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Original Research Article

An Assessment of Three Different Plane Block Techniques in the Management of Post-Operative Pain Relief after Thoracotomy: A Comparative Study

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Abstract

Aim: The aim of the present study was to compare the ultrasound guided thoracic para vertebral block, serratus anterior plane block and thoracic erector spinae plane block for post-operative pain relief after thoracotomy.

Methods: The present study was performed at department of Anesthesia for the period of one year. During the study period, 150 patients were assessed for eligibility. The study enrolled patients who were 18 to 80 years old, American Society of Anesthesiologists class I and II and scheduled for non-emergent lobectomy under VATS.

Results: The average age of the study population was 57.33 ± 11.53 years and 60.66% of study participants were female. There was no significant difference among the 3 groups in demography and intra- operative characteristics, including age, gender, weight, BMI, American Society of Anesthesiologists classification, smoking history, surgery duration and chest tube placed (P > 0.05). The sufentanil consumption and supplementary analgesic requirements were comparable in the 3 groups. A total of 14 patients (7%) required supplementary analgesic, and 17 patients (8.5%) experienced PONV within 48 h. There was no difference in the incidence of PONV and supplementary analgesic requirements within 48 h postoperatively. The length of stay in PACU, ambulation time and postoperative days in hospital was similar in the 3 groups. Two patients from Group B developed hematoma at the site of puncture, but there was no difference in the incidence of hematoma among the three groups and no other side effects was observed during the study period.

Conclusion: In our study, we concluded that the SAPB, applied safely and rapidly as a part of multimodal analgesia in patients who will undergo VATS, is not inferior to the TPVB and can be an alternative to it.

Keywords: Postoperative analgesia, Video assisted thoracoscopic surgery, Erector spinae plane block, Thoracic paravertebral block, serratus anterior plane block

Introduction

In thoracic surgery, video-assisted thoracoscopic surgery (VATS) procedures are gaining popularity due to the minimally invasive approach resulting in limited tissue trauma, shorter recovery time, and lesser postoperative pain. [1,2] Even though VATS is less invasive than open thoracotomy, moderate to severe acute pain is common after VATS, and is also associated with significant chronic pain. [1,3] In the early postoperative period, poorly managed acute pain has significant adverse effects on respiratory mechanics and mobilization and increased risk of postoperative pulmonary complications. [4] The mechanism of chronic pain after thoracic surgery is still under debate. One of the possible mechanisms of chronic pain is intercostal nerve damage during surgery. Previous studies have shown chronic pain in 40% to 80% of patients after thoracotomy and in 20% to 40% after VATS. [5]

Video-assisted thoracoscopic surgery (VATS) has many potential advantages over thoracotomy, such as early mobilization, a more cosmetic incision type, less postoperative pain, and a shorter length of hospital stay. Although VATS is a minimally invasive surgery and causes less postoperative pain than thoracotomy, it should be treated carefully in terms of both chronicity and disruption of the patient's healing process. [6] Various blocks are performed with the widespread use of

ultrasonography (USG) to relieve postoperative pain and reduce the need for opioids in VATS. The serratus anterior plane block (SAPB) provides analgesia in the chest wall by blocking the lateral branches of the intercostal nerves, usually between the T2-T9 levels. [7] The paravertebral block (PVB) has been used for many years in the treatment of breast, thorax, and abdominal surgeries; rib fractures; and cancer pain. [8] The PVB was found to be as effective as a thoracic epidural in postoperative pain control in thoracic surgery. [9] Both blocks are applied more safely with the increasing use of USG.

Thoracic paravertebral block (TPVB) has been employed to prevent postoperative pain after thoracic surgery. [10] Erector spinae plane block (ESPB), a novel plane block first introduced by Forero et al [11] in 2016, provide analgesia for different surgeries such as lung surgery, laparoscopy, mastectomy, and pediatric surgery, and may also be effective for the management of chronic pain. The possible mechanism of action of ESPB is related to the distribution of the local anesthetic solution into the paravertebral and epidural space [12] and subsequently blocking the dorsal and ventral branches of the spinal nerve.

The aim of the present study was to compare the ultrasound guided thoracic para vertebral block, serratus anterior plane block and thoracic erector spinae plane block for post-operative pain relief after thoracotomy.

Materials and Methods

The present study was performed at department of Anesthesia ,Sri Krishna Medical College & Hospital, Muzaffarpur, Bihar, India March 2020 to Feb 2021 for the period of one year. During the study period, 150 patients were assessed for eligibility. The study enrolled patients who were 18 to 80 years old, American Society of Anesthesiologists class I and II and scheduled for non-emergent lobectomy under VATS. Exclusion criteria were history of chronic pain or daily use of analgesics, history of psychiatric disorder or inability to understand the consent form or how to use a visual analog scale (VAS) for pain measurement, severe renal or hepatic dysfunction, allergy to any required drug, second thoracic surgery, participation in other clinical trials, obesity with body mass index > 35 kg/m2, intake of antiplatelet or anticoagulant agents, local infection at the injection site, spinal deformity and severe bradycardia. Patients were withdrawn from the study if technical failure happened in the block or VATS procedure was converted to open procedure.

