Original Article

Serratus anterior plane block and erector spinae plane block in postoperative analgesia in thoracotomy: A randomised controlled study

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ABSTRACT

Background and Aims: Managing pain after thoracic surgery is crucial and the traditional methods have many adverse effects. We aimed to evaluate serratus anterior plane block (SAPB) and erector spinae plane block (ESPB) in acute pain control in thoracic cancer surgeries. **Methods:** This randomised controlled, triple-blind study was performed on 90 patients, between 18 and 70 years old, scheduled for elective thoracic cancer surgery. Patients were allocated into three equal groups: Control group: received sham ESPB and sham SAPB. SAPB group received SAPB (20 ml bupivacaine 0.5%) and sham ESPB. ESBP group received ESPB (20 ml bupivacaine 0.5%) and sham SAPB. **Results:** Postoperative morphine consumption was significantly lower in ESBP and SAPB groups than control group [ESPB (8.52 ± 4.29 mg) < SAPB (19.57 ± 7.63 mg) < control (36.37 ± 8.27 mg)] ($P < 0.001$). Numerical rating scale pain score was comparable among the groups at rest, but was significantly lower at 30 min, 2, 4 h in ESPB and SAPB groups, than control group on coughing. The scores were better in SAPB compared to control group till 4 h. At 8, 12, 24 h, the difference between control and SAPB groups became insignificant, but it remained the least in ESPB group. Postoperative forced vital capacity and forced expiratory volume in the first second after 24 h were the best in ESPB group and better in SAPB group compared to the control group. **Conclusion:** Both ESPB and SAPB reduced intraoperative and postoperative opioid consumptions and postoperative dynamic pain scores with improved postoperative pulmonary functions in thoracic surgery with the ESPB being superior.

Key words: Analgesia, pulmonary function test, thoracotomy

INTRODUCTION

Managing pain after thoracic surgery is crucial as adequate postoperative analgesia can prevent subsequent serious complications such as pneumonia and respiratory failure and protect from chronic post-thoracotomy pain syndrome.[1] Traditional methods lead to respiratory depression, inadvertent intravascular injection, total spinal anaesthesia, haemodynamic instability, and pneumothorax.[2] Serratus anterior plane block (SAPB) is a novel, easy, and safe method used for analgesia of the lateral chest wall.[3] Another promising interfascial block is the erector spinae plane block (ESPB) where the local anaesthetic (LA) injected deep to erector spinae (ES) muscles can diffuse and block the ventral and dorsal primary rami and sympathetic fibres.[4]

This study was designed to evaluate the superiority of ESPB over SAPB in providing pain control in thoracic cancer surgeries. The primary outcome was to compare postoperative morphine consumption in patients receiving the block. The secondary outcomes were to compare intraoperative fentanyl requirements, numerical rating scale (NRS) scores, and postoperative pulmonary functions.

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METHODS

This prospective randomised controlled, triple-blind study received approval from the tertiary institutional review board and was registered at clinical trials.gov [ID: NCT04579302]. Ninety patients, between 18 and 70 years of age, belonging to American Society of Anesthesiologists physical status II, scheduled for elective thoracotomy from November 2020 to February 2021 were included after obtaining a written informed consent.

Patients with body mass index over 35, coagulation disorders, local infection at the block site, allergy to LA, pre-existing neurological disorders, chronic opioid use, uncontrolled hypertension, significant respiratory diseases (forced vital capacity (FVC)) or forced expiratory volume in the first second (FEV_1) < 50% of the predicted values), cardiac dysfunction (ejection fraction < 45%), pregnant patients and inability to use the patient-controlled analgesia (PCA) device were excluded.

History taking, clinical examination, routine investigations, and echocardiography were done preoperatively. Preoperative baseline FVC and FEV1 values were obtained by the hand-held spirometer (vitalograph) after training the patients. The method of using PCA device and reporting the pain intensity by NRS (where 10 = worst imaginable pain and 0 = no pain) was explained to all patients.

A computer-generated program (permuted block technique) was used by a statistician unrelated to patient management to randomise and allocate the patients in a parallel manner into three equal groups. The Control group received an ultrasound (US)-guided ESPB and SAPB, each with 20 ml of normal saline. SAPB group received a US-guided SAPB with 20 ml bupivacaine 0.5% and an ESPB with 20 ml normal saline. ESBP group received an US-guided ESPB with 20 ml bupivacaine 0.5% and a SAPB with 20 ml normal saline.

