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Analgesic effectiveness of serratus anterior plane block v/s thoracic paravertebral nerve block during video-assisted thoracoscopic surgery: a prospective randomized study

Lalwani J, Sonali Sahu, Vritika Manghnani

Pt. J. N. M. Medical College Raipur, Chhattisgarh, India

Abstract

Background: *Multimodal analgesia plays a vital role for adequate pain relief in postoperative period including regional nerve blocks in video-assisted thoracoscopic surgeries. The study aims to compare the analgesic efficacy of serratus anterior plane block and thoracic paravertebral nerve block using ultrasound guidance in VATS.*

Methods: *Eighty patients scheduled for VATS under general anaesthesia, aged 18–65 years, ASA grade II & III were randomised to receive either SAP block (Group A) or TPV block (group B) after induction. Intensity of postoperative pain relief at rest & on coughing till 48 hours using VAS score, intraoperative hemodynamic changes, time to 1st rescue analgesia, complications and patient satisfaction score at 24th hour postoperatively were compared. Unpaired t-test and Chi-Square test were used for analysis. A P value less than 0.05 was considered to be statistically significant.*

Results: *At rest, mean VAS scores in group B were slightly higher than group A till 18 hours, but the difference was statistically insignificant. At 24th and 48th hour, mean VAS scores were significantly more in group A than group B. On coughing, mean VAS scores at 12th, 18th, 24th, and 48th hour were significantly higher in group A as compared to group B ($p < 0.05$). Mean time to 1st analgesic requirement was earlier in group A (20.97 ± 4.9 hours) than group B (28.4 ± 9.5 hours) ($p < 0.001$). Both groups were hemodynamically stable with no side effects and no additional analgesic requirement. Patients in both groups at 24th hour were highly satisfied.*

Conclusion: *TPV block provided longer duration of post-operative analgesia both at rest and on coughing with delayed requirement of first rescue analgesia.*

Key words: *Serratus anterior plane block, thoracic paravertebral nerve block, video-assisted thoracoscopic surgery.*

Introduction

Video-assisted thoracoscopic surgery (VATS) is a minimal invasive surgical procedure for both major and minor thoracic interventions and a gold standard diagnostic procedure for exudative pleural effusion. It has become increasingly popular due to its early recovery and lesser postoperative pain compared to thoracotomy. However, 85 % patients who undergo VATS are often known to suffer with moderate to severe post operative pain [1] which makes achieving post operative analgesia challenging during coughing and moving and the risk of its conversion into chronic pain.

The various causes of pain in VATS are known to be of multifactorial origin i.e. pain from the surgical incision, rib retractions, intercostal nerve damage and dynamic pain such as during coughing /straining or mobilising. Inadequate pain control can result into ineffective ventilation and inadequate clearance of secretions leading to hypoxia and atelectasis which preclude early recovery. Therefore, pain management becomes an important part in post-operative period to prevent various complications due to pain and for early recovery of patients.

Multimodal analgesia plays a vital role in postoperative period including various regional nerve blocks like Thoracic Epidural Block (TEB), Serratus Anterior Plane (SAP) block, Thoracic Paravertebral (TPV) nerve block, intercostal block and intra- or extra pleural block. These blocks are increasingly being performed with the use of ultrasonography (USG) following thoracic surgery to relieve postoperative pain and reduce the need for opioids intra- and post-operatively. Decreased need of postoperative narcotic analgesic usage thereby reduces opioid induced side effects like postoperative respiratory depression, nausea, vomiting, NSAID induced gastritis etc. Nerve blocks not only shorten post-anaesthesia care unit stay time but also increase patient satisfaction. They are known to cause less interference with the physiology of our body as they act by interrupting the nociceptive impulse transmission through the peripheral nerves, though each of these has its own specific advantages and disadvantages.

SAP block and TPV nerve block are the two most novel evolving regional blocks and this clinical study hypothesized that there is a significant difference in the analgesic efficacy of SAP block and TPV nerve block undergoing VATS. This randomized study was carried out to evaluate the intensity of pain relief using VAS pain score post-operatively (primary outcome) and to record intraoperative hemodynamic changes, intraoperative analgesic requirement, time to 1st analgesic requirement post operatively, post operative complications and patients satisfaction score at 24th hour (secondary outcomes).

