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Research Article

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Comparison of Single-Injection and Multiple-Injection Thoracic Paravertebral Block in Preventing Pain after Video-Assisted Thoracoscopic Surgery

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Abstract

Aim: *In our study, we aimed to compare the effect of single and multiple thoracic paravertebral block (TPVB) patients who underwent video assisted thoracoscopic surgery (VATS) on hemodynamic parameters, postoperative visual analog scale (VAS) and sedation scores, and total analgesic consumption.*

Materials and Method: *The ASA II-III, age between 18 to 65 years, and body mass index lower than thirty, 60 patients who underwent elective VATS were included to this study. Patients were divided into two groups as single (Group S), (n:30) and multiple (Group M), (n:30) TPVB. Block was performed at T6 level in Group S and at T4, T6, T8 levels in Group M by using 21 mL 0.5 % bupivacaine. Intravenous patient-controlled analgesia (PCA) was performed for both groups after surgery. Systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), peripheral oxygen saturation (SpO2), Ramsay sedation score (RSS), tramadol consumption during 24 hours, resting and coughing VAS scores were recorded before PCA and at 30th, first, second, 6th, 12th, 20th, and 24th hours of postoperative periods. 50 mg iv dexketoprophene was administered when coughing VAS score above the 4. Despite the iv dexketoprophene, in case of consistent pain 1 gr iv paracetamol was given to the patients, and all additional analgesic requirement was recorded.*

Results: *Hemodynamic parameters were similar in both groups during postoperative period ($p>0.05$). VAS scores were higher in Group M but there were not statistically significant ($p>0.05$). Additional analgesic requirement was significantly higher in Group M, ($p>0.04$). Cumulative tramadol consumption was comparable between the groups, ($p>0.05$).*

Conclusion: *In TPVB, it was observed that single and multiple injections provided similar postoperative pain scores and postoperative cumulative tramadol consumption, but we observed a high additional analgesic requirement in multiple injection group. Based on this result, we concluded that there would be no need to disturb patient comfort and prolong the procedure by applying multiple injections.*

Keywords: Regional Block, Thoracic Paravertebral Block, Video Assisted Thoracoscopic Surgery, Single Injection, Multiple Injection, Visual Analog Scala, Patient Controlled Analgesia, Postoperative Pain, Analgesic Administration.

Introduction

Pain relief with effective analgesia after thoracic surgery accelerates recovery, reduces complications, promotes early mobilization, and thus, shortens patient's hospital stay [1]. Inadequate pain management leads to delayed mobilization and rapid shallow breathing. These troubles lead to serious complications, such as impaired tissue oxygenation, atelectasis, and deep vein thrombosis [2, 3].

With the advancement of techniques in endoscopic surgery in recent years, video-assisted thoracoscopic surgery (VATS) has become a widely used method in thoracic surgery. This method has been reported to have the advantages of early recovery of pulmonary functions, shorter length of hospital stays, and shortened surgical time [4-6]. Pain occurring after VATS is mainly treated with patient-controlled analgesia (PCA) and paravertebral block. Instead of taking on a single approach using combinations of medications and techniques to minimize potential complications and provide adequate analgesia ensures more effective analgesia in pa-

tients having VATS [7]. Thoracic paravertebral block (TPVB) has been shown to provide adequate analgesia in patients undergoing thoracotomy, cholecystectomy, and nephrectomy [8-10]. Despite novel techniques such as erector spinae block (ESB) and serratus plane block for pain management in VATS, TPVB still a common method for preventing pain after VATS [11-15]. Complications resulting from thoracic sympathetic block, such as hypotension, bradycardia and urinary retention, occur less in TPVB [2, 16, 17].

Blocking nociception by applying analgesic methods before the onset of painful stimuli is called preemptive analgesia. As peripheral hypersensitivity and central nervous system hyperexcitability may occur if analgesic treatment is started after the onset of nociceptive stimuli, pain management can be challenging in such patients [19, 20].