The random allocation number was properly concealed in opaque closed envelopes and opened during the preoperative assessment visit and after obtaining the consent. Patients, anaesthesiologists, statistician, and outcome assessors were blinded to grouping. All regional anaesthetic techniques were done by an experienced anaesthesiologist, unrelated to group assignment or data collection. The medications used in the regional anaesthetic techniques were prepared by a pharmacist unrelated to the data management according to the group.

We preferred to perform the sham blocks to increase the internal validity by decreasing bias. Also, these techniques are safe with very low incidence of complications when performed under US-guidance.

After arrival to the procedure room, an intravenous (IV) line was established in all patients and the standard monitoring devices (pulse oximetry, electrocardiography, and non-invasive blood pressure measurements) were connected. Then, 0.04 mg/kg intravenous (IV) midazolam was given. A 6–13 MHz multi-frequency linear probe of US machine (Fujifilm Sonosite.inc Bothell, United States of America) was used to guide SAPB and ESPB.

US-guided SAPB technique was done in the lateral position with the surgical side upwards and the ipsilateral arm abducted. The point of needle entry was identified at the 5th rib in the midaxillary line. Latissimus dorsi muscle identification was done with the serratus anterior (SA) muscle deep to it and lying over the 5th rib. Subcutaneous injection of 5 ml of lidocaine 2% was done at the needle entry site. By an in-plane approach, an 18-gauge Tuohy needle (Epidural kit; Portex, Smiths Group, London, United Kingdom) was inserted till its tip was positioned deep to the SA muscle plane and over the 5th rib. Confirmation of the needle's tip site was done by injection of 2 ml saline and by visualising SA muscle separation from the 5th rib. After negative aspiration, 20 ml of bupivacaine 0.5% was injected through the needle, and the cranial and caudal spread of the injected fluid was seen. In sham block done in ESPB and control groups, the injectate was 20 ml saline instead of bupivacaine. US-guided ESPB technique was done in sitting position. The spinous process of the T5 vertebra was identified by counting down from the spinous process of C7 vertebra. With aseptic precautions, subcutaneous injection of 5 ml of lidocaine 2% was done at the point of the needle entry 3 cm lateral to the 5th thoracic spinous process. By applying the US probe in a sagittal paramedian plane, three muscles were visualised (trapezius muscle, rhomboid major muscle, then ES muscle lying over the transverse process) from superficial to deep. An 18-gauge needle was advanced by in-plane approach till visualisation of its tip deep to the ES muscle and superficial to the 5th thoracic transverse process. Two ml of saline was injected to

confirm the needle tip's placement by visualisation of the hydrodis section and ES muscle separation from the transverse process. After negative aspiration, 20 ml of bupivacaine 0.5% was injected through the needle, and the cranial and caudal spread of the injected fluid was seen. In sham block, done in the SAPB and the control groups, the injectate was 20 ml saline instead of bupivacaine.

The block success was assessed by a blind observer unrelated to data collection. The presence of the cold sensation in T1–T8 dermatomes in the blocked side after 30 min indicated a failed block, and the patient was excluded.

After performing the regional techniques, all patients were transferred to the operating room. After preoxygenation with 100% oxygen, general anaesthesia was induced with IV fentanyl 2 μg/kg and propofol 2 mg/kg. Tracheal intubation was facilitated by rocuronium 0.6 mg/kg and was done with a left-sided double-lumen endobronchial tube (Mallinckrodt's 37 or 39 Fr) using fibreoptic bronchoscope. An arterial line and a central venous catheter were placed.

