The Egyptian Journal of Hospital Medicine (January 2023) Vol. 90 (2), Page 3119-3126

Serratus Anterior Plane Block versus Paravertebral Plane Block for Post Thoracotomy Pain Relief: A Comparative Study

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ABSTRACT

Background: Many analgesic options were suggested for thoracotomy including wound infiltration by local anesthetics, systemic analgesics, regional techniques [such as thoracic paravertebral block (PVB) and serratus anterior plane block (SPB)].

Objective: This study aims to compare the efficacy of the SPB and the PVB as a sole analgesic technique after thoracotomy regarding the pain relief, analgesic consumption, hemodynamic stability, and drug related adverse effects.

Patients and Methods: This double-blinded, randomized controlled study was done on 60 patients older than 18 years undergoing thoracotomy. Patients were allocated into two equal groups (30 patients each). Group S: Standard anesthesia in addition to SPB. II. Group P: Standard anesthesia in addition to PVB.

Results: Visual analogue scale (VAS) at rest and cough was significantly increased in group S than group P at 0, 3, 6, 9, 12, 24, 48 and 72 hours. First time to request morphine was significantly earlier in group S than group P. Total morphine and ketorolac in the 1st, 2nd and 3rd days were significantly increased in group S than group P. Heart rate and mean arterial blood pressure were insignificantly different between both groups at all time measurements. Nausea and vomiting, urinary retention, apnea and ileus were insignificantly different between both groups.

Conclusions: Ultrasound guided SPB is an alternative regional block to PVB for thoracotomy but PVB has a more prolonged analgesia with lower VAS and longer analgesic time till 1st analgesic request, which makes it a useful alternative to the traditional, opioid-based, general anesthetic technique after thoracotomy, but both blocks were equivalent in terms of hemodynamic stability and negative medication side effects.

Keywords: Serratus Anterior Block, Paravertebral Block, Thoracotomy.

INTRODUCTION

Intercostal muscle and soft tissue injury, as well as rib fractures, are the most common sources of early postoperative pain. To ease thoracotomy discomfort, intravenous (IV) medications such as morphine and nonsteroidal anti-inflammatory drugs (NSAIDs), wound infiltration blocal anesthetics, and area anesthetic procedures are used. The IV path is currently used to treat medications (morphine, fentanyl, etc.) and adjuvant medicines (ketamine and dexmedetomidine) [1, 2].

Thoracic epidural block, paravertebral block (PVB), intercostal block, and intra/extrapleural block are all common regional anesthetics. Symptoms such as respiratory distress, sedation, and pruritus induced by higher opioid levels, as well as the risk of temporary or irreversible nerve injury after neuraxial block, also prompted physicians to look at other options [3, 4].

Serratus anterior plane block (SPB) is a novel plane block that is performed under the guide of ultrasound (US) providing analgesia between the levels of thoracic 2 (T2) and T9 dermatomes [5]. This block may be used to block the cutaneous divisions of intercostal muscles in T2–T9 dermatomes. SPB is used for controlling pain in breast surgeries in addition to thoracic surgery, may have a sensorial blockade for around 12 hours [6].

This study aims to compare the efficacy of SPB and the PVB as a sole analgesic technique after thoracotomy surgeries regarding the pain relief, analgesic consumption, hemodynamic stability, and drug related adverse effects.

PATIENTS AND METHODS

This interventional, prospective, randomized comparative study was carried out in Sohag University Hospital from January 2019 to June 2020, 30 patients in each group that were undergoing thoracotomy surgeries. Sixty patients, older than 18 years undergoing thoracotomy surgery, at least 72 hours postoperative hospital admission and possibility of anatomical structures US identification in a satisfactory way were enrolled.

Ethical approval:

After an approval of the Ethics Committee and according to the guidelines noted in the World Health Organization Chronicles in 1976 ;30: 360-362. Every patient signed an informed written consent for acceptance of participation in the study. The ideals of the Declaration of Helsinki (1964) and its subsequent amendments were applied in the report. With the research ID ISRCTN35517318, the study was sent to the ISRCTN list.