The present prospective study aimed to evaluate 24-hour postoperative VAS scores, analgesic consumption, hemodynamic parameters, and complications in patients receiving preoperative TPVB with single injection versus multiple injections to prevent pain after VATS.

Material and Method

This study was conducted with the approval of the Keçiören Training and Research Hospital Ethics Committee, dated 20.08.2013 and no 368. (ID 082013/368). A total of 60 patients undergoing elective VATS between June, 2013 and December, 2013 and patients were randomized into two groups by using computer generated randomization with independent researcher. All patients participating in the study were informed about the procedure to be performed and its potential complications and gave oral and written consent to the study.

Inclusion criteria included ASA II-III, age between 18 and 65 years, eligibility for VATS and a body mass index (BMI) lower than of 30 kg/m2. Exclusion criteria included preoperative pain, mental disorders, use of anticoagulants, bleeding disorders, alcohol use, disturbance of liver function, diagnosed neurological diseases, musculoskeletal diseases, heart failure, renal failure, significant metabolic or endocrine diseases, history of allergy to local anesthetics, infection at the surgical site, and rejection to giving consent to the procedure. All patients were evaluated one day prior to the surgery. Patients were informed about VAS measurements and given information on resting VAS (VASrest) and coughing VAS (VAScough) scores.

Before being taken to the operating room, all patients were given 500 ml saline following intravenous (IV) cannulation with 18-gauge branule. Thirty minutes prior to the surgery, patients were received premedication with intramuscular (IM) midazolam 0.07 mg/kg and atropine 0.01 mg/kg. When patients were transferred to the operating room, they were monitored for systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), and peripheral oxygen saturation (SpO2).

Patients were randomized into two groups; the first group received single injection (Group S) (n: 30) and the second group received multiple injections (Group M) (n: 30) for TPVB. In order to prevent anxiety and pain during the procedure, patients were given 25 mcg IV fentanyl before TPVB. Prior to TPVB, surgical site was cleaned and covered according to antiseptic protocol, 1-2 ml 2% prilocaine was used for skin anesthesia. The first group (Group S) was stimulated using a 10 cm 22-gauge nerve stimulator needle (2.5 milliamperes, 0.3 milliseconds, and 1 Hz) in the sitting position. The needle was introduced at the T6 level, 2.5 cm lateral to the spinous process. When the transverse process of vertebrae was reached, the needle was withdrawn till the subcutaneous tissue and then reintroduced with an angle of 10 degrees and the transverse process was passed. Then, when the paravertebral space was entered, nerve stimulation was reduced by 0.5 mA. If the intercostal muscles did not give any response to the stimulation, the needle was moved to find the appropriate location. The TPVB procedure was applied at the levels of T6 in Group S and at the T4, T6, and T8 levels in the second group (Group M). While 21 mL 0.5% bupivacaine was administered at a single level (T6) to Group S for TPVB, patients in Group M were given 7 ml 0.5% bupivacaine at T4, T6, and T8 levels. After the procedure, unilateral sensory blockade was checked 10 minutes after the TPVB to evaluate the block success. For the induction of general anesthesia, all patients were given 2 mg/kg propofol, 0.5 mg/kg atracurium, and 1 mcg/kg fentanyl intravenously. All patients were intubated using endobronchial double lumen tubes and patients were positioned as lateral decubiti's position. Anesthesia management was maintained with 2-3% sevoflurane in O2 / air mixture (50 - 100%) and fentanyl boluses in both groups when necessary, 0.1 mg/kg atracurium was added.

During TPVB, induction and intraoperative period, a 20% decrease in MAP according to the preoperative period was considered hypotension while a HR of <50 pulse/minutes was defined as bradycardia. Hypotension treatment was planned as initial fluid infusion followed with IV administration of a vasoconstrictor agent (ephedrine 5-10 mg), if necessary. In case of bradycardia, IV administration of 0.5 mg atropine sulfate was planned.