Anaesthesia was maintained using 2–2.5% sevoflurane in100% oxygen, and supplemental doses of rocuronium 0.1 mg/kg. The ventilator settings were adjusted to keep the end-tidal CO_2 between 30 and 35 mmHg. Supplemental doses of fentanyl (0.5 μg/kg) were used if mean arterial blood pressure and heart rate increased >20% above their baseline values, after excluding other causes. At the end of surgery, 4 mg IV ondansetron was given as anti-emetic prophylaxis, and 2 mg/kg sugammadex was given to reverse the muscle relaxant and then extubation was done. The patients were then transferred to surgical intensive care. Each patient's IV route was connected to a PCA device containing a morphine solution (1 mg/ml) set to deliver a demand dose of 1 mg morphine, with a lockout interval of 10 min without a continuous background infusion. The PCA morphine amount during the first 24 h postoperatively was the primary outcome. The secondary outcomes were the amount of intraoperative fentanyl requirements, NRS (used to assess the pain intensity after 30 min and subsequently at 2, 4, 8, 12, and 24 h postoperatively and measured both at rest and on coughing), and FVC and FEV1 (expressed as a proportion from the predicted values and measured preoperatively and after 24 h postoperatively). Intraoperative hypotension and bradycardia and postoperative opioid side effects in the first 24 h like postoperative nausea and vomiting (PONV) and pruritus were recorded and managed accordingly.

G Power 3.1.9.2 program (Universität Kiel, Germany) was used for sample size calculation. We performed a pilot study (five cases in each group). The postoperative opioid consumption (our primary outcome) was 21.60, 19.80, and 17.00 mg in control, SAPB and ESPB patients, respectively, with common standard deviation of 3.88. Therefore, 23 patients per group were required with a 95% significance level and 95% power. To compensate for possible dropouts, we increased the sample size to 30 patients per group.

International Business Machines Statistical Package for the Social Sciences (SPPS) version 25 (Chicago, Illinois, United States of America) was used in data analysis. Shapiro-Wilks normality test and histograms were used to assess numerical data distribution. For normally distributed numerical data, mean and standard deviation were used for data description. One-way analysis of variance (ANOVA) was used to compare the means of the three groups, and post hoc pairwise tests (Tukey) were selected after testing for equality of variances. For numerical data showing skewed distribution, median and interquartile range were used for data description. Kruskal Wallis test was used for comparing with Mann-Whitney test for comparison between each two groups. Qualitative data were presented as frequency and percent, and Chi-square test was used for analysis. The *P* value was two-tailed and was considered significant at 0.05.

RESULTS

For data analysis, there were 30 patients in control group, 28 in SAPB group, and 27 in ESPB group as SAPB failed in one case and ESPB failed in three cases (cold sensation did not disappear from T1 to T8) [Figure 1]. Also, massive blood loss and postoperative mechanical ventilation occurred in one case in SAPB group. Demographic data were similar in the three groups [Table 1]. ESPB group consumed the least amount of postoperative morphine (8.52 ± 4.29 mg) as compared to SAPB and control groups (19.57 ± 7.63 mg and 36.37 ± 8.27 mg respectively) and group SAPB consumed significantly less than control group (p value <0.001). The mean intraoperative fentanyl requirement was least in ESPB group (225.93 ± 59.03 μg) and was lower in group SAPB (290.18 ± 72.76 μg) compared to control group (368.33 ± 92.13 μg) (p value <0.001).

