Ultrasound-Guided Thoracic Paravertebral Block for Controlling Pain in Percutaneous Radiofrequency Ablation of Hepatic Tumors: A Prospective Case Series

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ABSTRACT

Objective: Patients with hepatic tumors undergo percutaneous radiofrequency ablation (PRFA) performed under local anesthesia and intravenous sedation can experience severe post-procedural pain. This prospective case series evaluated the feasibility, efficacy, and safety of ultrasound-assisted thoracic paravertebral blocks (TPVB) at three levels (T5-6, T7-8, and T9-10) for post-procedural pain control.

Methods: 35 patients with hepatic tumors received 3 levels ultrasound-guided right thoracic paravertebral blocks (TPVB) at T5-6, T7-8, and T9-10. Patients were administered with propofol bolus with continuous infusion for sedation. Pain score at post anesthesia care unit and maximum pain score during 24 hours were recorded.

Results: All patients except one reported minimal pain after PRFA. Mean NRS on arrival in PACU was 0.51 (SD: 1.50; range: 0-7) at rest and 1.20 (SD: 1.95; range: 0-10) on movement. The maximum pain score during 24 hour post-procedure period was 1.31 (SD: 1.93; range: 0-10). One case reported severe pain at shoulder due to the tumor adjacent to the diaphragm. Patients can tolerate TPVB well and there were no complications associated with the blocks.

Conclusion: 3 levels ultrasound-guided TPVB can produce effective post-procedural pain control. The technique is promising and may also be appropriate for other interventional radiological procedures such as trans-arterial chemoembolization (TACE) of hepatic tumors and percutaneous trans-hepatic biliary drainage (PTBD).

Keywords: Percutaneous radiofrequency ablation of hepatic tumors; ultrasound-guided thoracic paravertebral block (Siriraj Med J 2018;70: 145-151)

INTRODUCTION

Percutaneous radiofrequency ablation (PRFA) is widely used in the management of small primary, inoperable primary, recurrent, or metastatic hepatic tumors.1-4 PRFA is a localized thermal treatment technique designed to produce tumor destruction by heating tumor tissue to a temperature that approximates 50-60°C via a needle electrode. Anesthetic management for PRFA of hepatic tumors can be performed using mild sedation, deep sedation, general anesthesia, or epidural analgesia.5-7 At our institution, local anesthesia with intravenous sedation is usually applied. However, early post-procedural pain is reported by the majority of patients undergoing this procedure.5-12 These results are similar to our pilot study, in which 11 out of 15 patients (73%) endured PRFA of hepatic tumors under usual anesthetic technique (local anesthesia with intravenous sedation) reported moderate to severe pain at recovery room (pain score 4-10 out of 10) and required the intravenous opioids such as morphine or pethidine.

Thoracic paravertebral block (TPVB) is a technique that involves injecting local anesthetic alongside the thoracic vertebral body, close to where the spinal nerves emerge from the intervertebral foramen. This procedure...
provides ipsilateral, segmental, somatic, and sympathetic nerve blockade in multiple contiguous dermatomes.\textsuperscript{13} Paravertebral block is an analgesic technique used for pain relief after chest and abdominal surgery.\textsuperscript{14,15} There are several different techniques for performing TPVB, including loss-of-resistance, nerve stimulator-guided, and ultrasound-guided techniques. The ultrasound provides several advantages such as preventing pneumothorax which is the serious complication of TPVB.\textsuperscript{16} From previous studies, multiple paravertebral injections resulted in more reliable radiographic and clinical distribution compared with a single-injection technique.\textsuperscript{17,18} The objective of this study was to evaluate the pain control effectiveness of 3 levels ultrasound-guided right TPVB in patients undergoing PRFA of hepatic tumor. Effectiveness was defined as more than 90 percent of all patients having mild pain (less than 4 out of 10) and not requiring any rescue analgesic drugs in the post-anesthesia care unit.