Methods

A prospective randomised double-blind study was conducted in the Department of Anaesthesiology and Pain Medicine along with the Department of Respiratory Medicine in a tertiary hospital after receiving approval from the institutional scientific & ethics committee. The study was registered in Clinical Trials Registry of India (CTRI No. CTRI/2024/02/062378) before enrolment of patients for the study.

All the patients between 18–65 years and ASA grade II & III, undergoing VATS with surgical time less than 90 minutes under general anaesthesia were included. Patients who had BMI > 30 kg/m^2, allergy to study drugs, coagulopathy, local site infection, rib fracture or local site deformity, severe cardiorespiratory, hepatic, renal disorders, or who were pregnant, unable to communicate and refused to participate were excluded from the study. Also, the surgeries which were later converted into open thoracotomy and the patients who experienced block failure (who complained pain after the surgery) were excluded from the study.

The sample size was calculated on the basis of mean & standard deviation of numerical rating pain score of a previous study [2]. The number of participants in each group was derived as, n = 40, at 95 % confidence interval and power of 80 %. Taking drop outs and failure to follow up, 10 % was added to the current sample size(n = 80 + 8 = 88). Thus,88 participants were enrolled, out of which three patients were excluded, one due to language barrier and two being ASA grade IV.

Eighty-five patients were randomly allocated into group A(n = 43) & group B(n = 42) using online software (Open Epi software version 3.01, Atlanta, GA, USA). The random allocation sequence was concealed in sequentially numbered opaque, sealed envelopes that were opened on the day of surgery after induction of anaesthesia. **Group A** received SAP block and **group B** received TPV nerve block. An anaesthesiologist experienced in regional blocks performed the blocks. He was not involved in perioperative management or data collection. The participants and the attending anaesthesiologist in the operating room, both were blinded to the type of block (SAP Block or TPV nerve block). Both the groups received 20 ml of 0.5 % injection Levobupivacaine + 20 μg

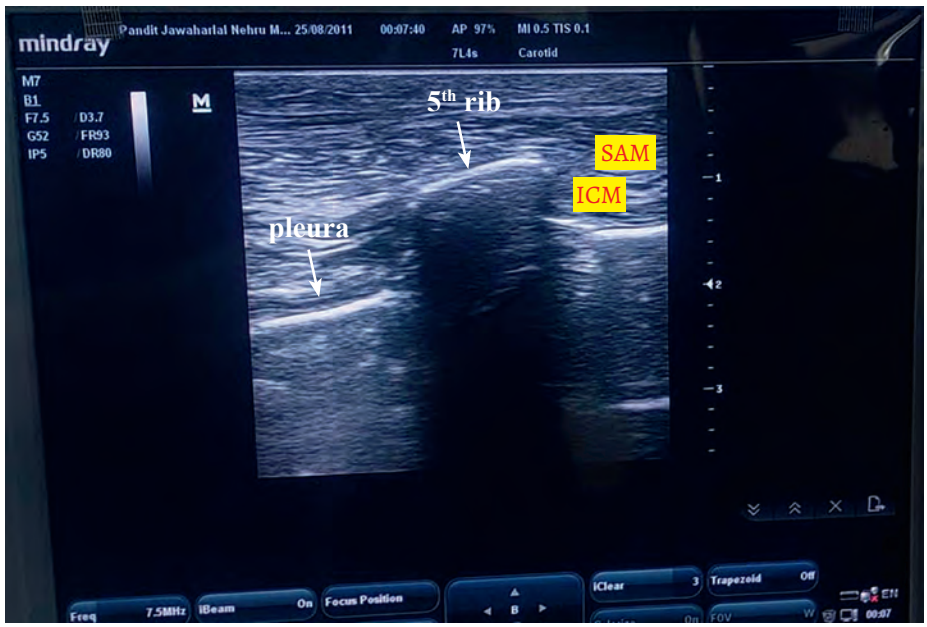

Figure 1: Ultra-sound image of serratus anterior plane block ICM: intercostal muscle; SAM: serratus anterior muscle

of injection Fentanyl (2 ml of 100μg fentanyl diluted with 10ml normal saline), making the total drug volume to be 22 ml.