All methods were performed in accordance with the relevant guidelines and regulations. All participants followed a standard perioperative care protocol. After the patient arrived at the outpatient anesthesia room, an investigator explained the details of the study protocol to the recruited patient and obtained the written informed consent. Anesthetic evaluation was performed by the anesthesia team, who were not aware of patient's group assignment, and patients were instructed to use a 10-cm pain VAS (0 = no pain, 10 = worst imaginable pain).

Serratus Anterior Plane Block (Group A = 50)

While the patient was in the supine position, a high-frequency linear ultrasound probe was placed horizontally on the mid-axillary line at the level of 4th or 5th ribs on the side of the block. The serratus anterior, latissimus dorsi, and intercostal muscles were identified. The block needle (22-gauge 80 mm, Stimuplex Ultra; B. Braun Melsungen AG, Melsungen, Germany) was advanced below the serratus anterior muscle (SAM) towards the fifth rib (using in-plane technique). The prepared 0.25% bupivacaine was administered at 0.4 mL/kg (max. 20 mL) between the SAM and the rib. It was observed that the solution of local anesthesia was spread between the SAM and the rib.

Thoracic Paravertebral Block (Group B=50)

In the anesthesia preparation room, patients were monitored according to ASA standards than sedated with midazolam (0.04 mg/Kg). An experienced anesthesiologist performed unilateral, single-injection TPVB at T5 level of the operation side with ultrasound guided (USG) in lateral position before anesthesia induction. A low- frequency convex array USG probe (2 to 5 MHz) was placed longitudinally 2.5 cm lateral to the tip of spinous process to identify the hyperechoic image of pleura between shadows of consecutive transverse processes. Peripheral block needle (22 gauge; Stimuplex® A; B Braun, Melsungen, Germany) was advanced to the pleura using in-plane technique. After negative aspiration, downward displacement of the pleura by administration of saline was visualized on USG and then block was achieved with 20 ml of 0.375% ropivacaine. Local anesthetic distribution above pleura was checked by moving the probe up and down to confirm success of block.

Erector Spinae Plane Block (Group C=50)

Similar to TPVB procedure, patients were sedated after monitoring. The same anesthesiologist who applied TPVB performed unilateral single-injection ESPB at T5 level of the operation side with USG in lateral position before anesthesia induction. A high-frequency linear USG probe (5 to 13 MHz; Konica Minolta Son image HS1,Shanghai,China.) was placed longitudinally 2.5 cm lateral to the tip of spinous process to identify the trapezius, rhomboid major, and erector spinae muscles superficial to the hyperechoic transverse process shadow. Peripheral block needle (22 gauge; stimuplex D; B.Braun Melsungen AG, Melsungen, Germany) was inserted

in the interfascial plane deep to the erector spinae muscle using in-plane technique. After negative aspiration, spread of saline in the interfacial plane was visualized on USG and then block was achieved with 20 mL of 0.375% ropivcaine. (The success of block was confirmed by USG. The probe was shifted over two upper (for T3, T4) and two lower (for T6, T7) transverse processes to check interfacial spread of local anesthetic at these levels.

During the operation, standardized monitoring was applied. Anesthesia was induced with propofol (1.5 mg/ kg), sufentanil (0.5ug/kg), and rocuronium(0.6 mg/kg) was administered to facilitate left double lumen tube (DLT) intubation. The correct position of DLT was con- firmed with a fiberoptic bronchoscope. After tracheal intubation, a volume-cycled ventilator was applied with the following settings: tidal volume of 6-8 ml/kg ideal body weight and inspiratory-to-expiratory ratio of 1:2 were used for double lung ventilation. While during single-lung ventilation, tidal volume of 4-6 ml/kg and inspiratory-to-expiratory ratio of 1:2 was set. The petCO2 was 35-45 mmHg(1 mmHg = 0.133kpa) maintained by intraoperative regulation of respiratory rate, and oxygen saturation > 95% was maintained by regulation of oxy- gen concentration (0.6–1). Anesthesia maintenance was achieved with sevoflurane inhalation, continuous infusion of propofol and remifentanil to maintain the bispectral index 40 to 60. Intraoperative hypotension (defined as decrease of 20% from baseline value or mean arterial pressure less than 65 mmHg) was treated with noradrenaline infusion, and bradycardia (heart rate < 50 beat per minute) was treated with atropine. The lobectomy procedure was performed by the same surgical team. All patients underwent lobectomy in lateral decubitus position. At the end of the surgery, chest tube was placed through the seventh intercostal space as required.