**MATERIALS AND METHODS**

The protocol for this study was approved by the Siriraj Institutional Review Board (Si 070/2014), and written informed consent was obtained from all study participants. This study was registered on the ClinicalTrials.gov website (ID NCT02271646). During the March 2014 to December 2014 study period, 35 patients undergoing percutaneous radiofrequency ablation of hepatic tumors at Siriraj Hospital were included. Study subjects ranged in age from 47 to 84 years, each with ASA physical status of either 2 or 3. The number of patients was based on the hypothesis that more than 90 percent of all patients receiving paravertebral blocks will have mild pain. Using a two-sided test with 90% power and an alpha level of 0.05, the calculated sample size was 35 patients. Patients were excluded if they had a history of psychiatric illness, chronic pain, regular analgesic usage, or contraindications to TPVB, to include chest wall deformity, severe coagulopathy (PT > 16 sec, aPTT > 32 sec, and platelet < 45,000/mm\textsuperscript{2}), local or systemic infection, and/or allergy to local anesthetic drugs.

The study design was a prospective case series. All patients were instructed in the use of the Numeric Rating Scale for Pain (NRS: 0, no pain to 10, worst imaginable pain) for pain assessment during the pre-operative visit. Patients were also instructed regarding pain assessment at rest and when they cough (involving movement). Patients fasted for at least 6 hours before surgery and no premedication was given. Intravenous access and standard monitoring, including electrocardiography (ECG), pulse oximetry, and non-invasive blood pressure monitoring (cycle every 3 minutes), were established before TPVB was performed. Patients were positioned in the left lateral decubitus position with the neck slightly flexed and the right arm resting on a pillow to properly position the scapula. All patients received oxygen (2 L/min) via nasal cannula. Midazolam (1-2 mg) and fentanyl (25-50 mcg) were administered intravenously, as needed, for analgesia when performing the block. A review scan was performed using a low frequency (2-5 MHz) curved ultrasound transducer, with the objective of obtaining a transverse view of the thoracic paravertebral space. The thoracic paravertebral levels were counted, starting from the seventh cervical vertebra which is not attached to a rib. The thoracic paravertebral spaces for T5-6, T7-8, and T9-10 were identified and marked with a marker pen. All patients were blocked by the principal investigator who experienced ultrasound-guided TPVB for more than 100 injections.

Using aseptic precautions, skin and subcutaneous tissue at the marked levels were anesthetized with 1-2 ml of 1% lidocaine. Starting at the T5-T6 level, a 10 cm 22 g block needle was advanced from a lateral to medial direction under ultrasound visualization, using the in-plane approach. When possible, needles were inserted at the articular process level, because the area of acoustic shadow is significantly smaller than the level of the transverse process (Fig 1). The advantages are this window offers less bony obstruction when advancing the block needle and the needle tip is not in the acoustic shadow of the transverse process. If not possible, needles were compromised and inserted at the transverse process level (Fig 2). Bupivacaine 0.5% with adrenaline 1:200,000 7 ml, 7 ml, and 6 ml was injected at T5-6, T7-8, and T9-10, respectively. After injection was completed, patients were returned to the supine position with any procedure-related complications (e.g., pneumothorax, hypotension

![Fig 1. Transverse sonogram of the thoracic paravertebral space at the articular process window.](image)

**Abbreviation:** TPVS = thoracic paravertebral space
and local anesthetic systemic toxicity) being observed and appropriately treated. Sensation was tested by alcohol soaked cotton at 5, 10, 20, and 30 minutes after injection. Patients were then transferred to the intervention room which is equipped with CT fluoroscopy for difficult cases of localizing hepatic tumor.

