ISSN: 1607-8322, e-ISSN: 2220-5799 Anaesthesia, Pain & Intensive Care
Vol 28(6); December 2024 DOI: 10.35975/apic.v28i6.2489

ORIGINAL RESEARCH REGIONAL ANESTHESIA

A comparative study between ultrasound guided thoracic paravertebral block vs ultrasound guided serratus anterior muscle block in video-assisted thoracoscopic surgeries

Rania Maher Hussien Maamoon [1], Galal Aboelseoud Saleh Afifi [2], Sherif Farouk Ebrahim Elshantory [3], Aya Gamal Mohamed Mohie [4], Marwa Mostafa Hassan Salem [5]

Author affiliations:

1. Rania Maher Hussien Maamoon, Associate Professor, Department of Anesthesia, ICU & Pain Management, Faculty of Medicine, Ain Shams University, Cairo, Egypt; E-mail: drrania_maamon@med.asu.edu.eg; Phone: 01000544520
2. Galal Aboelseoud Saleh Afifi, Professor of Anesthesia, Intensive Care, & Pain Management, Faculty of Medicine, Ain Shams University, Cairo, Egypt; E-mail: Drgalal_saleh@med.asu.edu.eg
3. Sherif Farouk Ebrahim Elshantory, Professor of Anesthesia, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, Cairo, Egypt; E-mail: Drsherif_ibrahim@med.asu.edu.eg
4. Aya Gamal Mohamed Mohie, Assistant Lecturer of Anesthesia, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, Cairo, Egypt; E-mail: aya.gamal@med.asu.edu.eg
5. Marwa Mostafa Hassan Salem; Lecturer of Anesthesia, Intensive Care & Pain Management, Faculty of Medicine, Ain Shams University, Cairo, Egypt; E-mail: marwamostafa@med.asu.edu.eg

Correspondence: Rania Maher Hussien Maamoon, E-mail: drrania_maamon@med.asu.edu.eg; Phone: 01000544520

ABSTRACT

Background & Objective: Video-assisted thoracoscopic (VATS) procedures, are becoming increasingly popular. It is recommended to utilize loco-regional analgesia for reducing post-surgical pain because it encourages early postoperative recovery and provides opioid sparing. Various regional analgesic methods, such as paravertebral, intercostal, and serratus plane blocks, may be utilized to alleviate pain after thoracic surgery. This study compares serratus anterior muscle blocks (SAPB) and thoracic paravertebral blocks (TPVB) in providing postoperative pain alleviation following VATS using ultrasound.

Methodology: In this randomized prospective comparative trial, 80 patients scheduled for VATS were allocated at random to one of two equal groups; group A received USG- TPVB, and group B received USG-guided SAPB. The postoperative VAS score, time of rescue analgesia, and postoperative nalbuphine consumption were documented throughout a 24-hour period. We also documented the onset of ambulation and any nerve block consequences.

Results: VAS was considerably lower in the TPVB group at 12 and 24 h compared to SABP with P value (< 0.001 & 0.029) respectively; also, patients in the TPVB group took longer to request rescue analgesia (10.77 ± 2.28) vs (6.12 ± 1.43) in SABP group with P < 0.001. Also, TPVB group consumed fewer nalbuphine doses (5.56 ± 1.56) than patients in the SAPB group (9.5 ± 3.49) with P < 0.001.

Conclusion: When compared to SAPB block, TBVP block was more successful in lowering postoperative pain scores and lowering the overall 24-h postoperative opioid intake following VATS procedures performed under general anesthesia.

Keywords: Serratus anterior muscle block; thoracic paravertebral blocks; Pain control; Video-assisted thoracoscopic procedures; VATS

Citation: Hussien RM, Afifi GAS, Elshantory SFE, Mohie AGM, Salem MMH. A comparative study between ultrasound guided thoracic paravertebral block vs ultrasound guided serratus anterior muscle block in video-assisted thoracoscopic surgeries. Anaesth. pain intensive care 2024;28(6):996-1003; DOI: 10.35975/apic.v28i6.2489

Received: June 11, 2024; **Revised:** August 29, 2024; **Accepted:** September 28, 2024