All the patients had thorough pre-anaesthetic evaluation, involving detailed history, clinical examination and routine investigations (Hb, TLC, platelet counts, BT, CT, random blood sugar, urine examination, LFT, KFT, X-ray chest and ECG). Written informed consent was obtained from all the patients after explaining about the procedure and the associated possible risks. Also, they were explained about how to use the 10 cm visual analogue scale for the assessment of pain.

All the patients were kept nil per oral for 8 hours before the surgery. On the scheduled day of the surgery, an 18 G intravenous cannula was secured and ringer lactate at the rate of 10 ml/kg/h was infused. A standard ASA monitoring was applied to record the baseline values and intra-operative vitals every 10 minutes throughout the surgery.

A conventional balanced general anaesthesia was given which comprised of preoxygenation for 5 minutes, premedication with glycopyrrolate 0.01 mg/kg iv, midazolam 1 mg, pentazocine 0.5 mg/kg. Induction and orotracheal intubation were facilitated with propofol 2mg/kg i.v. and succinylcholine 1 mg/kg i.v. Maintenance of anaesthesia was done by injection atracurium (loading dose 0.3 mg/kg with 0.1 mg/kg of maintenance dose intermittently), oxygen, nitrous oxide ($N_2O : O_2 = 60 : 40$) and 1–2 % sevoflurane.

The nerve blocks were performed under all aseptic precautions according to the group of the patient, using USG (MINDRAY M-7) guidance after the induction of general anaesthesia.

USG guided SAP block was given, with the patient lying in the lateral decubitus position with the upper arm over the head, the ultrasound probe was positioned in a sagittal plane over the midclavicular region of the thoracic cage. Then the ribs were counted down until the fifth rib was identified close to the mid axillary line. The following muscles were identified overlying the fifth rib, the latissimus dorsi (superficial and posterior), teres major (superior), and serratus muscles (deep and inferior). The needle was introduced in plane with respect to the ultrasound probe, targeting the plane deep to the serratus anterior muscle and study drug was injected after negative aspiration of blood and air in the syringe.

USG guided TPV nerve block was given, with the patient in lateral decubitus position and the surgical side uppermost, the probe was placed in a parasagittal plane over the transverse process of T4 and T5 vertebrae, approximately 2.5 cm lateral to the spinous processes. The thoracic paravertebral space was identified as a hypoechoic space between the superior costotransverse ligament and the pleura. A 20-gauge, intravenous cannula connected with 10 cm extension was inserted using an in-plane approach from the top side of the probe, superior costotransverse ligament was penetrated with the tip. The needle was aspirated to confirm the absence of

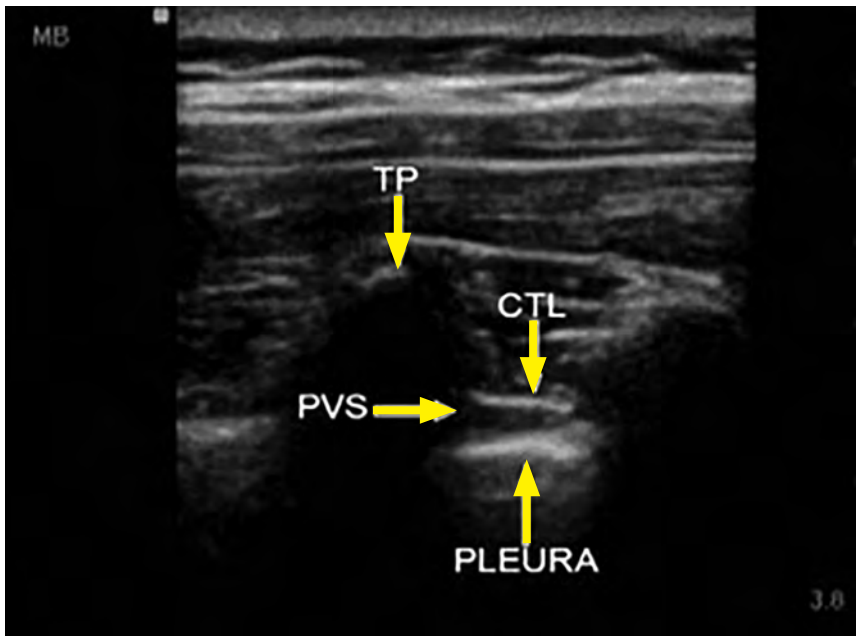

Figure 2: Ultrasound-guided TPV nerve block using a paramedian sagittal scan.
TP: transverse process; CTL: superior costotransverse ligament, PVS: Paravertebral Space

blood or air, and subsequently the study drug was injected. The block was deemed satisfactory when the pleural membrane was displaced downwards during injection of drug.

