performing surgery due to unexpected pleural metastasis (1 from Group S). Therefore, 46 patients were analyzed (Fig. 1). There were no differences between the groups in terms of demographics, duration of anesthesia and surgery, and initial SBP and HR (Table 1).

Intraoperative remifentanil consumption was significantly lower in Group S (519.9 ± 246.7 μg) compared to Group G (1047.7 ± 390.8 μg) (P < .001) (Table 2).

Emergence time was significantly shorter in Group S (10.8 ± 4.6 minutes) compared to Group G (14.9 ± 6.1 minutes) (P = .01) (Table 3). There were no significant differences in SBP and HR between the groups at each time point (Figs. 2 and 3). The doses of rescue drugs used for controlling blood pressure and HR were not significantly different between the 2 groups.

There were no block-related complications, such as local anesthetic toxicity, pneumothorax, bleeding, and infection.

4. Discussion

In the present study, we demonstrated that ultrasound-guided SPB, in combination with general anesthesia, significantly reduced intraoperative remifentanil consumption and shortened emergence time compared with general anesthesia alone in patients who underwent VATS lobectomy. Intraoperative hemodynamic parameters were maintained stably in both groups, and there were no block-related complications, such as local anesthetic toxicity, bleeding, and infection.

Over the past 2 decades, VATS has been widely used for lobectomy as an alternative to thoracotomy. Numerous studies have reported advantages of VATS compared with multiportal VATS, including less postoperative pain, shorter duration of hospitalization, and improved quality of life. Although VATS reduces postoperative pain, it is still a painful surgery. A recent randomized study reported that the proportion of patients with clinically relevant pain was significantly lower in the VATS group than the thoracotomy group during the first 24 hours; however, 38% of patients in the VATS group still had moderate-to-severe pain.

While conventional VATS lobectomy has been performed with multiport approaches (our institution uses a standard three-port VATS technique) uniportal VATS lobectomy has recently emerged. Some studies have reported that the uniportal approach has several benefits compared with multiportal VATS, including shorter duration of hospitalization, reduction in the duration of postoperative drainage, and morbidity. However, uniportal...
VATS has not been widely performed and its efficacy is still under debate.\(^{21,22}\) Preemptive analgesia is the notion that pain control is more effective if administered before the surgical incision.\(^{23}\) The goal of preemptive analgesia is to prevent sensitization of the peripheral and central nervous systems, thereby decreasing perioperative opioid consumption and postoperative pain. Therefore, techniques of regional anesthesia techniques have been suggested as one of the means to achieve this goal by blocking the conduction of surgical stimuli.\(^{24–27}\)

Epidural, paravertebral, and intercostal blocks are some of the conventional techniques of regional anesthesia for thoracic surgery. However, each of these blocks has some drawbacks. Epidural block has been considered the gold standard for managing thoracotomy pain.\(^{23}\) However, it involves unnecessary bilateral block, including the sympathetic nervous system, and several complications, such as hypotension, epidural hematoma, abscess, and dural puncture.\(^{28,29}\) Hence, some clinicians have suggested paravertebral block as the new gold

### Table 1

**Demographics of the study patients.**

| Demographics        | Group G (n = 23) | Group S (n = 23) | P value |
|---------------------|-----------------|-----------------|--------|
| ASA class (I/II)    | 1/22            | 3/20            | .61    |
| Sex (M/F)           | 15/8            | 14/9            | >.99   |
| AGE (year)          | 65.1 ± 8.4      | 63.6 ± 9.9      | .57    |
| Height (cm)         | 161.9 ± 8.1     | 162.5 ± 8.9     | .83    |
| Weight (kg)         | 61.7 ± 10.2     | 63.5 ± 12.3     | .63    |
| Anaesthesia time (min) | 176.6 ± 31.7   | 173.7 ± 38.7    | .78    |
| Surgery time (min)  | 131.9 ± 30.5    | 128.0 ± 41.8    | .72    |
| SBP (preanaesthesia)| 143.2 ± 19.9    | 151.4 ± 26.4    | .24    |
| HR (preanaesthesia) | 72.5 ± 13.4     | 74.7 ± 17.8     | .64    |

Data are presented as mean ± standard deviation or number. Group G, patients who received general anesthesia; Group S, patients who received a combination of general anesthesia with serratus plane block. 

ASA = American Society of Anesthesiologists; F = female; HR = heart rate; M = male; SBP = systolic blood pressure

### Table 2

**Intraoperative remifentanil consumption.**

|                          | Group G         | Group S         | P value |
|--------------------------|-----------------|-----------------|--------|
| Intraoperative remifentanil dose (μg) | 1047.7 ± 390.8 | 519.9 ± 246.7  | <.001  |

Data are presented as mean ± standard deviation. Group G, patients who received general anesthesia; Group S, patients who received a combination of general anesthesia with serratus plane block.

### Table 3

**Emergence time.**

|                          | Group G         | Group S         | P value |
|--------------------------|-----------------|-----------------|--------|
| Emergence time (min)     | 14.9 ± 6.1      | 10.8 ± 4.6      | .01    |

Data are presented as mean ± standard deviation. Group G, patients who received general anesthesia; Group S, patients who received a combination of general anesthesia and serratus plane block.

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**Figure 1.** Flow diagram of the study design.
In the present study, intraoperative remifentanil consumption was significantly lower in patients administered SPB than in those who received general anesthesia alone. This could be attributed to the analgesic effect of the SPB, which probably acted as a substitute for opioids with regard to managing hemodynamic stability. The SPB blocks peripheral nerves, that is, the lateral cutaneous branches of the intercostal nerves. Since nociceptive afferent transmission is blocked, the sympathetic response of increasing blood pressure and HR is reduced. Therefore, SPB could reduce the required dose of remifentanil without causing hemodynamic instability. This result suggests that SPB is effective in maintaining hemodynamic stability intraoperatively during VATS lobectomy.

In this study, the doses of rescue drugs were not statistically significantly different between the 2 groups. This study was designed to compare the required dose of opioids between SPB with general anesthesia and general anesthesia alone. Thus, hemodynamic changes during surgery were preferentially managed using remifentanil to reduce the effect of other variables. Rescue drugs for hemodynamic stability were administered only when the vital signs were not controlled using remifentanil and fluid administration.

In the present study, emergence time was significantly shorter in patients administered SPB than those administered general anesthesia alone. Side effects of opioids, such as opioid-induced hyperalgesia, sedation, nausea, and respiratory depression, could delay recovery from general anesthesia. Uncontrolled pain is associated with insufficient spontaneous respiration and could delay extubation. We speculate that the emergence time was short in patients administered SPB because there was adequate pain control and reduced opioid consumption.

To our knowledge, this is the first study to describe the effects of SPB during the intraoperative period as regional anesthesia technique for VATS. However, our study has several limitations. First, our sample size was relatively small, although we calculated the minimal sample size based on a pilot study to achieve an adequate power. Second, patients in the study were from a single center. Therefore, the results may not be generalizable. Further, multicenter studies in various populations are needed to validate our findings. Finally, the effect of SPB on postoperative opioid consumption and pain were not evaluated. However, previous reports have already shown that SPB is effective in reducing postoperative opioid consumption and pain.

In conclusion, we demonstrated that ultrasound-guided SPB decreases intraoperative opioid consumption in patients undergoing VATS. In addition, emergence time was reduced and hemodynamic stability was maintained without block-related complications. Therefore, ultrasound-guided SPB could be a safe and effective technique for achieving regional anesthesia technique for VATS.

**Author contributions**

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