Exclusion criteria:

Received: 11/10/2022
Accepted: 14/12/2022

Morbid obesity (BMI > 40), difficulty accurately identifying anatomical features in the US, use of painkillers prior to surgery or drug misuse, sepsis and/or infection at the puncture sites.

Patients were randomly assigned into two groups, 30 patients each: Study group S for whom standard anesthesia in addition to SPB were done. Study group P for whom standard anesthesia in addition to PVB were done.

In the two groups, a uniform anesthetic procedure was used following 3 minutes of preoxygenation of 100 percent oxygen. To promote endotracheal intubation, propofol (2 to 3 mg/kg), IV fentanyl (2 g/kg), and atracurium 0.5 mg/kg were used to trigger anesthesia. Isoflurane (1- 2 MAC) in 100% oxygen was used to preserve anesthesia. Muscle relief and analgesia were achieved using an intermittent injection of atracurium and fentanyl, respectively.

The goal was to achieve an end tidal carbon dioxide tension of 35 mmHg while mechanically ventilating both patients using volume-regulated positive pressure ventilation with tidal volumes of 6 to 8 mL/kg and a 1:2 inspiratory to expiratory ratio. Both groups of patients had their pulse oximetry, noninvasive blood pressure, a 5-lead electrocardiogram, and end tidal carbon dioxide screening done.

In group (S) patients, an US guided SPB was performed after induction of general anesthesia with the patient lying supine.

In group (P), Once general anesthesia was induced, the patient was placed in a lateral decubitus posture with the operative side uppermost, and the probe was placed in a parasagittal plane over the transverse processes of the T4 and T5 vertebrae, about 2.5 cm lateral to the spinous processes. The thoracic paravertebral space was a wedge-shaped hypoechoic region located between the pleura and the superior costotransverse ligament. An epidural needle was inserted using an out-of-plane approach starting from the top side of the probe and moving from lateral to medial.

After chest closure, all groups received a loading dosage of 30 mL 0.25 percent bupivacaine, accompanied by a 0.125 percent bupivacaine infusion of 0.1–0.25 mL/kg/hour. Since satisfying the requirements for extubation, the inhalation anesthetic was halted and the neuromuscular blockade was reversed with an IV injection of neostigmine 0.05 mg/kg and atropine 0.01 mg/kg. The patients were sent to the surgical ICU after being extubated. Any of the patients were monitored using a five-lead electrocardiogram (ECG), pulse oximetry, non-invasive blood pressure control (NIBP), end-tidal CO_2, and turnover frequencies (TOF). When the VAS score exceeded 3 to 5, a rescue analgesic in the form of ketorolac 30 mg (maximum 120 mg/24 hours) was provided for postoperative pain control. To hold the VAS score below 3, a 3-mg dose of morphine was issued for a VAS of less than 6. (a satisfactory level of analgesia). The timing of the first rescue analgesia (ketorolac and morphine) was reported, as well as the total analgesia doses provided over the course of 72 hours.

Patients' systemic blood pressure, pulse rate, and oxygen saturation were measured every 10 minutes for the first hour of the blockade, every 30 minutes for the next two hours, and then every two hours for the next 12 hours. Every 2 hours, the VAS score of pain (10 mm vertical scale from 0 to 10 where 0 means no pain and 10 means the worst pain) was registered as soon as the patient was aware enough. Respiratory distress (breaths/min and SpO_2 90%), bradycardia, hypotension, and postoperative nausea and vomiting scores were both documented as signs of opioid and local anesthetic side effects (none, mild, moderate and severe). 10 mg metoclopramide was administered intravenously in the event of nausea and/or vomiting.

Sample size calculation:

The sample size calculation was done by G*Power 3.1.9.2 (Universitat Kiel, Germany). We performed a pilot study (5 cases in each group) and we found that the mean (± SD) total morphine in the 1st 24 hours was 3±2.12 mg in Group S and was 1.2±1.64 mg in Group P. Based on the following factors, the sample size was determined: A 1:1 group ratio, a 0.94 effect size, a 95% confidence limit, a 95% power of the study, and five cases were added to each group to prevent dropout were all used. As a result, we added 30 patients to each group.