In the postoperative period, both groups received IV patient-controlled analgesia (PCA). In 100 mL 0.9% normal saline solution, 500 mg tramadol was added. PCA device was adjusted to a basal infusion of 10 mg/hr, bolus dose of 20 mg, lock-up time of 30 minutes, and a 4-hour limit of 120 mg, and the PCA administration was ended at the 24th hour. Complications (nausea and vomiting, respiratory depression, constipation, sedation, bradycardia, and hypotension) occurring during PCA were recorded. Patients with nausea and vomiting were given 10 mg IV metoclopramide. Independent from sedation, a respiratory rate of <8/min and an SpO2 of 90% was regarded as respiratory depression. In case of hypotension not responding to crystalloids and colloids, patients were planned to be given IV ephedrine and to be given IV atropine in case of bradycardia.

Patients' SAP, DAP, MAP, HR, RR, SpO2, VASrest, VAScough, and RSS were recorded prior to PCA, at the 30th minute and 1st, 2nd, 6th, 12th, 20th, and 24th hours after PCA. During follow up, patients' tramadol demand in PCA, number of PCA bolus doses delivered and total analgesic consumption were recorded. If the VAS score was ≥4, 50 mg dexketoprofen was administered intravenously as additional analgesic. When pain continued despite the

use of dexketoprofen, 1 g IV paracetamol was administered and recorded as need for additional analgesia.

Sedation score was evaluated using the RSS (1: Awake, agitated and restless; 2: Awake, cooperative, oriented, calm; 3: Responds to commands only; 4: Asleep, a brisk response to a light glabellar tap/loud auditory stimulus; 5: Asleep, a sluggish response to a light glabellar tap/loud auditory stimulus, but responds to painful stimulus; 6: No response to painful stimulus).

Statistical Analysis

The Power analysis envisaged that to test the statistical significance of a minimum of 35% difference in pain incidence between the single-injection and multiple-injection TPVB groups with an 80% power and a 5% error level, there should be at least 27 subjects in each group. The information of 35% difference was obtained from the pilot study conducted and personal clinical experiences. Sample size was calculated using the NCSS & PASS 2000 package program.

Study data was analyzed using the SPSS (Statistical Package for Social Science) for Windows 11.5. The Kolmogorov Smirnov test was used to determine the normality of the distribution of continuous and discrete numerical variables. The descriptive statistics used for continuous and discrete numerical variables were average ± standard deviation or median (minimum-maximum) while the number of patients and percentage (%) were used for nominal variables.

The significance of difference between groups regarding average values was tested with the Student's T test while the difference regarding median values was evaluated with the Mann Whitney U test. Nominal variables were analyzed using the Pearson's Chi-square test or the Likelihood Ratio test.

Hemodynamic measurements were assessed using the Repeated Measurements of ANOVA with Greenhouse-Geisser test statistics. Whether the groups differed in terms of the change in hemodynamic measurements over time was evaluated by checking the significance of Group x Time interaction effect. When the results of the Wilks' Lambda test statistics were significant, we used the Bonferroni Correction for multiple comparisons in order to determine the follow-up periods causing the difference.

Additionally, the Friedman test was employed to analyze whether VAS and sedation scores showed a significant difference over time. When the results of the Friedman test were significant, Wilcoxon signed-rank test was conducted with a Bonferroni Correction applied in order to determine the follow-up periods causing the difference.

Unless otherwise stated, $p<0.05$ was considered statistically significant. However, we applied the Bonferroni's Correction to control potential Type 1 errors in all multiple comparisons.

Results

Sixty patients were included in the study. No statistically significant difference was found between the groups regarding average age, gender distribution, ASA physical status, height and weight measurements, median duration of operation and distribution of operation types ($p>0.05$). No statistically significant difference was observed between Group S and Group M in intraoperative fentanyl consumption ($p>0.435$), (Table 1).