1. INTRODUCTION

Patients may suffer severe pain following thoracic surgery due to thoracic movement, injury to the intercostal nerve, and pleura stimulation induced by the thoracic catheter. Following a thoracotomy, up to 50% of patients may experience chronic pain.[1] VATS has replaced thoracotomy as the main surgical approach having the merit of providing better patient outcomes and causing less discomfort. However, postoperative pain may persist.[2] In addition to raising the risk of cardiac ischemia and arrhythmia, pain also increases the possibility of hypoxemia and hypercapnia. Lowering postoperative pain also lowers the risk of respiratory complications and reduced mobility.[3] Therefore, it is recommended to use regional analgesia for managing post-surgical pain following VATS since it allows early postoperative recovery and provides opioid sparing.[3]

Several regional analgesic techniques, such as paravertebral blocks, intercostal blocks, and serratus plane blocks, can be applied to control pain following thoracic surgery.[4] Blanco et al. initially suggested the Serratus anterior plane (SAPB) block in 2013.[5] Its simplicity and precise analgesic impact minimize the need for opioids both before and after surgery, as well as decreasing the risk of hemodynamic changes, nerve injury, and other unfavorable reactions. It is thought to be an alternative to perineural blockage. Consequently, it is often used in thoracotomy, thoracoscopic, and breast surgeries.[6] SAPB affects the lateral cutaneous branch of the intercostal nerves from the T2 to the T9 level, allowing prolonged analgesia of the hemithorax.[5] Hugo Sellheim, a Native American, developed the idea of the paravertebral block in 1905. It was further modified by Lawen (1911) and Kappis (1919).[7] The paravertebral block provides ipsilateral anesthesia and analgesia, causing a continuous dermatomal blockage of the somatic and sympathetic nervous system.[8] At the point where the spinal nerves exit the intervertebral foramina, which is near the thoracic vertebra, the local anesthetic is administered. This approach is now widely recognized and effective in treating both acute and chronic thoracic discomfort.[9]

Thus, the aim of this trial was to compare the effectiveness of the ultrasound-guided thoracic paravertebral block (TPVB) and serratus anterior muscle block (SAPB) in providing postoperative pain control in VATS.

2. METHODOLOGY

Following approval by institutional Research Ethics Committee, and registration at clinical trial. Eighty patients scheduled for VATS were allocated at random to one of two groups using sealed opaque envelopes. The patients or the patients' legal guardians if the patient is under 21 years of age signed written informed consent forms after receiving a thorough description of the procedures and their likely outcomes.

The study included patients of both sexes, aged ≥ 20 to <65, ASA physical status I to II, and planned for VATS under general anesthesia (GA). Patients who refused to participate, ASA III / IV, those with severe spine abnormalities, and those whose local anatomy was disrupted (for example, because of the presence of surgical emphysema or chest drains, which can cause distortion of tissue planes and make it difficult to interpret ultrasound images), patients suffering from bleeding disorders and coagulopathy, injection site infection, allergic to local anesthetics, and ipsilateral diaphragmatic paresis were all excluded from the trial.

Every patient had standard preoperative tests performed, which included laboratory testing for prothrombin time, partial thromboplastin time, and full blood picture. Age, weight, and sex were also noted.

Prior to the induction of anesthesia, every patient had baseline monitoring, which comprised an electrocardiogram (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2). This monitoring continued to the end of the procedure and during the recovery period.

On induction of anesthesia, every patient received 100% oxygenation at 8 L/min via a face mask for three minutes and Ringer solution infused. For all patients, sedation was done by an intravenous injection of midazolam 0.02 mg/kg and then propofol 2 mg/kg was used to induce GA. Fentanyl (2µg/kg) was used for analgesia. 0.5 mg/kg IV atracurium facilitated intubation using an appropriate standard-sized (double lumen) endotracheal tube. Anesthesia was maintained by 1.5% isoflurane in 50% O2/air and atracurium (0.1 mg/kg IV every 20 minutes) together with mechanical ventilation to keep the end-tidal CO_2 ($ETCO_2$) between 30-35 mmHg.

After induction of anesthesia, Group A received TPVB. While the patients were in the lateral decubitus position, using a portable ultrasound machine “GE venue 40”, a high-frequency linear array probe was positioned to locate the transverse process at T4 level (the level of port introduction) in the paramedian plane. The probe was manipulated slightly caudad or cephalad to locate the intercostal space and avoid acoustic shadowing from neighboring ribs. The transverse process was visualized medially with the pleura dipping under the inferolateral aspect. The internal intercostal membrane, which is

contiguous with the superior costotransverse ligament, was generally seen as a thin, radiopaque line extending from the transverse process, creating a wedge-shaped pocket, which represents the thoracic paravertebral space. A maximum of 40 mL (0.4 mL/kg) of the prepared 0.25% bupivacaine were injected into the thoracic

paravertebral space using a 22-gauge block needle, after the pleura, superior costo-transverse ligaments, and transverse processes were all clearly visible. Diffusion of the local anesthetic was observed to cause depression of the pleura (as shown in Figures 1 & 2).

