A Comparison of the Perioperative Management Between ultrasound-Guided Thoracic Paravertebral Block and Local Anesthesia for Video-Assisted Thoracic Surgery with a Miniaturized Thoracoscope under Non-Intubation Anesthesia

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Summary
Video-assisted thoracic surgery using a miniaturized thoracoscope can be performed safely without general anesthesia and endotracheal intubation by providing adequate analgesia and appropriate sedation. Our study supports the use of an ultrasound-guided thoracic paravertebral block to provide adequate analgesia instead of the use of local anesthesia alone.

In our institution, video-assisted thoracic surgery with a miniaturized thoracoscope is performed without general anesthesia and endotracheal intubation for empyema, pleural effusion, and pneumothorax. We retrospectively compared the perioperative management of patients who underwent ultrasound-guided thoracic paravertebral block under non-intubated anesthesia for video-assisted thoracic surgery with a miniaturized thoracoscope, to patients who underwent the procedure under local anesthesia alone, without a thoracic paravertebral block. This was an observational comparative study. The data were retrospectively collected from a single-center hospital; 30 patients who underwent this surgery without general anesthesia and endotracheal intubation were included from April 2006 to December 2016. Of them, 10 underwent ultrasound-guided thoracic paravertebral block under local anesthesia with sedation and the other 20 underwent local anesthesia alone without TPVB.

Results
The primary outcomes included the total volume of local anesthetic administered during the first local infiltration, complaints of any pain, and requirement of additional local infiltration during the procedure. The secondary outcomes included complaint of any pain for 60 minutes after the surgery and the need for any analgesics for 360 minutes after the surgery. The patients were evenly matched for the baseline characteristics. Intra-operative pain and requirement of additional local infiltration were significantly less frequent in the thoracic paravertebral block group than in the local anesthetic group. There were no significant differences between the two groups regarding postoperative outcomes. However, complaints of pain for 60 minutes and the need for analgesics for 360 minutes after the surgery were less frequent in the thoracic paravertebral block group than in the local anesthetic group.

Key words: Video-Assisted Thoracic Surgery with a Miniaturized Thoracoscope; Ultrasound-Guided Thoracic Paravertebral Block; Non-Intubation Anesthesia

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This was an observational comparative study. The data were retrospectively collected from a single-center hospital; 30 patients who underwent mini VATS without general anesthesia and endotracheal intubation were included. Of them, 10 underwent USG-TPVB under local anesthesia with sedation and the other 20 underwent local anesthesia without USG-TPVB.

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The secondary outcome measures included complaints of any pain for 60 minutes after the surgery, need for any analgesics for 360 minutes after the surgery, and the timing of resumption of drinking.

**Anesthesia Technique**

Upon arrival at the operating room, the patients were positioned in a lateral decubitus position with the affected side up. Their bodies were restrained on mattresses (Magic Bed, Okada Medical Co. Ltd., Tokyo on the operating tables. Their blood pressure, heart rate, and oxygen saturation were monitored noninvasively. Their upper limbson the affected side was not placed on the armrest and were hanged down. All patients were administered oxygen via anasal or facial mask during the procedure. We started a continuous intravenous administration of 1mg/kg/h propofol.

We performed a pre-scan under ultrasound guidance. With the surgeon, we determined an appropriate site for a first thoracoport incision and the level of the paravertebral block by preoperative ultrasonography. We used a high-frequency linear array probe. USG-TPVB punctures were performed at one intercostal level in which a first thoracoport incision was planned or at two intercostal levels. The probe was placed at the selected intercostal space parallel to the ribto enable a horizontal view of the paravertebral space. The paravertebral space was surrounded by the hyperechoic line of the parietal pleura below and the internal intercostal membrane above. We marked the needle insertion points for USG-TPVB using an in-plane technique [2].