Statistical analysis

SPSS version 22.0 (release 22.0.0.0 IBM, SPSS Inc., USA) was used to analyse the data. Mean, standard deviation (SD), median, and range were used to describe quantitative data. The frequency and percentage were used to describe qualitative characteristics. The Student t-test was used to compare numerical data. Chi square test was used to compare qualitative data. Significant results were those with a two-tailed $P < 0.05$.

RESULTS

Patients' characteristics (age, sex, weight, height, BMI, ASA physical status and surgical procedure) were insignificantly different between both groups (Table 1).

Table (1): Patients' characteristics in both studied groups

		Group S (n = 30)	Group P (n = 30)	P value
Age (years)	**Mean ± SD**	39.26 ± 11.99	40.37 ± 11.19	0.714
	Range	22.5-59	19-59	
Sex	**Male**	25 (83%)	19 (63%)	0.080
	Female	5 (17%)	11 (37%)	
Weight (Kg)	**Mean ± SD**	78.05 ± 11.02	77.63 ± 10.27	0.880
	Range	59-98.5	52-94	
Height (m)	**Mean ± SD**	1.70 ± 0.06	1.72 ± 0.06	0.202
	Range	1.63-1.79	1.58-1.79	
BMI (kg/m^2)	**Mean ± SD**	27.01 ± 4.43	26.42 ± 3.87	0.581
	Range	19.4-35.8	18.6-36.7	
American Society of Anesthesiologists (ASA) physical status	**ASA I**	11 (37%)	15 (50%)	0.297
	ASA II	19 (63%)	15 (50%)	
Surgical Procedure	**Lobectomy**	8 (27%)	5 (17%)	0.162
	Segment Resection	3 (10%)	5 (17%)	
	Biopsy	2 (7%)	4 (13%)	
	Decortication	14 (47%)	13 (43%)	
	Exploration	3 (10%)	0 (0%)	
	Wedge Resection	0 (0%)	3 (10%)	

Block duration was significantly decreased in group S than group P. Surgery duration and total duration were insignificantly different between both groups (Table 2).

Table (2): Block, surgery and total durations (min) in both groups

		Group S (n = 30)	Group P (n = 30)	P value
Block duration (min)	**Median**	22.5	26.5	**0.003***
	Range	19-30	20-272	
Surgery duration (min)	**Mean ± SD**	230.67 ± 47.21	207.80 ± 51.10	0.077
	Range	115-300	90-290	
Total duration (min)	**Mean ± SD**	254.27 ± 47.79	249.33 ± 87.80	0.788
	Range	136-320	115-562	

*: Significant

VAS at rest was significantly increased in group S than group P at 0, 3, 6, 9, 12, 24, 48 and 72 hours (P = 0.005, 0.012, 0.029, 0.040, 0.034, <0.001, <0.001 and <0.001 respectively), (Figure 1).