Group B, however, was given SAPB. Using a portable ultrasound machine "GE venue 40", a high-frequency linear array probe was positioned horizontally on the side of the block, at the level of the fourth or fifth ribs, on the mid-axillary line, while the patient remained in the supine posture. It was determined which muscles were the intercostal, serratus anterior, and latissimus dorsi. Using an in-plane method, the block needle (22-gauge) was advanced towards the fifth rib, superior to the serratus anterior muscle (SAM). A maximum of 40 mL (0.4 mL/kg) of the prepared 0.25% bupivacaine were injected between the SAM and latissimus dorsi muscle (as shown in figure 3&4).

Following surgery, the patients were extubated awake in a semi-sitting position and were sent to the PACU. Patients were monitored for hemodynamic (heart rate and mean blood pressure) and post-operative pain at 0 (PACU), 2, 4-, 8-, 12-, and 24-hours following surgery. A standard analgesic regimen was administered to each patient after being discharged from the PACU, which comprised taking 1 gram of paracetamol every 6 hours and 30 mg of ketorolac every 24 hours. The postoperative pain was measured using the visual analogue scale (VAS) both during the evaluation and whenever the patient expressed pain complaints. If the patient's VAS score was greater than 3, nalbuphine

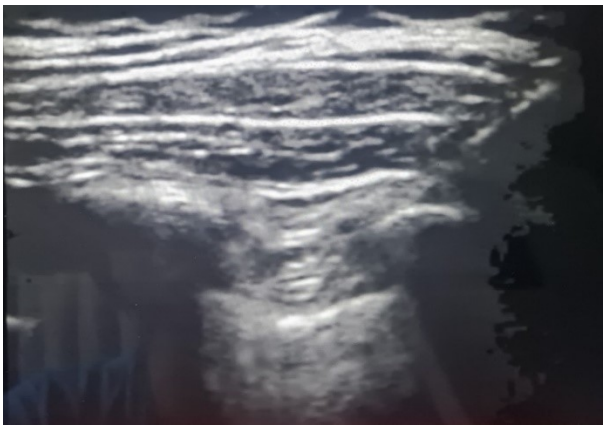

Figure 1: ultrasound scan of thoracic paravertebral block pre injection of local anesthetic agent.

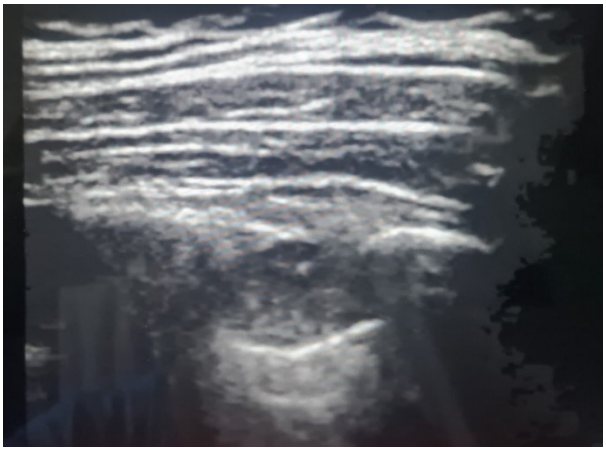

Figure 2: ultrasound scan of thoracic paravertebral block post injection of local anesthetic agent.

injection 0.05 mg/kg intravenously was used as a rescue analgesia to reduce the score to ≤ 3. If the patient persisted in complaining, a second titrating dose of 2–3 mg nalbuphine was considered to reach ≤ 3 (the

maximum dose of nalbuphine is 10 mg in each time). The total amount of nalbuphine consumed was recorded. The onset of ambulation and any adverse effects from the nerve block were monitored and recorded throughout the first twenty-four hours after the procedure. The total amount of nalbuphine used by the two groups within the first day post-operative was the primary outcome of the study.

The post-operative

Table 1: Comparative demographic data, surgical time, and onset of ambulation.