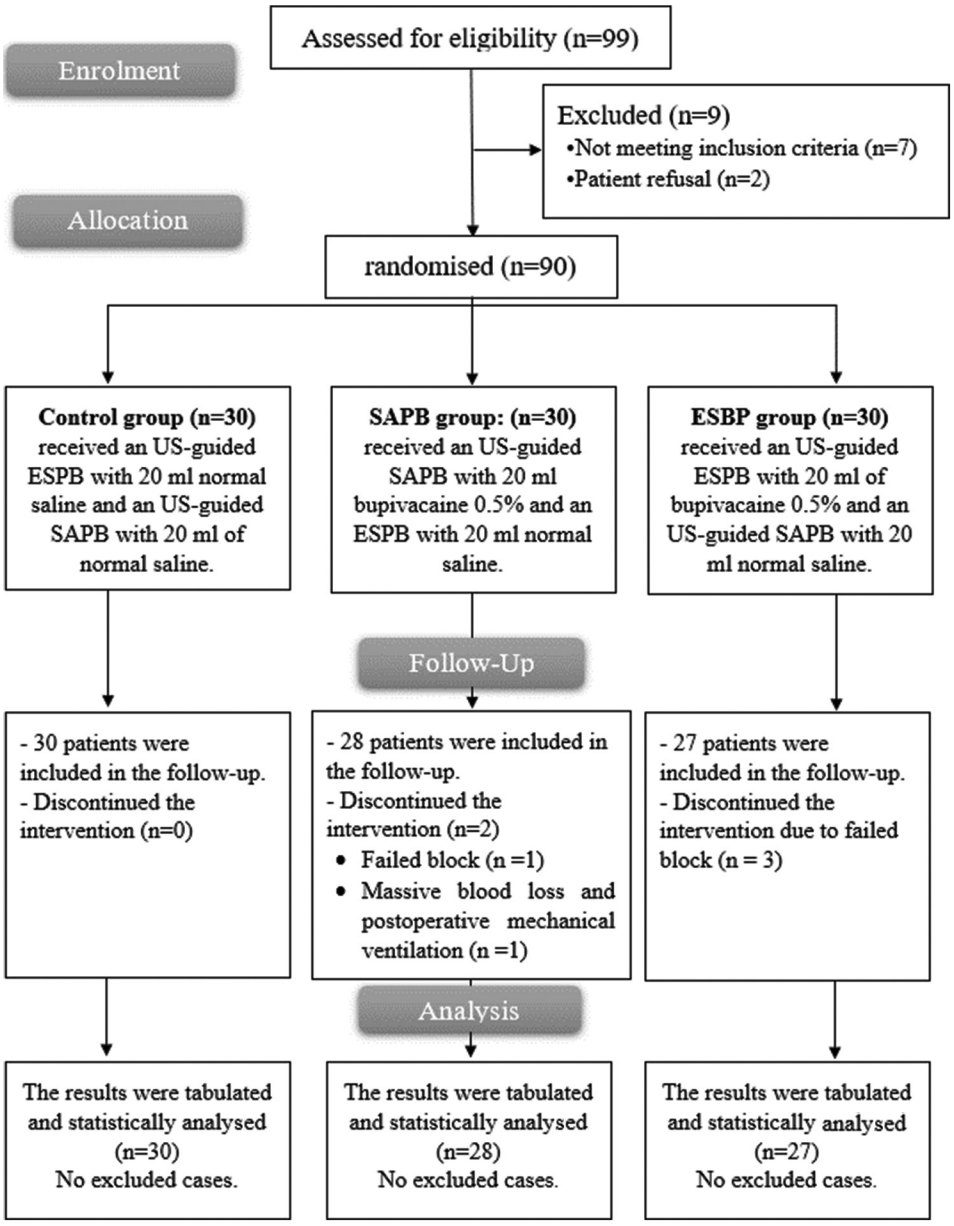

Figure 1: Consolidated Standards of Reporting Trials (CONSORT) flowchart of the studied patients. N: Number, US: ultrasound, ESPB: Erector Spinae Plane Block, SAPB: Serratus Anterior Plane Block

Baseline NRS scores at rest were comparable, yet with coughing, there was a change at 30 min, 2, and 4 h in the favour of ESPB group, than SAPB and control groups. The scores were better in SAPB compared to control group till 4 h. At 8, 12, and 24 h, the difference between control and SAPB groups became insignificant. NRS scores on coughing remained the least in ESPB group [Table 2].

The FVC and FEV1 were the best in ESPB group and better in SAPB group compared to that of the control group (p value <0.001) [Table 3].

Intraoperative hypotension occurred in four (13.3%) patients in control group, two (7.1%) patients in ESPB group, and five (18.5%) patients in SAPB group (p value = 0.453). Intraoperative bradycardia occurred in one (3.3%) patient in control group, one (3.6%) patient in ESPB group and two (7.4%) patients in SAPB group (p value = 0.724). PONV occurred in nine (30%) patients in control group, three (10.7%) patients in ESPB group, and three (11.1%) patients in SAPB group (p value = 0.088). Only one patient in control group complained of pruritus. No other opioid side effect or block-related complications were found.

Table 1: Comparison of demographic data among the three study groups

	Control group *N*=30	SAPB group *N*=28	ESPB group *N*=27	*P*
Age (years)	52.2±10.6	48.3±9.9	50.3±11.8	0.374#
Weight (kg)	75.9±9.2	76.1±9.5	73.2±6.2	0.366#
Height (cm)	169.6±6.0	171.6±6.9	171.3±6.7	0.451#
Sex				
Male	18 (60%)	17 (60.7%)	20 (74.1%)	0.467##
Female	12 (40%)	11 (39.3%)	7 (25.9%)	
Duration of Surgery (min)	283.2±45.4	275.9±52.3	271.1±57.1	0.674#
Hypertension	5 (16.7%)	3 (10.7%)	5 (18.5%)	0.700##
Type of surgery				
Segmentectomy	10 (33.3%)	13 (46.43%)	12 (44.44%)	0.855##
Lobectomy	9 (30%)	6 (21.43%)	7 (25.93%)	
Metastasectomy	11 (36.7%)	9 (32.14%)	8 (29.63%)	