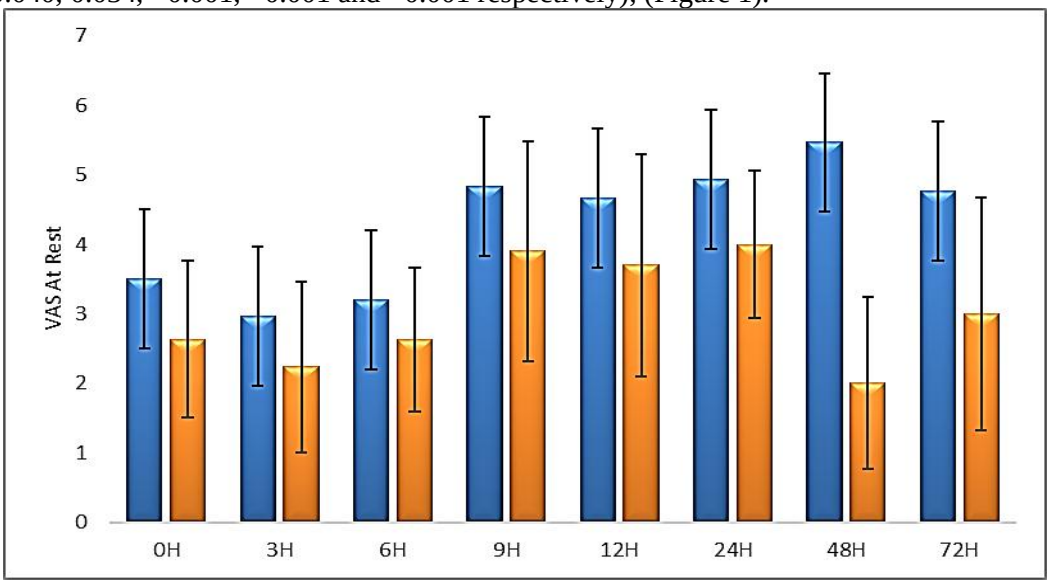

Figure (1): Visual analogue scale (VAS) at rest in both groups

VAS at cough was significantly increased in group S than group P at 0, 3, 6, 9, 12, 24, 48 and 72 hours (P = 0.002, <0.001, 0.001, 0.006, 0.001, <0.001, <0.001 and <0.001 respectively), (Figure 2).

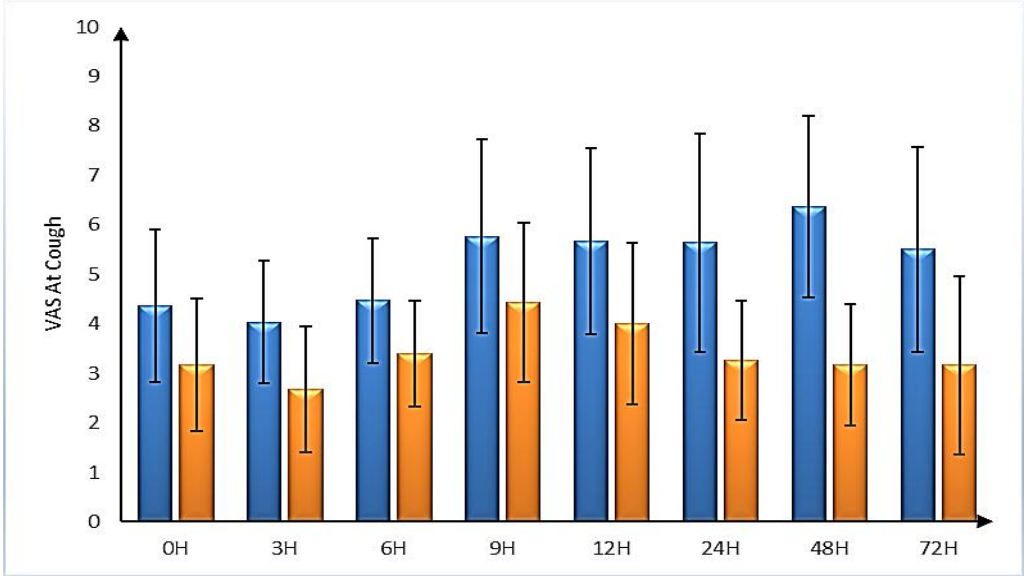

Figure (2): Visual analogue scale (VAS) at cough in both groups

First time to request morphine was significantly earlier in group S than group P. Total morphine in the 1st 24 hours, 2nd day, 1st 48 hours and 1st 72 hours were significantly higher in group S than group P. Total morphine in the 3rd day was insignificant between the two groups (Table 3).