After intravenous administration of a total dose of 25-50 μg (mean, 47.5±7.9μg) of fentanyl citrate, we performed USG-TPVB. The probe was placed at our planned site and the skin was anesthetized with a total volume of 2 -4ml of 1% mepivacaine. We used an 80-mm, 20-gauge Tuohy needle (Hakko, Japan). A needle was inserted in a lateral-to-medial direction from the outer edge of the probe using an in-plane approach until the needle tip penetrated the internal intercostal membrane. After a negative aspiration test for blood, we injected the local anesthetic into the paravertebral space slowly. We visually confirmed that the parietal pleura were being pressed ventrally as a result of the local anesthetic injection. USG-TPVB punctures of two patients were performed at only one intercostal level, at which a thoracoport incision was planned. In the other patients, an additional puncture was performed at the nextintercostal level. The total volume of local anesthetics for USG-TPVB ranged from 20 to 30 mL (mean, 28±4.2 mL). A mixture of 10mL of 2% of mepivacaine and 10-20 mL (mean, 18±4.2 mL) of 0.5%of levobupivacaine was administered for USG-TPVB.

**Conclusions**

Mini VATS can be performed safely without general anesthesia and endotracheal intubation with adequate analgesia and appropriate sedation. Our study supports the use of TPVB to provide adequate analgesia compared with the use of local anesthesia alone. Ultrasound guidance can enhance the safety of TPVB. Using light sedation may be effective to decrease the patient’s stress and perform a safe procedure. Furthermore, the surgeon may be required to adopt a delicate surgical technique.

**Introduction**

Conventionally, video-assisted thoracic surgery (VATS) is performed under general anesthesia and requires single-lung ventilation using a double-lumen endobronchial tube or bronchial blocker. Our preliminary report on video-assisted thoracic surgery with a miniaturized thoracoscope (mini VATS) suggested that local anesthesia was safe and stable during a short surgical procedure and circumvents the need for general anesthesia and an endotracheal intubation [1]. The limiting factor for long-term, stable anesthesia is the injection dose of an analgesic. Some local and regional anesthetic techniques that have been reported include local wound infiltration, intercostal nerve block, thoracic epidural analgesia, and thoracic paravertebral block with or without sedation. This study discusses how an ultrasound-guided thoracic paravertebral block (USG-TPVB) may overcome the limitations of non-intubated anesthesia during mini VATS to potentially allow a day or one-night-stay surgery.

**Methods**

This retrospective observational study analyzed the perioperative management and outcome data of 10 patients who underwent mini VATS under USG-TPVB and local anesthesia, without general anesthesia and endotracheal intubation, at our institution from April 2006 to December 2016. The Institutional Review Board of our hospital granted ethical approval for this study (IRB # 29-02, SMH, May 10, 2017) Informed consent was obtained from all patients.

The primary outcome measures included the total volume of local anesthetic administered during the first local infiltration, complaints of any pain, requirement of additional local infiltration during the procedure, and the need for conversion to general anesthesia and endotracheal intubation.

The secondary outcome measures included complaints of any pain for 60 minutes after the surgery, need for any analgesics for 360 minutes after the surgery, and the timing of resumption of drinking.
There were no USG-TPVB complications, such as pneumothorax, systemic toxicity due to the local anesthetic, and significant changes in the blood pressure and vagal reflex.

After USG-TPVB, the upper limbs of the affected side were placed on the armrest. A warm-cold discrimination test with ice cubes was used to assess the quality of TPVB. Subsequently, we confirmed cryoanesthesia (hypesthesia) of the surrounding incision sites and intravenously administered 1-2 mg of midazolam. When required, 10-20 mg of propofol was added to the continuous administration of 1 mg/kg/h of propofol. The level of sedation was evaluated using the Richmond Agitation-Sedation Scale (RASS). During the procedures, our patient’s RASS scores were maintained within a range of -2 to 0 [3]. The duration of anesthesia, which is the time from USG-TPVB to skin incision, ranged from 15 to 30 minutes (mean, 21.4±4.6 minutes).