Variable		Group A (TPVB) (n = 40)	Group B (SAPB) (n = 40)	P-value
Age (y)		41.93 ± 12.72	40.95 ± 11.23	0.717
Weight (kg)		75.68 ± 19.52	75.65 ± 19.99	0.991
Gender	**Female**	17 (42.5%)	19 (47.5%)	0.822
	Male	23 (57.5%)	21(52.5%)	
ASA physical status	**I**	27 (67.5%)	30 (75.0%)	0.622
	II	13 (32.5%)	10 (25.0%)	
Surgical time (hr)		2.70 ± 1.39	2.74 ± 1.63	0.48
Onset of ambulation (hr)		7.38 ± 1.56	7.50 ± 1.37	0.705

Data expressed as Mean ± SD using t-Independent Sample t-test, number (%) using x2=chi-square test for, P > 0.05 is insignificant; P < 0.05 is significant P < 0.001 is highly significant.

Table 2: Surgical procedures.

Surgical procedures	Group A (TPVB) (n = 40)	Group B (SAPB) (n = 40)
Lobectomy	4	4
Pneumonectomy	2	3
Bullectomy	8	7
Biopsy	14	13
Decortication	12	13

Data expressed as number of surgical procedures in each group.

Table 3: HR and MAP in the two groups at different times.

Variable	Group A (TPVB) (n = 40)	Group B (SAPB) (n = 40)	P-value
HR 0 hr (PACU)	75.08 ± 9.77	75.75 ± 5.88	0.709
HR 2 hr	74.50 ± 5.66	76.30 ± 6.38	0.186
HR 4 hr	77.48 ± 11.27	74.40 ± 5.62	0.127
HR 8 hr	78.25 ± 8.87	77.35 ± 6.27	0.602
HR 12 hr	76.28 ± 6.89	80.32 ± 7.01	0.689
HR 24 hr	76.03 ± 5.00	77.97 ± 6.63	0.138
MAP 0 hr (PACU)	75.73 ± 8.29	75.20 ± 6.97	0.760
MAP 2 hr	75.10 ± 6.71	76.45 ± 7.13	0.386
MAP 4 hr	80.53 ± 7.38	79.33 ± 5.98	0.427
MAP 8 hr	81.68 ± 8.70	81.55 ± 6.06	0.941
MAP 12 hr	77.50 ± 5.73	80.50 ± 6.56	0.187
MAP 24 hr	80.03 ± 6.33	82.38 ± 11.96	0.276

Data expressed as Mean ± SD using t-Independent Sample t-test, p-value > 0.05 is insignificant; p-value< 0.05 is significant; P < 0.001 is highly significant.

Table 4: Comparison of Visual Analogue Score (VAS) at different times.

Variable	Group A (TPVB) (n = 40)		Group B (SAPB) (n = 40)		P-value
	Median	IQR	Median	IQR	
VAS 0 hr (PACU)	1	0-2	1	0-2	0.839
VAS 2 hr	1	1-2	1	1-2	0.755
VAS 4 hr	1.5	1-2	1	1-2	0.225
VAS 8 hr	1	1-2	2	1-2	0.451
VAS 12 hr	1.5	1-2	2	2-3	<0.001
VAS 24 hr	1	0.5-2	1.5	1-3	0.029

Data expressed as range, median and inter quartile range (IQR), using Mann-Whitney test.

VAS, the commencement of the patient's first analgesic request, hemodynamics, ambulation onset, and nerve block complications during the first 24 hours of the study's surgery were the secondary outcomes.

Sample Size

Using PASS 11 program for sample size calculation , reviewing results from previous study (Baytar , et al 2021) showed that opioid consumption during 24 h (mg) was 18.54 ± 16.08 among TPVB vs 31.12 ± 23.08 for SAPB group based on these findings and after 20% adjustment for dropout rate, sample sizes of 40 patients per group will achieve a 80.174% power to reject the null hypothesis of equal means when the population mean difference is m1 – m2 = 18.5 -31.1= -12.4 with standard deviations of 16.0 for group 1 and 23.0 for group 2 , and with a significance level (alpha) of 0.050 using a one-sided two-sample unequal-variance t-test.

Statistical analysis

Data were collected, coded, tabulated, and then analyzed using Statistical package for Social Science (SPSS) version 27.0, mean ± standard deviation (SD) or median (IQR) were used to express quantitative data. Frequency and percentage were used to express qualitative data. The following tests were performed: When comparing two means, the t-test of significance was employed, Chi-square (X2) test of significance was used to compare proportions between two qualitative parameters, Mann Whitney U test: for two-group comparisons in non-parametric data, The confidence interval was set to 95% and the margin of error accepted was set to 5%. Thus, the following P < 0.05 was considered significant.