At the end of surgery, all patients received intravenous tramadol 100 mg as loading dose for analgesia. According to our clinical routine postoperative analgesia scheme, each patient received intercostal nerve block by the surgeon combined with patient-controlled analgesia(PCA) with opioids. ICNB was performed at the beginning of surgery, and a total of 20 ml of 0.375% ropivacaine (5 ml per each space) was injected at T4-T7 levels under video guidance. The PCA protocol was 0.1 mg of sufentanil diluted to 100 ml with a continuous dose of 0.03–0.05 ml•kg − 1•h − 1 and a bolus dose of 0.02–0.03 mL•kg − 1 with a lock-out of 15 min. PCA device was attached to the patient immediately after surgery and was stopped after 48 h. Group T and Group E received preoperative TPVB or ESPB respectively as demonstrated previously. If the analgesia was inadequate (visual analog scale, VAS ≥ 4) during the postoperative period, patients were recommended to press the PCA button. And if relief was not obtained, additional analgesics (40 mg Parecoxib sodium) were given intravenously as rescue, and consultation with the anesthetist was initiated as required. All patients received granisetron(3 mg) at the end of surgery to prevent postoperative nausea and vomiting, and additional antiemetic was given as rescue if vomiting occurred or if persistent nausea was reported for 2 h. Patients were transferred to post-anesthesia care unit (PACU) after tracheal extubation and discharged from PACU when Aldrete score reached 8. [13]

Patients were followed up by a trained data investigator at 2, 6, 8, 12, 24, 48 h after surgery, and the VAS at rest and coughing were recorded. The primary outcome was the proportion of patients suffering moderate-to-severe pain (VAS ≥ 4 when coughing) at 24 h after surgery. Secondary outcomes included VAS at rest and VAS when coughing at each time point, postoperative opioids consumption, incidence of postoperative nausea and vomiting, supplementary analgesic requirements within 48 h, length of stay in PACU, ambulation time and post-operative days in hospital. Potential side effects, such as hematoma, hypotension, bradycardia, hypersomnia, uroschesis, pruritus and apnea were recorded.

Statistical Analysis

In the descriptive statistics of the data, mean, standard deviation for quantitative data, and percentage values for qualitative data were used. In the distribution of variables, the Kolmogorov–Smirnov normal distribution test was used. Mann–Whitney U, Kruskal–Wallis, and chi-square tests were used in the analysis of data that did not match the normal distribution. P < 0.05 was considered statistically significant as the level of significance in the assessment.

Results

Table 1: Demographic and intraoperative characteristics of patients in the 3 groups

	Group A (*n* = 50)	Group B (*n* = 50)	Group C (*n* = 50)	P
Age	57.4 ± 11.7	58.2 ± 12.4	56.4 ± 10.5	0.258
Gender				0.512
Male (n, %)	22 (44%)	19 (38%)	18 (36%)	
Female (n, %)	28 (56%)	31 (62%)	32 (64%)	
Weight (kg)	62.8 ± 10.2	58.6 ± 8.0	60.6 ± 10.9	0.440
BMI (kg/m2)	22.9 ± 2.9	22.9 ± 2.9	22.6 ± 2.9	0.852

ASA				0.942
II	45 (90%)	46 (92%)	46 (92%)	
I	5 (10%)	4 (8%)	4 (8%)	
Smoking history (n, %)	22 (44%)	16 (32%)	17 (34%)	0.555
Duration of surgery (min)	136.4 ± 57.8	150.6 ± 53.4	131.3 ± 60.2	0.195
Chest tube (n, %)	47 (94%)	48 (96%)	45 (90%)	0.180

The average age of the study population was 57.33 ± 11.53 years and 60.66% of study participants were female. There was no significant difference among the 3 groups in demography and intra- operative characteristics, including age, gender, weight, BMI, American Society of Anesthesiologists classification, smoking history, surgery duration and chest tube placed (P > 0.05).

Table 2: Comparison of secondary outcomes among the 3 groups

	Group A (*n* = 50)	Group B (*n* = 50)	Group C (*n* = 50)	P
Sulfentanyl consumption (ug)				
Within 24 h	44.6 ± 6.8	45.5 ± 8.8	43.7 ± 12.0	0.484
Within 48 h	99.3 ± 3.4	96.7 ± 8.2	97.0 ± 9.8	0.164
PONV within 48 h (n, %)	5 (10%)	8 (16%)	4 (8%)	0.606
Supplementary analgesic requirements (n, %)	5 (10%)	5 (10%)	4 (8%)	0.913
Length of stay in PACU (min)	58.6 ± 19.4	53.4 ± 10.0	57.7 ± 14.3	0.150
Ambulation time (hours)	29.3 ± 15.2	29.3 ± 24.1	33.8 ± 26.4	0.465
Postoperative days in hospital (days)	5.3 ± 2.7	5.6 ± 2.4	4.7 ± 1.6	0.120
Incidence of hematoma(n,%)	0(0%)	2 (4%)	0(0%)	0.125