Table 1: Patients' demographic and clinical characteristics

Variables	Group S (n=30)	Group M (n=30)	P value
Age (years) (avg±sd)	44.5±17.1	45.3±13.8	0.836
Gender (%)			0.347
Male	22 (73.3%)	25 (83.3%)	
Female	8 (26.7%)	5 (16.7%)	
ASA (%)			1.000
2	16 (53.3%)	16 (53.3%)	
3	14 (46.7%)	14 (46.7%)	
Body Mass Index (kg/m^2) (avg±sd)	**23.7±4.7**	**25.0±3.9**	0.257
Dose of Intraoperative Fentanyl (mcg) median (minimum-maximum)	75 (75-150)	75 (75-125)	0.435
Operation Type			0.998
Biopsy, Discharge of Pleural Effusion	13 (43.3%)	12 (40.0%)	
Resection of Bullae	8 (26.7%)	8 (26.7%)	
Wedge Resection	6 (20.0%)	7 (23.3%)	
Lobectomy	2 (6.7%)	2 (6.7%)	
Thymectomy	1 (3.3%)	1 (3.3%)	

† $p<0.05$ was considered statistically significant.

avg±sd: average±standard deviation
ASA: American Society of Anesthesiolgist. TPVB: Thoracic paravertebral block

In Group S, there was a significant decrease in patients' VAS_{rest} scores as of the 2nd hour after PCA when compared with the measurements before PCA ($p<0.00091$). On the other hand, in Group M, there was a significant decrease in patients' VASrest scores as of the 1st hour after PCA when compared with the measurements before PCA ($p<0.00091$), (Table 2). According to the Bonferroni Correction, there was no statistically significant difference between Group S and Group M in terms of VAS_{rest} levels measured before and after PCA ($p>0.0045$), (Table 2).

Table 2: Patients' resting visual analog scale (VASrest) scores prior to PCA and postoperative 24 hours

avg±sd (min.-max.)	Group S (n=30) VAS_{rest} avg±sd (min.-max.)	Group M (n=30) VAS_{rest} avg±sd (min.-max.)	P value †
Before PCA	2.2±1.6 [2 (0-6)]	2.8±1.8 [3 (0-6)]	0.165
30th min	2.0±1.6 [2 (0-5)]	2.5±1.5 [2 (0-6)]	0.317
1st hr	1.4±1.0 [2 (0-4)]	2.0±1.2 [2 (0-6)][a]	0.076
2nd hr	1.0±1.0 [1 (0-3)][a]	1.6±1.2 [2 (0-5)][a]	0.036
6th hr	0.9±1.0 [1 (0-4)][a]	1.4±1.2 [1.5 (0-4)][a]	0.101
12th hr	0.9±0.9 [1 (0-3)][a]	1.1±1.0 [1 (0-3)][a]	0.302
20th hr	0.6±0.7 [1 (0-2)][a]	1.0±1.1 [1 (0-4)][a]	0.293
24 hr	0.7±0.6 [1 (0-2)][a]	0.8±0.9 [0.5 (0-3)][a]	0.717

Data is given as average±sandard deviation [median (minimum-maximum)].
† $p<0.0045$ was considered significant according to the Bonferroni Correction.
a: Difference between measurements before and after PCA was statistically significant ($p<0.00091$).

Table 3 shows patients' VAS_{cough} scores measured before and after PCA by groups. In Group S, there was a statistically significant decrease in patients VAS_{cough} scores only at the 24th hour after PCA as compared to VAS scores before PCA ($p<0.00091$). In Group M, the decrease in VAS_{cough} scores at the 2nd, 12th, 20th, and 24th hours after PCA as compared to the measurements before PCA was found to be statistically significant ($p<0.00091$). Nevertheless, there was no statistically significant difference between Group S and Group M regarding the VAS_{cough} scores measured at all times according to Bonferroni Correction ($p>0.0045$).