At the end of surgery, i.v. ondansetron 0.1 mg/kg and reversal was done with i.v. neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg. Patients were extubated and transferred to post anaesthetic care unit (PACU).

All patients were assessed for degree of postoperative pain at rest & on coughing at 1, 2, 3, 4, 6, 8, 12, 18, 24 and 48 hours using VAS pain score.

Time to 1st analgesic requirement was noted. The time interval from block given to the time of first analgesia when VAS score ≥ 3 at rest was defined as the **duration of block.**

Inj. Tramadol 100 mg intravenously was given as first rescue analgesic when patient had VAS score ≥ 3 at rest. Post operative assessment of the patients for VAS & supplement analgesic requirement was given by different anaesthesiologist who was blinded about the block given.

Complications, if any (nausea, vomiting, hypotension, excessive sedation) were noted and treated accordingly.

Satisfaction score was recorded on a 10-point scale. Patients were asked to rate their satisfaction of analgesia at 24th hour postoperatively from score 0 («highly unsatisfactory») to score 10 («highly satisfactory»). It was graded as per the pain control regimen as: Grade 0: not satisfied, Grade 1–4: confused, Grade 5–7: satisfied and Grade 8–10: highly satisfied.

The data collected from all the cases in both the groups were recorded and tabulated in the form of a master chart on excel sheet which was exported to **SPSS 21.0** for statistical analysis. The distribution of participants between the two groups was analysed using contingency tables. The descriptive analyses of categorical variables were reported as frequencies and percentages, whereas those of continuous variables were reported as mean ± standard deviation (SD). The association of the quantitative variables was analysed using the independent t-test, whereas the association of the qualitative variables was analysed using the Chi-Square test. If any cell had an expected value of less than 5, then Fisher's exact test was used. A p-value > 0.05 was considered as not significant, p-value < 0.05 as significant and p-value < 0.001 as highly significant.

Results

At rest, the mean VAS scores of group B were seen slightly higher than group A till 24 hours, but the difference was insignificant. A significant difference at 24th and 48th hour was seen between the mean VAS scores of both the groups with mean VAS scores of group A higher than group B (Figure 4).