Table (3): First time to request morphine and morphine consumption (mg) in both groups

		Group S (n = 30)	Group P (n = 30)	P value
First time to request morphine (H)	**Mean ± SD**	7.2 ± 6.59	15.83 ± 16.88	**0.012***
	Range	0-24	9-72	
Total morphine in the 1st 24 hours (mg)	**Mean ± SD**	2.10 ± 2.25	0.50 ± 1.14	**0.001***
	Range	0-6	0-3	
Total morphine in the 2nd day (mg)	**Mean ± SD**	1.20 ± 1.49	0.10 ± 0.55	**<0.001***
	Range	0-3	0-3	
Total morphine in the 1st 48 hours (mg)	**Mean ± SD**	3.30 ± 2.98	0.60 ± 1.22	**<0.001***
	Range	0 – 9	0 - 3	
Total morphine in the 3rd day (mg)	**Mean ± SD**	0.70 ± 1.29	0.20 ± 0.76	0.073
	Range	0-3	0-3	
Total morphine in the 1st 72 hours (mg)	**Mean ± SD**	4.0 ± 3.09	0.8 ± 1.35	**<0.001***
	Range	0 – 12	0 – 3	

*: Significant

First time to request ketorolac was significantly earlier in group S than group P. Total ketorolac in the 1st day, 2nd day, 3rd day, 1st 48 hours and 1st 72 hours were significantly higher in group S than group P (Table 4).

Table (4): First time to request ketorolac and ketorolac consumption (mg) in both groups

		Group S (n = 30)	**Group P (n = 30)**	**P value**
First time to request ketorolac in the 1st 72hours (H)	**Mean ± SD**	4.33 ± 5.74	8.83 ± 6.65	**0.007***
	Range	0-24	0-24	
Total ketorolac in the 1st day (mg)	**Mean ± SD**	66 ± 38.92	42 ± 20.24	**0.004***
	Range	0-150	30-90	
Total ketorolac in the 2nd day (mg)	**Mean ± SD**	13 ± 15.12	4 ± 10.37	**0.009***
	Range	0-30	0-30	
Total ketorolac in the 1st 48 hours (mg)	**Mean ± SD**	15.0 ± 20.47	5.0 ± 11.37	**0.023***
	Range	0 – 90	0 - 30	
Total ketorolac in the 3rd	**Mean ± SD**	14 ± 15.22	6 ± 12.21	**0.029***

day (mg)	**Range**	0-30	0-30	
Total ketorolac in the 1st 72 hours (mg)	**Mean ± SD**	93.0 ± 45.50	52.0 ± 20.74	**<0.001***
	Range	30 – 180	30 - 90	

*: Significant

For all time measures, the difference in heart rate between the two groups was modest, with the exception of "0H," which was considerably higher in group S than in group P (P = 0.033), (Figure 3).