Data are presented as mean±standard deviation or frequency (%). SAPB=Serratus Anterior Plane Block, ESPB=Erector Spinae Plane Block, N=Number. #compared by Analysis of variance (ANOVA) test, ##compared by Chi-square test

Table 2: Comparison of Numerical Rating Scale (NRS) at rest and at cough among the three study groups

	Control group *N*=30	SAPB group *N*=28	ESPB group *N*=27	*P*#	Mann-Whitney	
NRS at rest						
30 min	2 (2-3)	2 (1-3)	2 (1-2.5)	0.313	----	
2 h	2 (2-3)	2 (1.75-2.75)	2 (1.5-2.5)	0.430	----	
4 h	2 (1-2.75)	2 (2-2.25)	2 (1-2)	0.847	----	
8 h	2 (1.25-2)	2 (2-2)	2 (1-2)	0.486	----	
12 h	2 (1-2)	2 (1-2.25)	2 (1-2)	0.642	----	
24 h	2 (1-2)	2 (1.75-2)	2 (1-2)	0.111	----	
NRS at cough						
30 min	5 (5-6)	4 (4-5)	3 (2-4)	<0.001	P1	0.002*
					P2	<0.001*
					P3	<0.001*
2 h	5 (4-6)	4 (3-5)	3 (2.5-4)	<0.001	P1	0.005*
					P2	<0.001*
					P3	0.010*
4 h	4.5 (4-5)	4 (3-4.25)	3 (2-4)	<0.001	P1	0.006*
					P2	<0.001*
					P3	0.008*
8 h	4.5 (4-5)	4 (4-5)	3 (2-4)	<0.001	P1	0.206
					P2	<0.001*
					P3	0.001*
12 h	4 (4-5)	4 (3-5)	3 (2-3)	<0.001	P1	0.224
					P2	<0.001*
					P3	<0.001*
24 h	4 (3.25-5)	4 (3-4)	3 (2-3)	<0.001	P1	0.246
					P2	<0.001*
					P3	0.001*

Data are presented as median (inter quartile range), P1: *P* value between control group and SAPB group, P2: *P* value between control group and ESPB group, P3: *P* value between SAPB group and ESPB group. SAPB=Serratus Anterior Plane Block, ESPB=Erector Spinae Plane Block, N=Number, NRS=numerical rating scale. #compared by Kruskal-Wallis test with Mann-Whitney test for comparison between each groups, * significant as *P*<0.05

DISCUSSION

The present study is triple-blinded and used important objective variables (postoperative pulmonary functions). Improved pulmonary functions with ESPB and SAPB demonstrated the critical role of adequate pain control in reducing postoperative pulmonary complications.[5]

In our study, NRS pain score was comparable between both SAPB and ESPB groups as on-demand PCA was used for postoperative analgesia and patients' analgesic administration and the time of recording might not overlap. Therefore, postoperative morphine requirement was lower with ESPB group as opposed to SAPB group with the same level of NRS.

Table 3: Comparison of respiratory functions among the three study groups						
	Control group *N*=30	SAPB group *N*=28	ESPB group *N*=27	*P*#	Post hoc (Tuckey)	
			FVC (%)			
Baseline	83.5±9.5	81.3±10.4	81.6±8.0	0.619	----	
24 h postoperative	47.0±8.3	58.6±10.2	71.7±8.6	<0.001	P1	<0.001*
					P2	<0.001*
					P3	<0.001*
			FEV_1 (%)			
Baseline	80.4±10.9	81.39±11.3	83.93±9.1	0.431	----	
24 h postoperative	43.4±6.9	58.3±9.9	75.2±8.0	<0.001	P1	<0.001*
					P2	<0.001*
					P3	<0.001*

Data are presented as mean±standard deviation. FVC: forced vital capacity, FEV_1: forced expiratory volume in the first second, P1: *P* value between control group and SAPB group, P2: *P* value between control group and ESPB group, P3: *P* value between SAPB group and ESPB group. SAPB: Serratus Anterior Plane Block, ESPB: Erector Spinae Plane Block, N: Number. #compared by Analysis of variance (ANOVA) test with Post hoc (Tukey)* significant as *P*<0.05