Table 3: Patients' coughing visual analog scale (VAScough) scores measured before and after PCA by groups.

avg±sd (min.-max.)	Group S (n=30) VAS_{cough} avg±sd (min.-max.)	Group M (n=30) VAS_{cough} avg±sd (min.-max.)	P value †
Before PCA	2.2±1.6 [2 (0-6)]	3.1±1.6 [3 (0-6)]	0.049
30th min	2.1±1.6 [2 (0-5)]	2.8±1.4 [3 (0-6)]	0.088
1st hr	1.7±1.2 [2 (0-4)]	2.3±1.3 [2 (0-7)]	0.163
2nd hr	1.6±1.2 [2 (0-4)]	2.1±1.2 [2 (0-6)]a	0.176
6th hr	1.5±1.3 [1.5 (0-6)]	2.1±1.3 [2 (0-5)]	0.047
12th hr	1.5±1.3 [2 (0-6)]	1.7±1.1 [2 (0-4)]a	0.243
20th hr	1.2±0.8 [1 (0-2)]	1.6±1.2 [2 (0-4)]a	0.233
24th hr	1.0±0.7 [1 (0-3)]a	1.3±1.1 [1 (0-4)]a	0.243

Data is given as average±sandard deviation [median (minimum-maximum)].
† $p<0.0045$ was considered significant according to the Bonferroni Correction.
a: Difference between measurements before and after PCA was statistically significant ($p<0.00091$).

There was no statistically significant difference between Group S and Group M regarding to total amount (mg) of consumed tramadol before PCA and at any follow-up time after PCA according to the Bonferroni Correction (p>0.00625). Similarly, there was no statistically significant difference between Group S and Group M regarding the number of administered and demanded bolus doses of analgesics before PCA and at any follow-up time after PCA according to the Bonferroni Correction (p>0.00625).

When the adverse effects observed in the study, in Group S, there were three cases had nausea and vomiting, one at the 30th minute, one at the 1st hour, and one at the 12th hour after PCA and a case of hypotension at the 2nd hour after PCA. In Group M, on the other hand, there was only a case of nausea and vomiting at the 2nd hour after PCA.

The total need for additional analgesic was statistically higher in Group M than in Group S (p>0.0040), (Table 4). Patients needed additional analgesic in the early postoperative period and prior to PCA.

Table 4: Requirement of additional analgesic

Variables	Group S (n=30)	Group M (n=30)	P Value †
Total Need for Additional Analgesics			0.040
None	25 (83.3%)	18 (60.0%)	
Dexketoprofen	5 (16.6%)	11 (36.7%)	
Dexketoprofen + paracetamol	-	1 (3.3%)	

† p<0.05 was considered statistically significant.

Discussion

Present study shown that single and multiple TPVB injections provided similar postoperative pain scores and postoperative cumulative tramadol consumption. However higher additional analgesic requirement in multiple injection group was observed. Hemodynamic parameters were comparable in both groups and complications rate was quite limited.

Applying an effective analgesic method both during and after surgery ensures stability of hemodynamic parameters, which mainly results from the suppression of stress hormones related to the surgery [17, 18]. Different methods are used to prevent pain during and after VATS with varying effects on hemodynamic parameters [2, 12]. Hypotension resulting from intravenous analgesia and adverse effects of systemic opioids are among the most common problems [8, 21]. Additionally, sympathetic blockade resulting from thoracic epidural analgesia frequently preferred in thoracic surgeries can lead to severe hypotension [18]. However, this has been reported to be more limited in TPVB procedures [3, 17, 18]. Moreover, as in epidural blockade, TPVB reduces the need for systemic opioids and limits potential complications [3, 18]. In present study we did not observe any hemodynamic adverse events throughout the study period. This stable hemodynamic condition might be related to limited sympathetic effects of the TPVB.