After all standard monitoring devices were placed and activated, patients were positioned either supine with right arm resting above patient head or left lateral decubitus, according to the discretion of the interventional radiologist. The patient’s right upper abdominal quadrant was then cleaned and draped with sterile sheath. Patients were asked to hold their breath to allow the interventionist to clearly identify and define the location of the tumor before needle electrode tip insertion. Before inserting the needle electrode, the interventionist tested patient skin sensation with forceps. Patients who experienced pain received xylocaine 1% 5-10 ml via skin and subcutaneous injection. After the needle electrode was positioned in the tumor, but before starting thermal burn (radiofrequency ablation), patients received propofol bolus with continuous infusion for sedation. The following information was taken and recorded: patient characteristics; number, size, and location of hepatic tumor(s); block performance time; patient discomfort score while performing paravertebral block; total PRFA procedure time and total burning time. Complications of TPVB (e.g., pneumothorax, hypotension and local anesthetic systemic toxicity), PRFA (e.g., pneumothorax), and anesthesia (e.g., bradycardia and hypotension) were also recorded. Bradycardia was defined as patients’ heart rate less than 40 bpm or heart rate between 40 to 60 bpm with hypotension. Hypotension was defined as a 25% decrease in systolic blood pressure from baseline. Atropine, ephedrine or norepinephrine were appropriately administered by anesthesiologists in charge. At the end of PRFA procedure, the interventional radiologist’s satisfaction with the anesthetic technique was assessed and recorded (satisfaction score: 0, totally dissatisfied to 10, very satisfied). After completion of PRFA, sedation was discontinued and patient was transferred to the post-anesthetic care unit (PACU) where vital signs were monitored every 5 min for 30 min. A recovery room nurse not involved with this research evaluated patient pain score on arrival and before discharge from the PACU as normal. For patients with NRS ≥ 5 while in the PACU, morphine (2 mg intravenous bolus for patient age < 70 year and 1 mg for patient age ≥ 70 year) for analgesia was given, with dose being repeated, as needed, every 5 min for a maximum of 3 doses. Upon return to the surgical ward, patients were allowed to eat and drink as tolerated. All patients received paracetamol 500 mg oral every 6 hours and either paracetamol 500 mg oral when NRS < 5 or morphine 1-2 mg intravenous when NRS ≥ 5 for breakthrough pain. A blinded nurse anesthetist visited patients 24 h after PRFA and recorded maximum pain score during previous 24 hour period, patient satisfaction with anesthesia technique, and any complications.

### Statistical analysis

Data were processed using SPSS for Windows v.14.0 (SPSS, Inc., Chicago, IL, USA). Shapiro-Wilk test was used to evaluate the distribution of continuous data. Data that were normally distributed were presented as mean (SD) (range) and data that were not normally distributed were presented as median (range).

### RESULTS

Patients’ demographic data were demonstrated in Table 1. None of the enrolled patients had any exclusion criteria. Mean diameter of the first tumor nodule (35 nodules) was 1.94 cm (SD: 1.05; range: 0.50-4.70), with the mean diameter of the second nodule (14 nodules) being 1.50 cm (SD: 0.88; range: 0.40-3.20). Tumor nodule was located in right lobe of the liver in 22 patients, left lobe in 10 patients, and in both lobes in 3 patients.

Regarding coagulation values, 13 patients (37%) had platelet less than 100,000/mm$^3$ (11 patients had platelet count between 50,000-100,000 and 2 patients had platelet less than 50,000) and all patients had PT ≤ 16 sec and aPTT ≤ 32 sec.

Mean duration of 3 levels thoracic paravertebral block was 14.6 min (SD: 5.07; range: 5-25) and mean maximum NRS pain score experienced by patients
during block was 2.91 (SD: 1.4; range: 0-6). Onset of sensory loss after injection as determined by cold test (defined as decrease in sensation from 100% to 20%) was 20 min in 14 patients and 30 min in 11 patients. At 30 min block produced ipsilateral sensory blockade in over 5 dermatomes (range: 1-9), and in most cases the dermatome extent of anesthesia was T5 to T10. There was no bilateral blockade in any patients. Twenty percent of patients (7 of 35) required local anesthesia before inserting needle electrode. All 7 of those patients had left lobe hepatic tumor, which required puncture point at left side of the abdomen.

The entire radiofrequency ablation procedure lasted an average of 82.06 min (SD: 50.32; range: 25-260), with mean RFA burn time lasting 30.69 min (SD: 24.59; range: 2.61-100.45). One case of pneumothorax from PRFA procedure developed, which was treated with supplemental oxygen therapy. Two patients developed bradycardia, which was treated with atropine injection.

All patients except one reported minimal pain after PRFA. Mean NRS on arrival in PACU was 0.51 (SD: 1.50; range: 0-7) at rest and 1.20 (SD: 1.95; range: 0-10) on movement. While pain score on discharge from PACU was 0.23 (SD: 0.64; range: 0-2) at rest and 0.88 (SD: 1.02; range: 0-3) on movement. The maximum pain score during 24 hour post-procedure period was 1.31 (SD: 1.93; range: 0-10) (Table 2). One patient reported severe pain in her shoulder in the PACU (pain score 10). This patient had tumor at segment 8, which was adjacent to capsule and diaphragm. After giving morphine 1 mg, 3 times, the patient reported a satisfactory decrease in pain. NRS score reduced from 10 to 3 and patient was uneventfully discharged from PACU. Regarding overall satisfaction with the anesthetic technique, mean patient satisfaction score was 9.83 (SD: 0.71; range: 7-10) and mean interventional radiologist satisfaction score was 9.63 (SD: 0.64; range: 7-10). There were no complications from TPVB in all patients.