**Surgical Technique**

First, the surgeon induced local anesthesia from the percutaneous layer to the parietal pleura with 6-10 mL of 1% lidocaine hydrochloride. The thoracopore incision, for the operative procedure and monitoring using a mini-thoracoscope (2.9 mm Ideal Eyes, Stryker Co., Kalamazoo, MI), was made at a planned site. If the thoracoscope monitoring disturbed the handling of the other operating tools, an additional incision was made using a needle port (2.3-mm Endopath Bladeless Trocar, Johnson & Johnson, New Brunswick, NJ) for the minithoracoscope [4].

If the patients felt any pain during the procedure, we planned an additional local infiltration with 1% lidocaine and intravenous fentanyl citrate. All surgeries were performed by the same surgeon.

**Postoperative Management**

When the surgeon started the suture closure of the wound, we discontinued the administration of propofol. At the end of the surgery, the patients were conscious and alert. Once the patients were transferred to their room, liquid infusion was stopped immediately and oral intake was resumed. Urinary catheterization was not performed. Postoperatively, we administered 60 mg of loxoprofen sodium hydrate for any complaints of pain.

**Statistical Analysis**

The main baseline and intra-operative and post-operative outcome data were compared for 10 patients who underwent mini VATS under local anesthesia alone without TPVB or sedation from April 2006 to December 2016. Of them, 10 patients were excluded from this study. The reason for exclusion was the insufficiency of medical records (Figure 1). For this purpose, the non-parametric Mann-Whitney test was used to assess differences in continuous variables, while a Fisher’s exact test was used to compare the frequencies. A P value of less than 0.05 was considered statistically significant. The data are shown as means ± standard deviation. Microsoft Excel was used for the statistical analysis.

**Results**

**Patient Baseline Characteristics and Pre-Operative Data in Study Groups**

A comparison of the baseline characteristics (age, gender, physical status classification of American Society of Anesthesiologists [PS-ASA]) and preoperative data (preoperative SpO2 and placement of the chest drainage tube) indicated that the two study groups were relatively well-matched (Table 1). Co-morbidities included hypertension, diabetes mellitus, bronchial asthma, chronic articular rheumatism, chronic obstructive pulmonary disease (COPD), and interstitial pneumonia.

**Primary Diagnosis and Operative Procedure in Study Groups**

The primary diagnoses and operative procedures of the two study groups are detailed in Table 1. In curettage, irrigation, and drainage for empyema, the fibrin debris were removed to form a single lumen, and the pleural cavity was washed out and cleaned by irrigation with 2-3 L of warm electrolyzed saline (ES). At the end of the procedure, a double-lumen silicon catheter (18Fr Phicon Samp Catheter, Fuji Systems Co., Tokyo), for continuous ES irrigation and pleural drainage with low-pressure suction, was inserted into the dead space cavity. Regarding pleural biopsy for pleural effusions, after drainage of the pleural effusion and observation of the pleural cavity, biopsy of a parietal pleural lesion was performed with biopsy forceps. Chemical pleurodesis was performed for two patients with intractable pneumothorax and two patients with pleural effusion. Finally, an 18Fr silicon catheter was inserted into the dead space cavity under direct thoracoscopic visualization.

**Intra and postoperative Data**

A comparison of the intra-operative results of the two study groups is illustrated in Table 2. There were no significant differences in the duration of stay in the operating room, total volume of local anesthetic administered during the first local infiltration (1% lidocaine hydrochloride) by the surgeon, and total duration of the surgical procedure. There was also no significant difference in the frequency of intra-operative cough reflex in response to lung manipulation between the two groups. A spray of 10 mL of 1% lidocaine on the lung surface (as intra-pleural analgesia) might have minimized their cough reflexes. Intra-operative pain and requirement for additional infiltration of local anesthetic were significantly less frequent in the TPVB group than in the control group with 0 versus 7 patients (p=0.03), respectively. No patients required conversion to general anesthesia and endotracheal intubation. All patients were managed with a sole video thoracoscopic approach. All patients maintained spontaneous...
breathing during the procedure. No significant changes were found in the blood pressure and heart rate of all patients.