VATS is superior to thoracotomy due to its advantages, such as smaller surgical incision, less invasive method, shorter operation duration and shorter hospital stay [5, 22]. One of the major problems encountered after thoracic surgery is deterioration of pulmonary functions occurring in the early postoperative period [7, 8]. Poor pain management after thoracic surgery resulting in deterioration of respiratory function and the risk of opioid-related respiratory depression complicate pain management and lead to a need for multimodal analgesia [2, 7]. Although close monitoring of oxygenation level, chest physiotherapy, and similar approaches are indispensable, effective analgesia plays a key role in preventing complications [8, 18]. Multimodal analgesic techniques minimize respiratory depression and other similar problems associated with opioid use [2, 7, 21]. Regional techniques are the most effective components of multimodal analgesia in thoracic surgery. Recently ESB and serratus plane block preferred technique for VATS, but TPVB is still most common regional technique in VATS [2, 16-18, 23]. In the present study, we closely monitored SpO2 and respiratory rate during 24 hours to detect potential respiratory problems. In both groups, SpO2 levels and respiratory rates were at acceptable limits and we did not encounter any complications. This may be related to the reduction of systemic opioids due to TPVB, which is an essential component of multimodal analgesia.

One of the most important troubles in regional analgesia is anxiety of patients related to the procedure. This problem varies depending on the length and site of the procedure, preoperative sedation, and analgesia. Many studies have reported that application of sedation and analgesia prior to operation increases the comfort of both patient and practitioner resulting in shorter duration and increased success of the operation [24-26]. In order to minimize anxiety and pain in both groups, we performed premedication 30 minutes prior to TPVB and administered fentanyl just before the procedure. Multiple-injection TPVB application takes longer and requires higher number of injections. Even if we did not measure anxiety level in this study, it is not a surprise to face higher anxiety level in these patients due to multiple injections and long duration of procedure One of the main goals of regional analgesia in thoracic surgery is to reduce the dose of systemic opioids administered to patients as much as possible in order to decrease the side effects of opioids? Kaya et al. reported significant decrease in VAS scores and total morphine consumption of VATS patients at the postoperative 24th hour after TPVB application [12]. Hill et al. performed multiple paravertebral injections for pain management after VATS and observed a significant decrease in morphine con-

sumption as well as a significant reduction in VAS scores at the first 6 hours [13]. In another study in which Vogt et al. compared single-injection TPVB group with control group, patients were given 0.1 mg/kg bolus dose of morphine 30 minutes after the operation and reported 24-hour morphine consumption to be similar in both groups [14]. Uppal et al. found that with the administration of relative dose drug, the dermatomal distribution was similar in single-injection and multiple-injection TPVB applications [9]. In our study, the 24-hour tramadol consumption was similar in both groups. The need for additional analgesics was significantly higher in multiple-injection TPVB group as compared to the single-injection TPVB group and patients required additional analgesia in the early postoperative period and prior to PCA. In postoperative period, we did not observe deep sedation associated with tramadol. Besides, patients' demand for PCA analgesics and the bolus doses administered with the PCA device were similar in both groups. These results show that intravenous PCA application combined with either single-injection or multiple-injection TPVB is an effective and a reliable method in VATS.

The spread of local anaesthetics after TPVB is still a controversial topic [27-29]. Piraccini et al [27] mention that local anaesthetic diffuses outside the paravertebral space, especially into the epidural space, and the analgesic effect is related to this mechanism. Marhofer et al [28] showed that epidural spread of local anaesthetics happens approximately 25% of patients and spread outside paravertebral space in 40%. They also claim that despite a effective spread of local anaesthetics, the clinical results is unpredictable even with an ultrasound-guided technique. In present study block evaluation was performed by using pin-prick test after block in both groups. Nerve stimulator technique was also applied to increase the block efficiency.

We have several limitations in this study. First of all, we could not use ultrasound for TPVB due to limited facility, but nerve stimulator technique could be an alternative if clinicians could not reach ultrasound. Second, even though we evaluate acute postoperative pain, the follow-up of chronic postthoracotomy pain that may develop can give significant results in comparing this two TPVB techniques.

Conclusion

In conclusion, single injection and multiple injection TPVB have similar effects on hemodynamic parameters, postoperative VAS scores and 24-hour total analgesic consumption in VATS. However, the need for additional analgesic was higher in the multiple injection group, especially in the early postoperative period. We think that single injection is superior, considering multiple injections and the need for additional analgesics being higher in the multiple injection group.

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