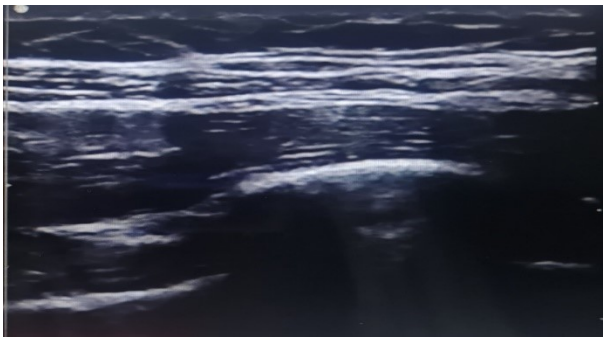

Figure 3: ultrasound scan of serratus anterior muscle block pre injection of local anesthetic agent.

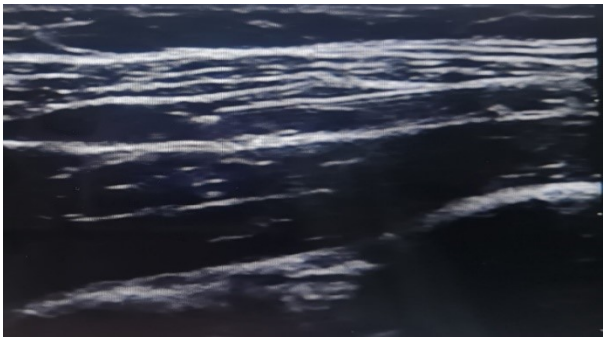

Figure 4: ultrasound scan of serratus anterior muscle block post injection of local anesthetic agent.

3. RESULTS

Throughout the study, no statistically significant differences were identified between the two groups regarding the hemodynamics noted in heart rate (HR) at 0, 2, 4, 8, 12, and 24 hours with P values (0.709, 0.186, 0.127, 0.602, 0.689 and 0.138) respectively and mean arterial blood pressure (MAP) with P values (0.760, 0.386, 0.427, 0.941, 0.187 and 0.276) respectively (Table 3). Also no significant difference between the two groups in surgical time (TPVB 2.70 ± 1.39 vs SAPB 2.74 ± 1.63) with P = 0.48 and surgical type (Table 1,2), Also there was no significant difference regarding demographic data (age, weight, and ASA score) with P values (0.717, 0.991, 0.622) respectively (Table 1). There was no statistically significant difference in the groups' commencement of ambulation (TPVB 7.39 ± 1.39 vs 7.5 ± 1.37 in SABP) with P value 0.7 (Table 1), and our records did not show any post-operative complications such as PONV, organ damage, or local anesthetic toxicity.

Regarding pain control, there was no significant difference between both groups regarding VAS scores at 0-, 2-, 4-, and 8-hours with P = 0.839, 0.225, and 0.451, respectively following surgery however the TPVB group's VAS scores were significantly lower at 12 and 24 hours compared to SABP group with P < 0.001 & 0.029, respectively (Table 4).

Furthermore, patients in the TPVB group required smaller doses of nalbuphine (5.56 ± 1.56) vs (9.58 ± 3.49) in SABP group with P < 0.001, Also , TPVB group waited longer to request rescue analgesia (10.77 ± 2.28) than patients in the SAPB (6.12 ± 1.43) with P < 0.001 (Table 5; Figures 5 & 6).

4. DISCUSSION

This randomized trial aimed to determine whether thoracic paravertebral block or serratus anterior muscle block was more efficient as a postoperative analgesic for patients undergoing VATS surgery by comparing pain scores and the amount of opioids used. The total amount of postoperative opioids consumed, the initial request for analgesia, the VAS score, patients' hemodynamic, the onset of ambulation, and the nerve block complication on the first postoperative day were all measured and compared.

In this trial, TPVB group consumed fewer nalbuphine doses and took longer to request rescue analgesia than SAPB group. Additionally, VAS was considerably reduced in the TPVB group at 12 and 24 hours.