Similarly, in another study, it was found that ESPB provided a better analgesic profile and lowered dynamic postoperative VAS scores, better than SAPB in patients undergoing video-assisted thoracoscopy.[6] Also, other researchers have demonstrated that ESPB had superior analgesia to SAPB after thoracotomy and video-assisted thoracoscopy.[7,8]

In yet another study in patients undergoing minimally invasive thoracic surgery, a more significant improvement of pain scales was seen with ESPB than with SAPB with no difference in postoperative opioid consumption.[9] This contrasting result may have been due to the different nature of the surgery. There was posterior extension of the thoracotomy wound in our study and hence ESPB may have an advantage in controlling pain from the posterior chest wall, while efficacy of SAPB may be confined to pain from anterior and lateral chest wall.

SAPB blocks the lateral cutaneous branches of the intercostal nerves providing analgesia to the anterolateral chest wall.[10] A larger dose of LA can be administered safely with a lesser incidence of toxicity as the injection area is poorly vascularised.[11] One of the limitations of SAPB is that, due to its superficial nature, the block is less effective in controlling visceral pleural pain, especially with pleural decortication surgeries.[12] Some researchers have demonstrated that SAPB was effective in controlling post-thoracotomy pain in cardiac surgery.[13] A meta-analysis[14] stated that SAPB decreased the postoperative pain and opioid consumption in the first 24 h compared to the control group.

ESPB blocks the ventral and dorsal primary rami of the spinal nerves and the rami communicans supplying the sympathetic fibres. LA can diffuse from the ES plane to the adjacent paravertebral and intercostal spaces, so some authors have considered this block as a peri-paravertebral block.[15] It provides a multilevel dermatomal block as ES fascia extends from the nuchal fascia to the sacrum that can control pain from the anterior, lateral, and posterior chest wall.[16] ES plane is a safe plane devoid of any vital structures that may be exposed to needle injury. This decreases the incidence of inadvertent haematoma. ESPB uses the transverse process as an anteromedial barrier to localise the injecting needle away from the pleura, thus decreasing the incidence of pleural injury.[17]

In 2016, Forero *et al*.[18] first described the ESPB and found that it improves analgesic efficacy and decreases postoperative opioid requirements in thoracic neuropathic pain. In agreement with our results, Gürkan *et al*.[19] demonstrated that postoperative ESPB decreased morphine consumption by 65% in breast surgery patients. They also found similar NRS values between ESPB and control groups. Yet, the incidence of PONV in both the groups was similar.

El Ghamry *et al*.[20] found that ESPB was effective in controlling postoperative pain after breast surgery and percutaneous nephrolithotomy.

In the current study, the regional blocks were performed preoperatively as pre-emptive analgesia prevents central sensitisation and provides more control of postoperative pain.[21]

This study has some limitations. The blocks were single shot, and the postoperative assessment was for short duration. Therefore, further studies with catheter insertion are needed to prolong the postoperative pain control. Also, further studies are needed with a longer duration of assessment for acute and chronic

postoperative pain. Another limitation of our study is the use of an 18-gauge needle. However, it allowed better needle visualisation, thus decreasing the incidence of block failure and prevented inadvertent trauma to vital structures. Also, local anaesthetic was infiltrated at the site to minimise the pain produced during needle entry.