The postoperative outcomes of the two study groups are detailed in Table 2. No significant differences between the two groups were found in postoperative data, whether or not an indwelling catheter was present and the interval of the indwelling catheter, and the duration of hospital stay (Table 2). However, during the 60 minutes after surgery, no patient felt any pain in the TPVB group, but 4 patients (40%) complained of pain in the control group (p=0.08). During the 360 minutes after the surgery, only 1 patient needed an analgesic in the TPVB group, while 4 patients required an analgesic in the control group (p=0.3). All patients resumed prompt drinking after the surgery. No significant postoperative respiratory or surgical complications were noted in any patient.

**Discussion**

A combination of general anesthesia and endotracheal intubation is the first-line anesthetic strategy for thoracic surgery with one-lung ventilation. However, the potential risks include respiratory complications linked to endotracheal intubation and pressure ventilation [5,6], impaired cardiac function, and hemodynamic instability [7]. Avoidance of general anesthesia and endotracheal intubation may reduce the complication rates and result in a faster postoperative recovery, improved mortality and morbidity, and reduced blood levels of stress hormones [8-10]. Furthermore, patients will not have intubation-associated discomforts, including sore throat, hoarseness, and coughing, and may return more quickly to daily activities, including drinking, oral intake, and walking. Consequently, a patient’s satisfaction level may be high [5,11]. In addition, several studies reported a shorter duration of anesthesia and surgical procedures, less need for nursing care, shorter hospital stays, and lower costs [8].

Previous studies have reported the use of local wound infiltration, intercostal nerve block, thoracic epidural block, thoracic paravertebral block, and intrapleural analgesia [12] without general anesthesia [13]. Non-intubated anesthesia in VATS is more difficult than under general anesthesia. An experienced surgeon, a comfortable anesthesiologist and nursing staff, careful patient selection and appropriate informed consent, detailed preparation, and vigilance are required [13]. If perioperative complications occur, a conversion to general anesthesia with endotracheal intubation should be considered without hesitation [14]. Situations characterized by hemodynamic and respiratory instability, panic attacks, and poor pain control caused by inadequate analgesia, as well as technical issues including the presence of extensive fibrous pleural adhesions, bleeding, inadequate lung collapse, and the need to convert to an open surgery may require a conversion to general anesthesia with endotracheal intubation [9].

Conversion to general anesthesia with endotracheal intubation was not required for our entire patients. We think that sufficient pain control caused by adequate analgesia and appropriate sedation are the most important factors for a safe surgery. With sufficient

**Table 1: Patient baseline characteristics and operative procedures**

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>TPVB group (n=10)</th>
<th>Control group (n=10)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean±SD) in years</td>
<td>72.2±10.5</td>
<td>67.4±10.1</td>
<td>0.29</td>
</tr>
<tr>
<td>Gender (M; F)</td>
<td>10; 0</td>
<td>8; 2</td>
<td>0.47</td>
</tr>
<tr>
<td>PS-ASA</td>
<td>3.1±0.32</td>
<td>3.1±0.3</td>
<td>1</td>
</tr>
<tr>
<td>Preoperative SpO₂ (%)</td>
<td>96±0.02</td>
<td>94±0.07</td>
<td>0.69</td>
</tr>
<tr>
<td>Previous indwelling catheter (yes; no)</td>
<td>4; 6</td>
<td>1; 9</td>
<td>0.3</td>
</tr>
<tr>
<td>Primary diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. empyema</td>
<td>6</td>
<td>4</td>
<td>0.66</td>
</tr>
<tr>
<td>2. pleural effusion</td>
<td>2</td>
<td>6</td>
<td>0.17</td>
</tr>
<tr>
<td>3. pneumothorax</td>
<td>2</td>
<td>0</td>
<td>0.47</td>
</tr>
<tr>
<td>Operative procedure (mini VATS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Curettage for empyema</td>
<td>6</td>
<td>4</td>
<td>0.66</td>
</tr>
<tr>
<td>2. Pleural biopsy</td>
<td>2</td>
<td>4</td>
<td>0.63</td>
</tr>
<tr>
<td>3. Chemical pleurodesis</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