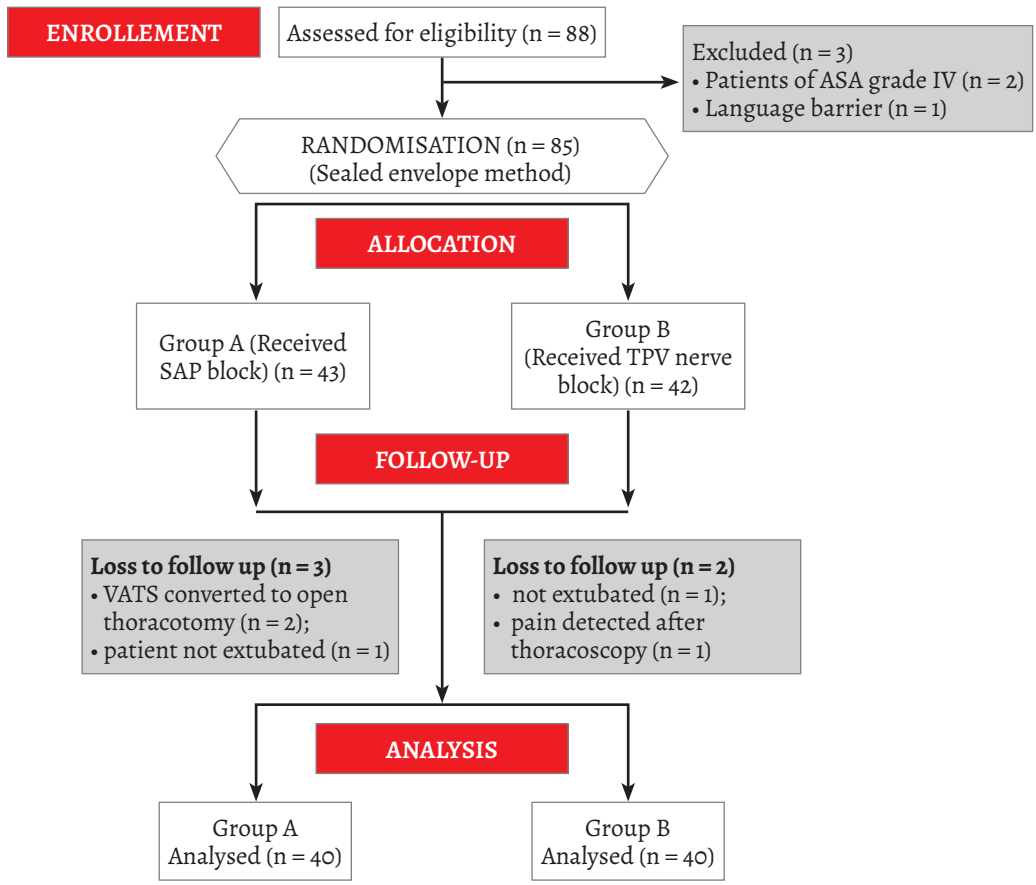

Figure 3. Consort diagram

On coughing, there was a significant difference between the mean VAS score of both the groups at 12th, 18th 24th and 48th hour. There was no significant difference between mean VAS score of both the groups at any other time intervals (Figure 5).

Also, there was delayed requirement 1st analgesic in group B with mean time of 28.4(±9.5) hours than in group A i.e. at 20.97(±4.9) hour. Time to 1st analgesic requirement ranged from 12–30 hours in group A and 10–48 hours in group B. This difference in the mean time to 1st analgesic requirement was significantly prolonged statistically in group B as compared to group A (T = 4.3, p = 0.001) (Table 3).

In both the groups, patients were highly satisfied at the end of 24 hours with maximum patients of satisfaction score of 8–10 i.e. 38(95 %) patients in group A and 39(97.5 %) patients in group B, which was statistically insignificant (Table 4).

Discussion

SAP block is a fascial plane block which can be applied with two different techniques, deep and superficial. In our study, we have administered deep SAP block i.e. the local anaesthetic (LA) was injected between the serratus anterior muscle and the external intercostal muscle, in which the anterior and lateral cutaneous branches of the thoracic intercostal nerves are blocked [3, 4, 5, 6]. **Piracha MM et al**[7] conducted a study to compare deep SAP block from superficial SAP block for post-mastectomy pain syndrome. They concluded that the patients benefited more from the deep SAP block and were more satisfied.

TPV nerve block involves injection of LA in a space immediately lateral to where the spinal nerves emerge from the intervertebral foramina [8]. This technique is being used increasingly for not only intraoperative and postoperative analgesia, but also as a sole anaesthetic technique for various surgical procedures of thorax.

Levobupivacaine, the S-enantiomer of bupivacaine was used due its improved CVS stability and safer neurological profile as compared to bupivacaine with 20μg of injection fentanyl as an adjuvant. The volume and concentration of drug, type of the local anaesthetic and

Table 1. The comparison between demographic parameters in the two groups (Data are expressed as mean± SD or numbers)

Variables	Group A (n = 40)	Group B (n = 40)	P value
Mean age (years) ± SD	42.6 ± 13.5	41.4 ± 13.8	0.69** (NS)
Sex (M: F)	31 : 9	30 : 10	0.79* (NS)
ASA Grade	Grade II-21; Grade III-19	Grade II-17; Grade III-23	0.37* (NS)
Mean BMI (kg/m²) ± SD	21.9 ± 3.4	22.7 ± 2.4	0.22** (NS)
Mean duration of surgery	76.5 ± 8.4	79.8 ± 7.4	0.06** (NS)

**Chi-square test, **Unpaired-t test*

Table 2. Pre-operative vital parameters

Pre op vitals	Group A Mean ± SD	Group B Mean ± SD	P value
HR (bpm)	94.1 ± 16.4	92.5 ± 8.64	0.58** (NS)
SBP (mmHg)	121.9 ± 13.6	126.4 ± 7.93	0.07** (NS)
DBP (mmHg)	75.8 ± 7.2	77.8 ± 5.7	0.16** (NS)
MBP (mmHg)	91.1 ± 8.7	93.5 ± 5.6	0.14** (NS)
RR (breaths/min)	15.2 ± 2.2	14.8 ± 1.1	0.30** (NS)
SPO_2 (%)	97.6 ± 1.94	98.1 ± 0.84	0.13** (NS)