In their study, Baytar et al.[10] noted that SAPB does not require autonomic blocking and may not impact the posterior cutaneous branches of the intercostal nerves. A three-port incision was used for every procedure in their investigation, with one of the ports being posteriorly located. They therefore believed that the SAPB group consumed more opioids than the TPVB group, which is consistent with our findings.[10]

Our results matched those of Jiang and colleagues, who compared the incidence of rescue analgesia between

Table 5: Time to first rescue analgesia in hours and total nalbuphine consumption (mg).

Variable	Group A (TPVB) (n = 40)	Group B (SAPB) (n = 40)	P-value
1ST rescue analgesia (time)	10.77 ± 2.28	6.12 ± 1.43	<0.001
Total nalbuphine used (mg)	5.56 ± 1.56	9.58 ± 3.49	<0.001

Data expressed as Mean ± SD using t-Independent Sample t-test, p-value > 0.05 is insignificant; p-value< 0.05 is significant; P < 0.001 is highly significant.

SAPB and TPVB recipients and concluded that TPVB

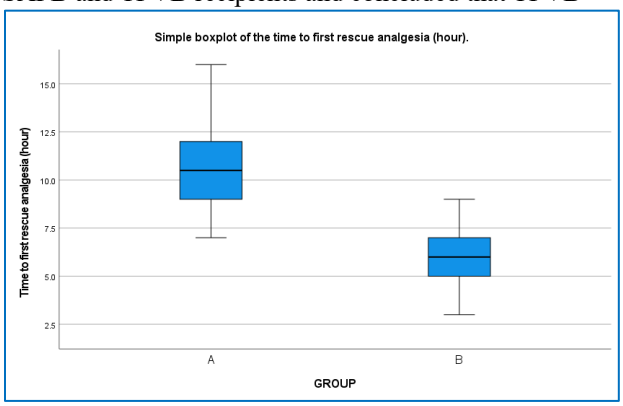

Figure 5: Simple boxplot of Time to first rescue analgesia (hour). A = TPVB, B = SAPB (Results are presented as median, IQR and range).

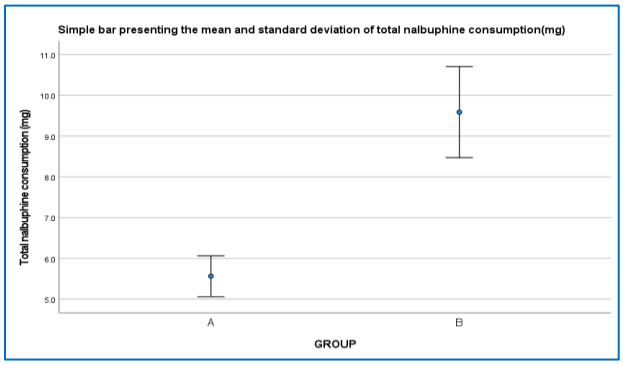

Figure 6: Simple Bar presenting the mean and standard deviation of total Nalbuphine used (mg). A = TPVB, B = SAPB

recipients were less likely than SAPB recipients to need rescue analgesia. They also demonstrated that TPVB performed much better than SAPB in minimizing the incidence of iatrogenic nausea and vomiting as well as postoperative opioid consumption.[11]

Contrary to our findings, Luo and colleagues reported that the SAPB group performed better regarding opioid consumption and static pain levels than the TPVB group. It's been proposed that the anterior and lateral cutaneous branches of the intercostal nerve, which are located between the latissimus dorsi and external intercostal muscles, are blocked when a local anesthetic is injected directly into the superficial or deep layer of the serratus anterior muscle. As a result, the anterolateral chest wall receives adequate analgesia.[12]

In contrast to our findings, Wang and colleagues discovered that the TPVB group and the SAPB group had similar total opioid intake and that both groups were equally effective regarding cumulative postoperative opioid usage and pain scores. They explained that this result was because the surgery only required one incision.[13]

No noticeable fluctuations in pain scores (VAS score) were observed in the current study throughout postoperative hours 0, 2, 4, and 8. On the other hand, VAS values in TPVB were significantly lower at postoperative hours 12 and 24 ($P < 0.001$), suggesting that TPVB provided better and longer-lasting analgesia. Our results were in close agreement with those of Vogt and associates, who investigated the effectiveness of analgesics of TPVB and SAPB in VATS procedures. They found that patients undergoing a single-injection TPV block for VATS experienced considerably lower pain levels, which lasted for 48 hours following surgery.[14] Like our results, Saad and colleagues' study revealed no differences in pain scores except for; at 12 and 24 hours, where the VAS score of the TPVB group was considerably less than that of SAPB.[15]