The sufentanil consumption and supplementary analgesic requirements were comparable in the 3 groups. A total of 14 patients (7%) required supplementary analgesic, and 17 patients (8.5%) experienced PONV within 48 h. There was no difference in the incidence of PONV and supplementary analgesic requirements within 48 h postoperatively. The length of stay in PACU, ambulation time and postoperative days in hospital was similar in the 3 groups. Two patients from Group B developed hematoma at the site of puncture, but there was no difference in the incidence of hematoma among the three groups and no other side effects was observed during the study period.

Discussion

Surgical resection remains one of the main methods for curative treatment of lung cancer in patients. Traditionally, resection is done via a thoracotomy, but video-assisted thoracoscopic surgery (VATS) provides significant advantages over open thoracotomy procedures including reduced surgical pain, improved post-operative pulmonary function, reduced mortality, shorten hospital stay and has emerged as a minimally invasive alternative. [14-16] Despite VATS association with lessened surgical trauma and better post-operative out- comes, a reduction in tissue damage did not necessarily lead to the same reduction in the need for analgesia. The intercostal nerve injuries, muscle injuries, rib contractions or even fractures and pleural lining damage all con- tribute to pain after thoracoscopic surgery. Controlling postoperative pain was crucial because increased acute pain has been related to the development of chronic pain, augmented respiratory complications, added hospital length of stay [17,18] and reduced patient satisfaction. Effective pain control would increase patients' ability for physiotherapy and pulmonary rehabilitation which could improve postoperative outcomes.

Video-assisted thoracoscopic surgery was related to reduce pain, lung function protection, faster recovery, shorter hospital stay, and better quality of life. In addition, the advantages of thoracoscopic approach for early lung cancer were also reported in ERAS guidelines. [19] Whereas, it still cause significant acute pain after surgery and it may even lead to neuropathic pain syndrome. Therefore, a multimodal approach to opioid retention such as TPVB, ESPB and ICNB is strongly recommended. TPVB is a method to block the movement, sensation and sympathetic nerve of the side by injecting local anesthesia near the spinal nerve of the intervertebral foramen to achieve the analgesic effect of ipsilateral body. The average age of the study population was 57.33 ± 11.53 years and 60.66% of study participants were female. There was no significant difference among the 3 groups in demography and intra- operative characteristics, including age, gender, weight, BMI, American Society of Anesthesiologists classification, smoking history, surgery duration and chest tube placed (P > 0.05).

SAPB can be applied with two different techniques, deep and superficial. In the superficial technique there is an injection of local anesthetic between the latissimus dorsi muscle and the SAM, while in the deep technique, the injection of local anesthetic is made between the SAM and the external intercostal

muscles.[20] By applying the deep SAPB, the anterior and lateral cutaneous branches of the thoracic intercostal nerves are blocked. [20-23] It is known that performing the superficial SAPB also blocks the thoracicus longus nerve and consequently a winged scapula can occur. [24] Piracha et al [25] applied deep SAPB to four patients who had previously undergone the superficial SAPB for post-mastectomy pain syndrome, to compare deep with superficial SAPBs. The sufentanil consumption and supplementary analgesic requirements were comparable in the 3 groups. A total of 14 patients (7%) required supplementary analgesic, and 17 patients (8.5%) experienced PONV within 48 h. There was no difference in the incidence of PONV and supplementary analgesic requirements within 48 h postoperatively. The length of stay in PACU, ambulation time and postoperative days in hospital was similar in the 3 groups. Two patients from Group B developed hematoma at the site of puncture, but there was no difference in the incidence of hematoma among the three groups and no other side effects was observed during the study period. Intravenous patient controlled analgesia is one of strictly recommended by international guidelines for pain management in thoracic surgery. [26] An observational study showed the efficacy and safety of sufentanil sublingual tablet system to manage postoperative analgesia following thoracic surgery. [27] In that study, pain management for all patients is only sufentanil sublingual tablet system, and patients experienced moderate to severe pain with a score around 5 at rest and around 7 at cough in PACU. Patients had a mean pain score of less than 3 at 6 h of rest and at 36 h of cough after surgery. This would be a terrifying experience for patients. While, the system was safety and not invasive, and patients benefited rapidly after taking tablets, as pain scores decreased rapidly to mild pain. This suggests that the system will be effective in dealing with acute pain. It provides a new idea for postoperative analgesia after thoracic surgery, which can be used as a remedial analgesic measure.

Conclusion

In our study, we concluded that the SAPB, applied safely and rapidly as a part of multimodal analgesia in patients who will undergo VATS, is not inferior to the TPVB and can be an alternative to it.

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