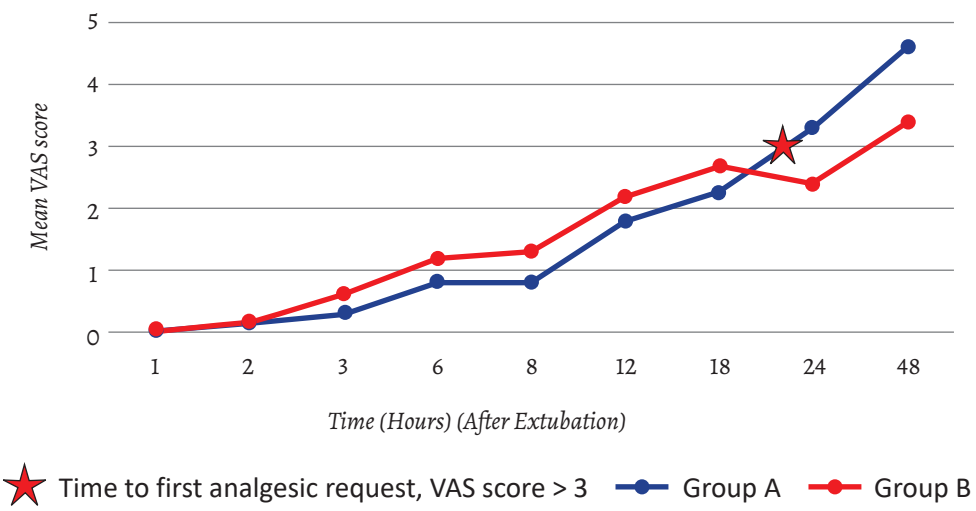

Figure 4. Mean VAS Scores of patients at rest

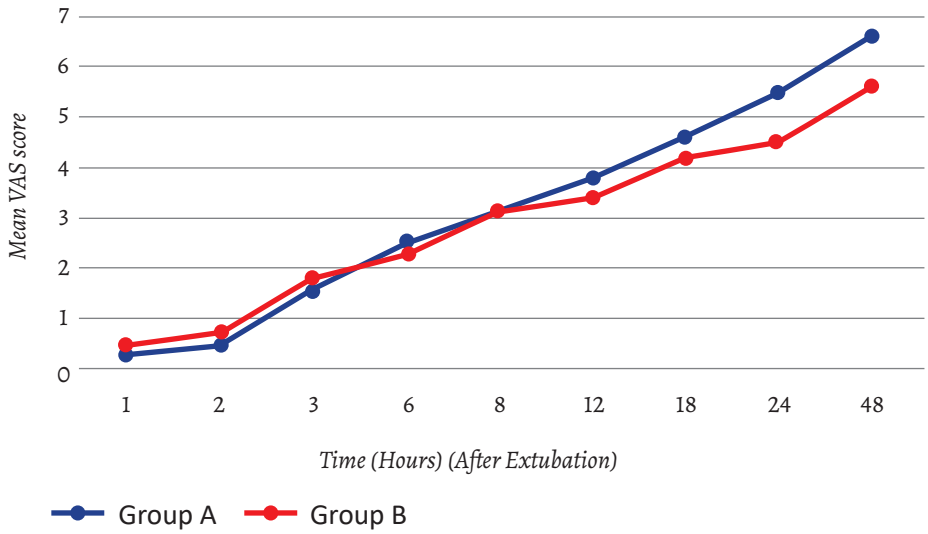

Figure 5. Mean VAS Scores of patients on coughing

Table 3. Mean time to first analgesic requirement

Time to 1st analgesic request post-operatively	Group A (n = 40)	Group B (n = 40)	Unpaired T test	
			T	P value
Mean Time (hours)	20.97 (±4.9)	28.4 (±9.5)	4.3	0.001
Min — Max	12–30	10–48		

Table 4. Satisfaction score by patients at 24th hour

	Group A N (%)	Group B N (%)	Total N (%)	Fisher's Exact Test	
				χ^2	P value
1–4	0 (0)	0 (0)	0 (0)	0.34	0.55
5–7	2 (5)	1 (2.5)	3 (3.7)		
8–10	38 (95)	39 (97.5)	77 (96.2)		
Total	40 (100)	40 (100)	80 (100)		

use of adjuvants are likely to be important determinants of the extent and duration of analgesia. In a study by **Hetta DF et al** [9], higher volume of bupivacaine was injected in SAP block (30 vs 20 ml in our study) resulting in more effective analgesia as compared to our study. SAP block being a fascial block requires a larger volume of LA to spread for effective analgesia.