CONCLUSION

Both ESPB and SAPB reduced intraoperative and postoperative opioid consumption and postoperative dynamic pain scores with improved postoperative pulmonary function in patients undergoing thoracotomy, with the ESPB being superior.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for clinical information to be reported in the journal. The patients understand thattheir names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Wojtyś ME, Wąsikowski J, Wójcik N, Wójcik J, Wasilewski P, Lisowski P, *et al*. Assessment of postoperative pain management and comparison of effectiveness of pain relief treatment involving paravertebral block and thoracic epidural analgesia in patients undergoing posterolateral thoracotomy. J Cardiothorac Surg 2019;14:78.
2. Gottschalk A, Cohen SP, Yang S, Ochroch EA, Warltier DC. Preventing and treating pain after thoracic surgery. Anesthesiology 2006;104:594-600.
3. Lee J, Kim S. The effects of ultrasound-guided serratus plane block, in combination with general anesthesia, on intraoperative opioid consumption, emergence time, and hemodynamic stability during video-assisted thoracoscopic lobectomy: A randomized prospective study. Medicine 2019;98:e15385.
4. Singh S, Kumar G, Akhileshwar P. Ultrasound-guided erector spinae plane block for postoperative analgesia in modified radical mastectomy: A randomised control study. Indian J Anaesth 2019;63:200-4.
5. Alzahrani T. Pain relief following thoracic surgical procedures: A literature review of the uncommon techniques. Saudi J Anaesth 2017;11:327-31.
6. Gaballah KM, Soltan WA, Bahgat NM. Ultrasound-guided serratus plane block versus erector spinae block for postoperative analgesia after video-assisted thoracoscopy: A pilot randomized controlled trial. J Cardiothorac Vasc Anesth 2019;33:1946-53.
7. Elsabeeny WY, Ibrahim MA, Shehab NN, Mohamed A, Wadod MA. Serratus anterior plane block and erector spinae plane block versus thoracic epidural analgesia for perioperative thoracotomy pain control: A randomized controlled study. J Cardiothorac Vasc Anesth 2021;35:2928-36.
8. Ekinci M, Ciftci B, Gölboyu BE, Demiraran Y, Bayrak Y, Tulgar S. A randomized trial to compare serratus anterior plane block and erector spinae plane block for pain management following thoracoscopic surgery. Pain Med 2020;21:1248-54.
9. Finnerty DT, McMahon A, McNamara JR, Hartigan SD, Griffin M, Buggy DJ. Comparing erector spinae plane block with serratus anterior plane block for minimally invasive thoracic surgery: A randomised clinical trial. Br J Anaesth 2020;125:802-10.
10. Blanco R, Parras T, McDonnell J, Prats-Galino A. Serratus plane block: A novel ultrasound-guided thoracic wall nerve block. Anaesthesia 2013;68:1107-13.
11. Piracha MM, Thorp SL, Puttanniah V, Gulati A. "A tale of two planes": Deep versus superficial serratus plane block for postmastectomy pain syndrome. Reg Anesth Pain Med 2017;42:259-62.
12. Semyonov M, Fedorina E, Grinshpun J, Dubilet M, Refaely Y, Ruderman L, *et al*. Ultrasound-guided serratus anterior plane block for analgesia after thoracic surgery. J Pain Res 2019;12:953–60.
13. Magoon R, Kaushal B, Chauhan S, Bhoi D, Bisoi AK, Khan MA. A randomised controlled comparison of serratus anterior plane, pectoral nerves and intercostal nerve block for post-thoracotomy analgesia in adult cardiac surgery. Indian J Anaesth 2020;64:1018-24.
14. Liu X, Song T, Xu HY, Chen X, Yin P, Zhang J. The serratus anterior plane block for analgesia after thoracic surgery: A meta-analysis of randomized controlled trails. Medicine 2020;99:e20286.
15. Forero M, Rajarathinam M, Adhikary SD, Chin KJ. Erector spinae plane block for the management of chronic shoulder pain: A case report. Can J Anaesth 2018;65:288-93.
16. López MB, Cadórniga ÁG, González JML, Suárez ED, Carballo CL, Sobrino FP. Erector spinae block. A narrative review. Cent Eur J Clin Res 2018;1:28-39.
17. Fang B, Wang Z, Huang X. Ultrasound-guided preoperative single-dose erector spinae plane block provides comparable analgesia to thoracic paravertebral block following thoracotomy: A single center randomized controlled double-blind study. Ann Transl Med 2019;7:174.
18. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: A novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med 2016;41:621-7.
19. Gürkan Y, Aksu C, Kuş A, Yörükoğlu UH. Erector spinae plane block and thoracic paravertebral block for breast surgery compared to IV-morphine: A randomized controlled trial. J Clin Anesth 2020;59:84-8.
20. El Ghamry MR, Amer AF. Role of erector spinae plane block versus paravertebral block in pain control after modified radical mastectomy. A prospective randomised trial. Indian J Anaesth 2019;63:1008–14.
21. Vadivelu N, Mitra S, Schermer E, Kodumudi V, Kaye AD, Urman RD. Preventive analgesia for postoperative pain control: A broader concept. Local Reg 2014;7:17-22.