As opposed to us, Wang and colleagues carried out a retrospective analysis in which they split 123 patients undergoing single incision (uniport) VATS into three groups for postoperative pain management: SAPB, TPVB, and a control group. They emphasized that there was no discernible variation between the SAPB and TPVB groups' VAS scores. The use of a single port that didn't require a posterior incision could account for this result.[13]

Baytar et al. carried out a prospective randomized investigation contrasting US guided TPVB with SAPB. There was no appreciable variation in the two groups' VAS scores. The study found that there was no discernible variation in the dynamic VAS ratings and rest ratings during postoperative hours 0, 1, 6, 12, and 24. Both groups' VAS values were less than three, which contradicts our findings; possibly due to the subjective nature of the VAS score.[10]

During our experiment, neither group experienced any side effects including PONV, hypotension, or urine retention. Furthermore, there was no appreciable difference between the two groups' hemodynamic changes or the commencement of ambulation.

Our results supported those of Baytar and associates, who found that there was no discernible variation between both groups concerning the incidence of complications and hemodynamic changes.[10] Upon assessing the TPVB and SAPB for pain after thoracotomy, Aly and Abd Ellatif found no statistically significant variation in the rate of complications.[16] On the other hand, Kelly and colleagues reported complications such pneumothorax, hemodynamic impairment, or total spinal anesthesia after US guided TPV block.[17]

According to Wang and colleagues, TPVB patients have a considerably higher incidence of intraoperative hypotension, hematoma formation at site of injection,

and pain at the block site than SAPB patients. The clarification provided was that the block-related hypotension is uncommon, local anesthetic medicines are unlikely to enter the epidural region, and the intervertebral foramina are not near the SAPB block site.[18]

Wong and others acknowledged that worries about the possible risk of pneumothorax outweigh the great analgesic effect of TPVB. However, because VATS involves the insertion of chest tubes at the end of the procedure, worries regarding pneumothorax are much decreased. This enables for the administration of TPVB without worrying about this consequence.[19]

5. CONCLUSION

In comparison to SAPB block, TPVB block was successful in lowering postoperative pain scores for 12 to 24 hours as well as the overall 24-hour postoperative opioid intake following VATS procedures performed under general anesthesia. When the placement of an epidural catheter is not recommended, this method has the potential to be a promising method of postoperative analgesia.

6. ACKNOWLEDGMENTS

The study's participating authors affirm that no financial affiliation or conflict of interest has been disclosed in relation to this work.

7. AUTHORS CONTRIBUTION

RMHM: Visualization, Validation, Writing- Reviewing and Editing

GASA: Conceptualization, Methodology, Supervision

SFEE: Validation, Project administration, Writing- Reviewing and Editing

AGMM: Investigation, Data curation, Writing- Original draft preparation.