### TABLE 1. Demographic information of all patients (n=35).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>n = 35 (Mean, SD, Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>61.51 (8.72), (47-83)</td>
</tr>
<tr>
<td>Sex (n/%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>26 (65.2%)</td>
</tr>
<tr>
<td>Female</td>
<td>9 (34.8%)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65.94 (11.59), (48-100)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.77 (4.49), (17.71-34.60)</td>
</tr>
<tr>
<td>ASA classification (n/%)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>24 (68.6%)</td>
</tr>
<tr>
<td>III</td>
<td>11 (31.4%)</td>
</tr>
</tbody>
</table>

Continuous data were shown as mean (SD) (min-max) and categorical data were presented as count (percentage).

**Abbreviations:** BMI = body mass index; ASA = American Society of Anesthesiologists

### TABLE 2. The numeric rating scale (NRS) reported by patients (n=35) at different times.

<table>
<thead>
<tr>
<th>Time</th>
<th>Numeric Rating Scale (NRS) At rest</th>
<th>Numeric Rating Scale (NRS) At movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>On arrival in PACU</td>
<td>0.51 (SD 1.50; range: 0-7)</td>
<td>1.20 (SD 1.95; range: 0-10)</td>
</tr>
<tr>
<td>On discharge from PACU</td>
<td>0.23 (SD 0.64; range: 0-2)</td>
<td>0.88 (SD 1.02; range: 0-3)</td>
</tr>
<tr>
<td>Maximum pain score within 24 hr</td>
<td>1.31 (SD: 1.93; range: 0-10)</td>
<td></td>
</tr>
</tbody>
</table>

The data was shown as mean (SD; range)

**Abbreviation:** PACU = post-anesthetic care unit
DISCUSSION

In this prospective case series, we successfully demonstrated the effectiveness of 3 levels ultrasound-assisted right TPVB for postoperative pain control in patients undergoing PRFA of hepatic tumors. All patients except one had mild pain (less than 4 out of 10) and did not require any rescue analgesic drug in the post-anesthesia care unit. This study focused on patients' pain score in PACU according to a pilot study showing the period of maximum pain in most patients was in PACU. Moreover in the literature review, early post procedural pain was reported by the majority of patients undergoing this procedure. Results from this study were consistent with those of Cheung, et al., who used 5 level thoracic paravertebral blocks (T6-T10) with loss-of-resistance with glass syringe technique. Their patients (20 patients) reported minimal pain after PRFA, with mean (SD) NRS on arrival in PACU 2.0 (2.5), at discharge from PACU 1.7 (2.1), and at 24 h ward visit 1.3 (1.6). The spreading pattern of paravertebral block is unpredictable. Injected solution may remain localized in the space where it was injected or it may spread to the contiguous spaces above and/or below, the intercostal space laterally, or a combination of the above outcomes. A recent magnetic resonance imaging study (MRI) showed the spread of local anesthetic solution after ultrasound-guided thoracic paravertebral block. Using 20 ml at T6 level, they detected variability in the spread of local anesthetic between two and six levels. Moreover, the extent of sensory block was highly variable and significantly larger, when compared with the spread of local anesthetic. The ultrasound-assisted technique may facilitate more accurate placement and more controlled spread of local anesthetic. For this study, we decided to evaluate the efficacy of 3 levels, as compared to 5 levels in the Cheung, et al., study. Patients would suffer less puncture-related discomfort and be at lower risk with less injection punctures.