PS-ASA: physical status classification of American Society of Anesthesiologists

TPVB: thoracic paravertebral block

Mini VATS: video-assisted thoracic surgery with a miniaturized thoracoscope

M: males

F: females
Figure 1: Flow-chart of study design (tanaka)

Enrollment

30 patients underwent mini-VATS without general anesthesia and endotracheal intubation from April 2006 to December 2016 (n=20)

Allocation

Study (TPVB) group (n=10)
- Underwent USG-TPVB under local anesthesia with sedation

Control group (n=20)
- Underwent local anesthesia without USG-TPVB or sedation

Lost to follow-up (n=0)

Lost to follow-up (n=10)
- Insufficiency of medical records.

Analysis

- Analysed (n=10)
- Required additional infiltration of local anesthetic intraoperatively (n=0)

- Analysed (n=10)
- Required additional infiltration of local anesthetic intraoperatively (n=7)

Figure 1: mini-VATS: video-assisted thoracic surgery using a miniaturized thoracoscope, USG-TPVB: ultrasound-guided thoracic paravertebral block
analgesia, it is possible that a thoracic surgery may be performed without sedation, but panic attacks may occur [13,15]. Panic attacks may be reduced by step-by-step explanation and reassurance, although we think that using light sedation may decrease a patient’s stress.

We expected that a patient’s spontaneous respiration could be maintained and that their RASS scores could also be maintained within the range of -2 to 0 [3]. This level of sedation is characterized by sleeping without any stress, but the patient may be briefly awakened by a voice. We were concerned about desaturation during light sedation. Sedation is characterized by frequent hypoxemia caused by a decreased respiratory rate and increased a tectasis due to decreased muscle tones of the diaphragm, intercostal muscles, and auxiliary inspiratory muscles. In addition, after the parietal pleurais opened during spontaneous breathing, the lung will collapse on exposure to the atmospheric pressure. In all our patients, oxygen was prophylactically administered during the procedure and their SpO2 levels remained stable between 94 to 99%. However, patients with severe COPD or neuromuscular disease have higher risks for perioperative hypercapnia [16]. Respiratory and end-tidal CO2 (EtCO2) measurements should be monitored. For sedation, we administered a continuous intravenous administration of propofol and a small dose of midazolam. In order to prevent a patient’s body movement due to inadequate analgesia, in sufficient sedation, or panic attacks, we carefully monitored their conditions intraoperatively.

For safe surgery, appropriate sedation and adequate analgesia are important. There are many reports of non-intubated anesthesia in VATS with local anesthetic wound infiltration alone. However there are cases in which local anesthesia alone resulted in inadequate intraoperative analgesia. In our study, no patient in the TPVB group complained of any pain throughout the procedure or required additional local anesthetic, but 70% patients in the control group experienced intra-operative pain and required an additional infiltration of local anesthetic. Furthermore, the postoperative pain was also less frequent in the TPVB group than in the control group. Thus, we inferred that TPVB might provide a better analgesic effect. We believe that a combination of local anesthesia and TPVB may offer more sufficient intra-operative analgesia compared to local anesthesia alone. We may combine any other regional anesthesia techniques with local anesthesia, such as intercostal nerve block [17] and epidural block [10,18].