MMHS: Validation, Writing- Reviewing and Editing, Project administration

8. REFERENCES:

1. Elmore B, Nguyen V, Blank R, Yount K, Lau C. Pain management following thoracic surgery. Thorac Surg Clin [Internet]. 2015;25(4):393–409. Available from: http://dx.doi.org/10.1016/j.thorsurg.2015.07.005
2. Bendixen M, Jørgensen OD, Kronborg C, Andersen C, Licht PB. Postoperative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage lung cancer: a randomised controlled trial. Lancet Oncol [Internet]. 2016;17(6):836–44. Available from: http://dx.doi.org/10.1016/s1470-2045(16)00173-x
3. Ochroch EA, Gottschalk A. Impact of acute pain and its management for thoracic surgical patients. Thorac Surg Clin [Internet]. 2005;15(1):105–21. Available from: http://dx.doi.org/10.1016/j.thorsurg.2004.08.004
4. Steinthorsdottir KJ, Wildgaard L, Hansen HJ, Petersen RH, Wildgaard K. Regional analgesia for video-assisted thoracic surgery: a systematic review. Eur J Cardiothorac Surg [Internet]. 2014;45(6):959–66. Available from: http://dx.doi.org/10.1093/ejcts/ezt525
5. Blanco R, Parras T, McDonnell JG, Prats-Galino A. Serratus plane block: a novel ultrasound-guided thoracic wall nerve block. Anaesthesia [Internet]. 2013;68(11):1107–13. Available from: http://dx.doi.org/10.1111/anae.12344
6. Chai B, Wang Q, Du J, Chen T, Qian Y, Zhu Z, et al. Publisher correction: Research progress on serratus anterior plane block in breast surgery: A narrative review. Pain Ther [Internet]. 2023;12(2):339. Available from: http://dx.doi.org/10.1007/s40122-022-00471-0
7. Cheema SP, Ilsley D, Richardson J, Sabanathan S. A thermographic study of paravertebral analgesia. Anaesthesia [Internet]. 1995;50(2):118–21. Available from: http://dx.doi.org/10.1111/j.1365-2044.1995.tb15092.x
8. El-Boghdadly K, Madjdpour C, Chin KJ. Thoracic paravertebral blocks in abdominal surgery-a systematic review of randomized controlled trials. BJA. 2016;117(3):297–308.
9. Wild K, Chin KJ. Regional techniques for thoracic wall surgery. Curr Anesthesiol Rep [Internet]. 2017;7(2):212–9. Available from: http://dx.doi.org/10.1007/s40140-017-0212-y
10. Baytar MS, Yılmaz C, Karasu D, Baytar Ç. Comparison of ultrasonography guided serratus anterior plane block and thoracic paravertebral block in video-assisted thoracoscopic surgery: a prospective randomized double-blind study. Korean J Pain [Internet]. 2021;34(2):234–40. Available from: http://dx.doi.org/10.3344/kjp.2021.34.2.234
11. Jiang T, Mo X, Zhan R, Zhang Y, Yu Y. Regional block techniques for pain management after video-assisted thoracoscopic surgery: a covariate-adjusted Bayesian network meta-analysis. Wideochir Inne Tech Malo Inwazyjne [Internet]. 2023;18(1):52–68. Available from: http://dx.doi.org/10.5114/wiitm.2023.124407
12. Luo G, Tao J, Zhu J, Xie K, Ni C. Comparison of analgesic effects of different regional blocks in video-assisted thoracic and breast surgeries: A network meta-analysis

and systematic review. Pain Physician. 2022;25(5):339–54.

13. Wang L, Wang Y, Zhang X, Zhu X, Wang G. Serratus anterior plane block or thoracic paravertebral block for postoperative pain treatment after uniportal video-assisted thoracoscopic surgery: a retrospective propensity-matched study. J Pain Res [Internet]. 2019;12:2231–8. Available from: http://dx.doi.org/10.2147/JPR.S209012

14. Vogt A, Stieger DS, Theurillat C, Curatolo M. Single-injection thoracic paravertebral block for postoperative pain treatment after thoracoscopic surgery. Br J Anaesth [Internet]. 2005;95(6):816–21. Available from: http://dx.doi.org/10.1093/bja/aei250

15. Saad FS, El Baradie SY, Abdel Aliem MAW, Ali MM, Kotb TAM. Ultrasound-guided serratus anterior plane block versus thoracic paravertebral block for perioperative analgesia in thoracotomy. Saudi J Anaesth [Internet]. 2018;12(4):565–70. Available from: http://dx.doi.org/10.4103/sja.SJA_153_18

16. Aly A, Abd Ellatif S. Comparison of ultrasound-guided serratus plane block and thoracic paravertebral block for postoperative analgesia after thoracotomy: a randomized controlled trial. Res Opin Anesth Intensive Care [Internet]. 2018;5(4):314. Available from: http://dx.doi.org/10.4103/roaic.roaic_72_17

17. Kelly ME, Mc Nicholas D, Killen J, Coyne J, Sweeney KJ, McDonnell J. Thoracic paravertebral blockade in breast surgery: Is pneumothorax an appreciable concern? A review of over 1000 cases. Breast J [Internet]. 2018;24(1):23–7. Available from: http://dx.doi.org/10.1111/tbj.12831

18. Wang Y, Shi M, Huang S, He X, Gu X, Ma Z. Ultrasound-guided serratus anterior plane block versus paravertebral block on postoperation analgesia and safety following the video-assisted thoracic surgery: A prospective, randomized, double-blinded non-inferiority clinical trial. Asian J Surg [Internet]. 2023;46(10):4215–21. Available from: http://dx.doi.org/10.1016/j.asjsur.2022.11.125

19. Wong H-Y, Pilling R, Young BWM, Owolabi AA, Onwochei DN, Desai N. Comparison of local and regional anesthesia modalities in breast surgery: A systematic review and network meta-analysis. J Clin Anesth [Internet]. 2021;72(110274):110274. Available from: http://dx.doi.org/10.1016/j.jclinane.2021.110274