Picconi, et al., used 2 level thoracic paravertebral block with nerve stimulator guidance as the sole anesthetic for percutaneous radiofrequency ablation of hepatic tumor. Their result delivered adequate pain relief during RFA, with median VNS (verbal numeric scale) of 0.5 (range: 0-6). No patients requested sedatives or opioids during the procedures in the Picconi, et al., study. Using only ultrasound guidance, the patients in our study were not able to tolerate procedure-related pain and required sedative medication. For the last 10 cases, we decided to combine with nerve stimulator, but we were not able to elicit intercostal muscle contraction at low current (0.5 mA). We successfully elicited muscle contraction at 0.5 mA for all 3 levels of injection in only 3 patients, with all 3 patients able to tolerate the burning segment without any sedation requirement. Because patients were awake, the radiologists were very satisfied with the patients’ cooperation (breath holding) during the procedure especially when they inserted the needle at the second nodule. However, there were disadvantages of not giving sedation which included patient fatigue and malaise due to an extended period in the supine position and a pronounced unpleasant feeling from heat created by the RFA procedure. Furthermore, theoretically TPVB alone may not provide adequate anesthetic for the PRFA procedure, because the liver and its capsule are innervated by sympathetic and parasympathetic nerves via the hepatic plexus. Sympathetic fibers extend from the thoracic sympathetic chain from T5 (or T6) to T11 and reach the liver via the greater and lesser splanchnic nerves and the coeliac plexus. Thus, using only thoracic paravertebral block as the sole anesthetic is not yet clearly explained.

Two out of 3 patients that were able to tolerate the burning segment without any sedation requirement developed severe bradycardia during the PRFA procedure which was not seen in patients receiving sedation. The Valsalva maneuver or repeating the Valsalva maneuver may have been responsible for this bradycardia. This maneuver involves compressing the liver to prevent it from shifting or moving during placement of the RFA needle. The Valsalva maneuver causes increased vagal tone and decreased venous blood return, resulting in bradycardia and low cardiac output. In this situation, vagal crisis can be treated with atropine administration.

From this study, one patient with tumor adjacent to diaphragm that had severe shoulder pain may have benefited from superficial cervical plexus block, because the phrenic nerve receives innervation from both the cervical plexus and the brachial plexus.

Onset of paravertebral block in our study took longer, as compared with Cheung, et al., and Picconi, et al., Only 71.43% of our patients (25 of 35 patients) had onset within 30 minutes, while Cheung, et al., reported onset within 10 minutes and Picconi, et al., reported onset within 15-20 minutes. This may be explained by differences in technique and/or number of injections. There was no contralateral spreading in our study. This result was similar to Picconi, et al., but remains in contrast with Cheung, et al. Similar to onset, this may be explained by differences in technique.

Thoracic paravertebral block may prove to be an excellent post-procedure analgesia for other radiology procedures, such as transarterial chemoembolization.
(TACE). Most patients scheduled for TACE procedure have platelet and coagulopathy complications, for which paravertebral block can safely be used. TPVB is a technique that involves injecting local anesthetic solution alongside vertebra; unlike epidural block, which may cause epidural hematoma. In this study, paravertebral block could be performed in 11 patients who had platelet count between 50,000 and 100,000 and 2 patients with platelet count lower than 50,000/mm³ without any following complications. However the future study with larger sample size should be investigated before drawing this conclusion. In addition, the continuous presence of an ultrasound machine in the radiology department is an added advantage to using the ultrasound-guided technique.

In this study we were unable to compare TPVB with an alternative anesthetic technique for overall analgesia efficacy and complication rates. A double-blind randomized controlled trial would be a better study design. However, this involves performing a sham TPVB in patients, which is ethically less acceptable for a pilot study investigating the safety and efficacy of ultrasound guided TPVB. Nevertheless, 3 levels ultrasound-guided TPVB demonstrated effectiveness in postoperative pain control as shown in Table 2. Interventionists expressed satisfaction that patients were able to cooperate with them while experiencing only mild pain. In patients that have more than one tumor, we recommend selecting the most difficult one first, because onset of sedation for burning procedure makes it difficult for the patient to cooperate with the inserting needle electrode on the next nodule. While a distinct advantage of ultrasound-guided TPVB is low risk of pneumothorax, a combination of nerve stimulator-guided and ultrasound-guided TPVB may be the safest and most efficacious method. We may be able to use only thoracic paravertebral block as the sole anesthetic for PRFA of hepatic tumors.

CONCLUSION

A 3 levels ultrasound guided right TPVB is an effective technique for providing postoperative pain control for PRFA of hepatic tumors. This blocking technique was well-tolerated by patients and was well-received by interventional radiologists.

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