Our study demonstrated that SAP block provided a better analgesia in the initial hours till 18th hour with lesser VAS pain scores compared to that in TPV nerve block (Figure 4). The thoracoscopic surgeries were mostly uniportal and a chest tube drainage port was created for post operative drainage of blood and air from the chest cavity and to restore normal negative lung pres-

sure. One of the major causes of post operative pain in VATS is chest tube related pain. The chest tube directly stimulates the contraction and spasm of the serratus anterior muscle, which aggravates the pain [10]. This pain is known to be insufficiently blocked by TPV nerve block because of unblocked nociceptive signals from the long thoracic nerve (LTN), the phrenic nerve, the thoracodorsal nerve, and the vagus nerve, as well as incompletely blocked inter costal nerves [11, 12]. It has been reported that SAP block can be used to provide analgesia for chest tube site pain, inadequately relieved by TPV block.[13] The long thoracic nerve and thoracodorsal nerve are located on the surface of the serratus anterior muscle and because of their origin and pathway, they are not blocked by TPV block [14]. And this might totally explain lower VAS scores in SAP block compared to TPV nerve block, in initial hours on rest. **Patel A et al** also observed lower incidence of chest tube related pain in SAP group i.e. 44 % of patients as compared to 56 % in TPV nerve block [15].

After 18 hours it was observed that VAS scores increased in SAP group, whereas TPV nerve block group patients showed mean VAS score below 3 for significantly longer duration. Previous studies [2, 16, 17, 18, 19] also show similar results of longer duration of analgesia in TPV nerve block as compared to SAP block (Figure 4).

A longer duration of analgesia of TPV nerve block in comparison to SAP block can be explained based on the mechanism of action of both the blocks. SAP block is known to cause blockade of anterior and lateral cutaneous branches of the intercostal nerves (T2 to T9) and sparing of the posterior cutaneous branches of intercostal nerves and supraclavicular nerves, thus expected to produce incomplete anaesthesia of the chest wall. Paravertebral thoracic nerve block is known to induce deep analgesia depending on the spread of local anaesthetics. LA injected into the thoracic paravertebral space spreads directly to the spinal nerves and can block the sympathetic chain, laterally to the intercostal nerves, and by spreading through the intervertebral foramina into the epidural space located in the medial region [20, 21]. A comparison of SAP and TPV nerve blocks in patients with MRM, reported adequate sensory blockade over T1-T7 dermatome levels in 100 % of the patients after TPV nerve block, although 40 % of the patients had inadequate sensory blockade in axilla after SAP block [9].

A recent study concluded no significant differences of VAS scores at rest and on coughing at post operative 12h, 24h, 48h and 72h between the three groups i.e. PVB, deep (DSPB) and superficial Serratus anterior plane (SSAP) block in VATS [22]. None of the patients suffered severe pain. The reason of their prolonged analgesic effect could be because of the use of patient controlled intravenous analgesia (PCIA) regimen with a set background of infusion rate at 2ml/h, in the postoperative period.

This wide variation in the results of different studies in the duration of the block may be explained by various drug factors like, varying concentration, volume, and type of local anaesthetic used, surgical factors like type and duration, surgeon's technique, different planes of drug deposition [15]. These heterogeneities in technique may also explain the wide variation in the time to first rescue analgesia in various studies.

All the patients in both the groups maintained intraoperative hemodynamic stability with no significant difference between the two groups as also seen in previous studies [15, 16, 17, 23, 24, 25, 26]. Also there was no requirement of additional analgesia after the initial analgesic given before the induction of general anaesthesia, implying good surgical analgesia.

No side effects associated with nerve block were observed, in any of the groups and both the groups were comparable in terms of satisfaction score.