An epidural block has the advantage of providing postoperative pain relief with a continuous infusion by a catheter. However the predicted risk for neurological complications due to thoracic epidural anesthesia was reported to be 3.1% [19]. In addition, there are other potential complications, including a dural perforation, unsuccessful catheter placement, postoperative radicular type of
pain, and epidural hematoma. Furthermore, the depth of anesthesia could be higher than our estimate and highly concentrated anesthetics could lead to a motor block of the respiratory muscles. A decreased tidal volume can lead to desaturation in the patient. In addition, a decrease in the blood pressure due to a vasodilatory effect, vagal reflex, and urinary retention are possible [5,16].

A study by Davies et al. reported that TPVB provides pain relief comparable to an epidural block, and it also has a lower incidence of failure and side effects, such as urinary retention and hypotension, compared to an epidural block [20]. Unlike an epidural block, TPVB offers the advantage of a unilateral block without bilateral sympathectomy [13]. Complications of TPVB are pneumothorax and pleural puncture, signs of epidural or intrathecal spread, and inadvertent vascular puncture [21]. In patients who have already undergone thoracotomy, the inevitable adhesion formation may alter the anatomy around the paravertebral space [22]. In TPVB with a loss-of-resistance technique, it is necessary to be careful. In these cases, TPVB with the assistance of an ultrasound can be useful for a safe performance.

We performed TPVB under ultrasound guidance. With the assistance of an ultrasound, anatomical variation could be identified. Due to pleural thickening and pleural effusion with inflammation, it may be difficult to identify the internal intercostal membrane and the parietal pleura in many cases. With the needle tip visualized on an ultrasound image, we should cautiously advance the needle and assess the proper paravertebral space with a small injection. In some cases, we cannot clearly confirm that the parietal pleura are pressed ventrally as a result of a local anesthetic injection.

In the TPVB group, we confirmed hypoesthesia of the surrounding incision sites by a warm-cold discrimination test with ice cubes before the surgery. None of our patients felt any pain, when the surgeon performed the local infiltration. If our patients complained of any pain during the procedure, we planned for additional local anesthesia administration and intravenous administration of fentanyl citrate. However, no patients complained of any pain during the surgery. Pain control was sufficient with TPVB and first local infiltration. Furthermore, since we administered both short-acting and long-acting local anesthetics, intraoperative and postoperative pain was controlled.

To secure a sufficient visual field and safe handling of operating tools in the pleural cavity, it is important to determine the target location and the appropriate site for the first thoracoport incision by preoperative computed tomography (CT) and ultrasonography. With a surgeon, we determined the appropriate intercostal level for the first thoracoport incision and TPVB puncture under...
ultrasonography on a pre-scan before TPVB.

During the procedure, lung manipulation can induce a cough reflex. Some methods that minimize a cough reflex for a safe surgery have been reported; including spraying lidocaine on the lung surface [23], aninathrathorac vagus nerve block [23], an inhalation of aerosolized lidocaine [24], and a stellate ganglion block [24]. However, complete suppression of the cough reflex may increase the risk of aspiration [13]. In our cases that had a cough reflex, the surgeon stopped the procedure and sprayed 10 mL of lidocaine on the lung surface. Subsequently, we waited for suppression of the cough reflex. It may also be effective for the surgeon to keep in mind to adopt more delicate surgical maneuvers without touching the lungs.

This study had some limitations and weakness. This study population is still small for analyzing the effect of TPVB, while significant differences between study (TPVB) and control groups were obtained. This less invasive approach for anesthesia will be discussed in future randomized control studies with larger sample size and prolonged follow-up.

Conclusion

Mini VATS can be performed safety without general anesthesia and endotracheal intubation with adequate analgesia and appropriate sedation. Our study supports the use of TPVB to provide adequate analgesia compared with the use of local anesthesia alone. Ultrasound guidance can enhance the safety of TPVB. Using light sedation may be effective to decrease a patient's stress and perform a safe procedure. Furthermore, the surgeon may be required to adopt delicate surgical technique.

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References