Pneumothorax is a potential complication associated with TPV nerve block because the pleura is located in the deep surface of paravertebral area, there is risk of pleural puncture. We were able to prevent this complication as we performed ultrasound guided block. Some studies have even noted winged scapula after performing superficial SAP block due to blocking of thoracicus longus nerve[27] which was not encountered in our study, as we performed only deep SAP block under ultra-sound guidance.

Various other complications like bradycardia, hypotension and nausea and vomiting in PVB group have been reported. The reason of bradycardia and hypotension reported in some studies in TPV nerve block could be explained with the blockade of sympathetic chain by the spread of LA to spinal nerves from paravertebral space [15]. Nausea and vomiting might be due to use of opioid based patient controlled intravenous analgesia (PCIA) after the surgery in one study [23]. The PCIA regimen in their study consisted of hydromorphone 14 mg mixed with normal saline to a total volume of 150 ml at an infusion rate of 2ml/hr. These side effects disappeared after stopping the PCIA. No complications related to nerve blocks were reported.

Similar to our study, no incidence of any side effects like nausea, vomiting, urinary retention or hemodynamic instability has been reported [2, 15, 28].

There were many limitations in our study. First, we could not evaluate the onset time and effects of blocks as both the blocks were performed after the induction of general anaesthesia. So, we could only confirm the diffusion of LA by ultrasound, but could not assess the affected dermatome. Second, total amount of opioid consumption was not measured during the perioperative period, thus were unable to compare the effectiveness of both the blocks in terms of total opioid consumption over time. Third, there was no control group in our study.

Conclusion

The study concluded that USG-guided TPV nerve block provided longer duration of post-operative analgesia both at rest and on coughing with delayed requirement of first rescue analgesia in TPV nerve block as compared to SAP block, in video-assisted thoracoscopic surgeries. Both the blocks maintained good hemodynamic stability with high patient satisfaction score.

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Знеболююча ефективність блокади простору переднього зубчастого м'яза проти грудної паравертебральної блокади під час відеоторакоскопічних операцій: проспективне рандомізоване дослідження

Лалвані Дж., Соналі Саху, Врітіка Мангнані

Меморіальний медичний коледж ім. Джавахара Лала Неру, Райпур, Чхаттісгарх, Індія

Анотація. Актуальність: *мультимодальна аналгезія відіграє важливу роль у забезпеченні адекватного знеболення в післяопераційному періоді, включаючи регіональні нервові блокади під час відеоторакоскопічних операцій. Дослідження спрямоване на порівняння знеболюючої ефективності між блокадою простору переднього зубчастого м'яза (SAP) та грудною паравертебральною блокадою (TPV) під ультразвуковим контролем у VATS.*

Методи: *вісімдесят пацієнтів, яким призначено VATS під загальною анестезією, віком від 18 до 65 років, зі ступенем ризику ASA II та III, були випадковим чином розподілені для отримання SAP-блокади (група A) або TPV-блокади (група B) після індукції. Порівнювали інтенсивність післяопераційного знеболення у спокої та при кашлі протягом 48 годин за шкалою VAS, інтраопераційні гемодинамічні зміни, час до першого введення анальгетику, ускладнення та оцінку задоволеності пацієнтів через 24 години після операції. Для аналізу використовували t-тест для незалежних вибірок і критерій Хі-квадрат. Значення P менше 0,05 вважалося статистично значущим.*

Результати: *у стані спокою середні бали за VAS у групі B були трохи вищими, ніж у групі A, протягом перших 18 годин, але різниця була статистично незначущою. На 24-й та 48-й годинах середні бали за VAS були значно вищими в групі A, ніж у групі B. При кашлі середні бали за VAS на 12-й, 18-й, 24-й і 48-й годинах були значно вищими в групі A порівняно з групою B ($p < 0,05$). Середній час до першого введення анальгетику був коротшим у групі A (20,97 ± 4,9 год), ніж у групі B (28,4 ± 9,5 год) ($p < 0,001$). Обидві групи були гемодинамічно стабільними, без побічних ефектів і додаткових знеболювальних. Пацієнти в обох групах через 24 години були дуже задоволені.*

Висновок: *TPV-блокада забезпечила довшу тривалість післяопераційного знеболення як у спокої, так і при кашлі з відтермінованою потребою першого введення анальгетику.*

Ключові слова: *блокада простору переднього зубчастого м'яза, грудна паравертебральна блокада, відеоторакоскопічна хірургія*