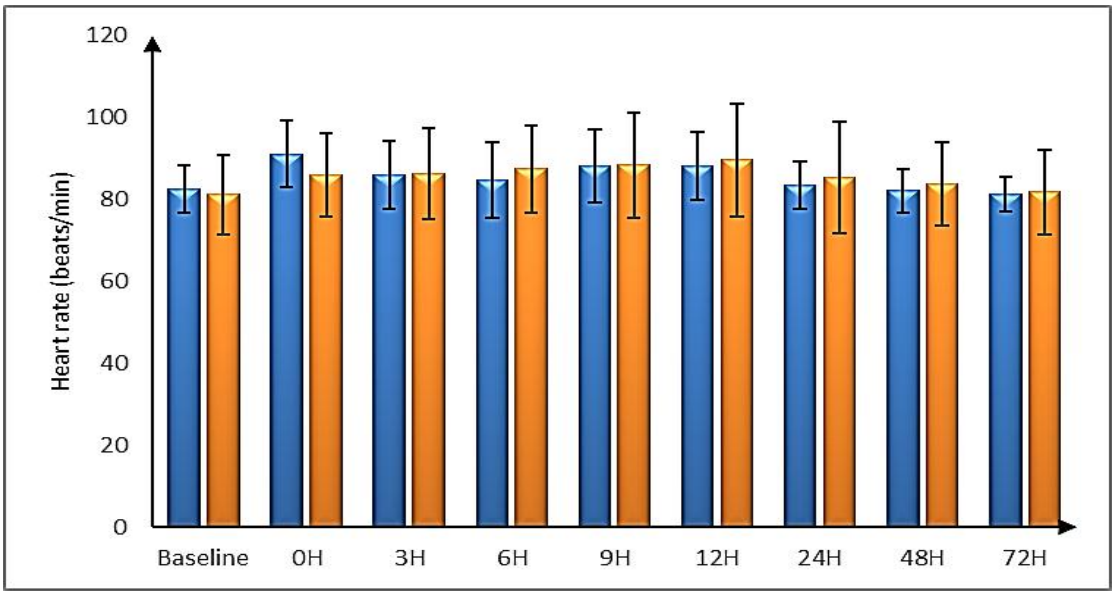

Figure (3): Heart rate (beats/min) in both groups

During all time measures, mean arterial blood pressure (MAP) was insignificantly different between the two groups, with the exception of "12H," which was significantly higher un group S than in group P (P = 0.024), (Figure 4).

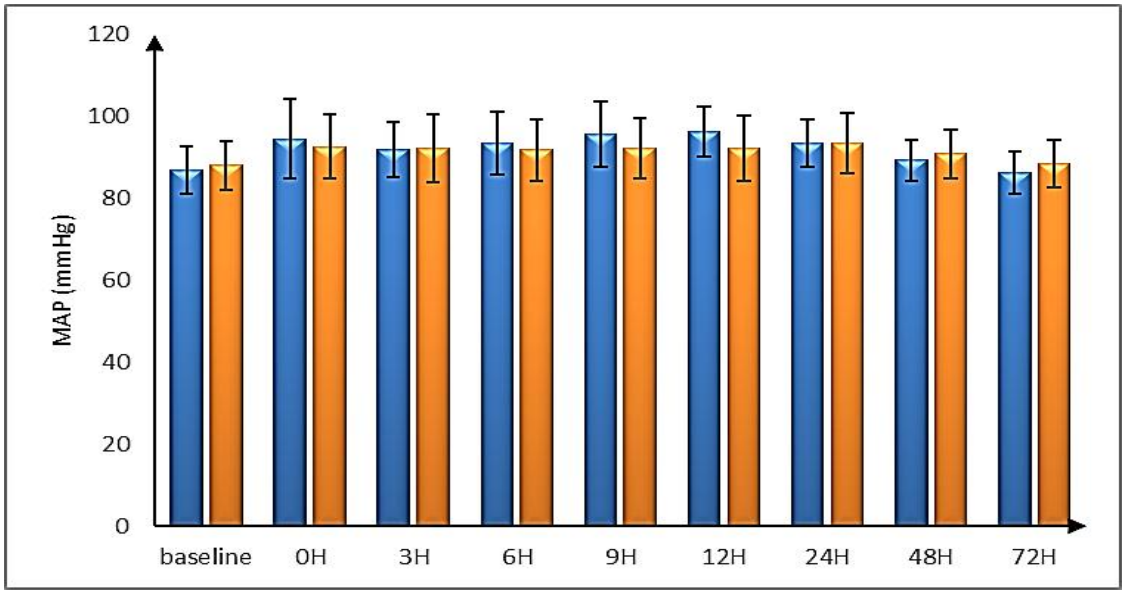

Figure (4): Mean arterial blood pressure (MAP) in both groups

Preoperative cortisol level and postoperative cortisol level were insignificantly different between both groups (Table 5).

Table (5): Preoperative cortisol level (mcg/dL) and postoperative cortisol level (mcg/dL) in both groups

		Group S (n = 30)	Group P (n = 30)	P value
Preoperative cortisol level (mcg/dL)	**Mean ± SD**	20.90 ± 2.60	21.47 ± 2.69	0.410

Postoperative cortisol level (mcg/dL)	**Mean ± SD**	26.30 ± 3.03	26.67 ± 2.77	0.627

Side effects (Nausea and vomiting, urinary retention, excessive sedation, hypotension, itching, cardiac arrythmias, apnea and ileus) were insignificantly different between both groups (Figure 5).

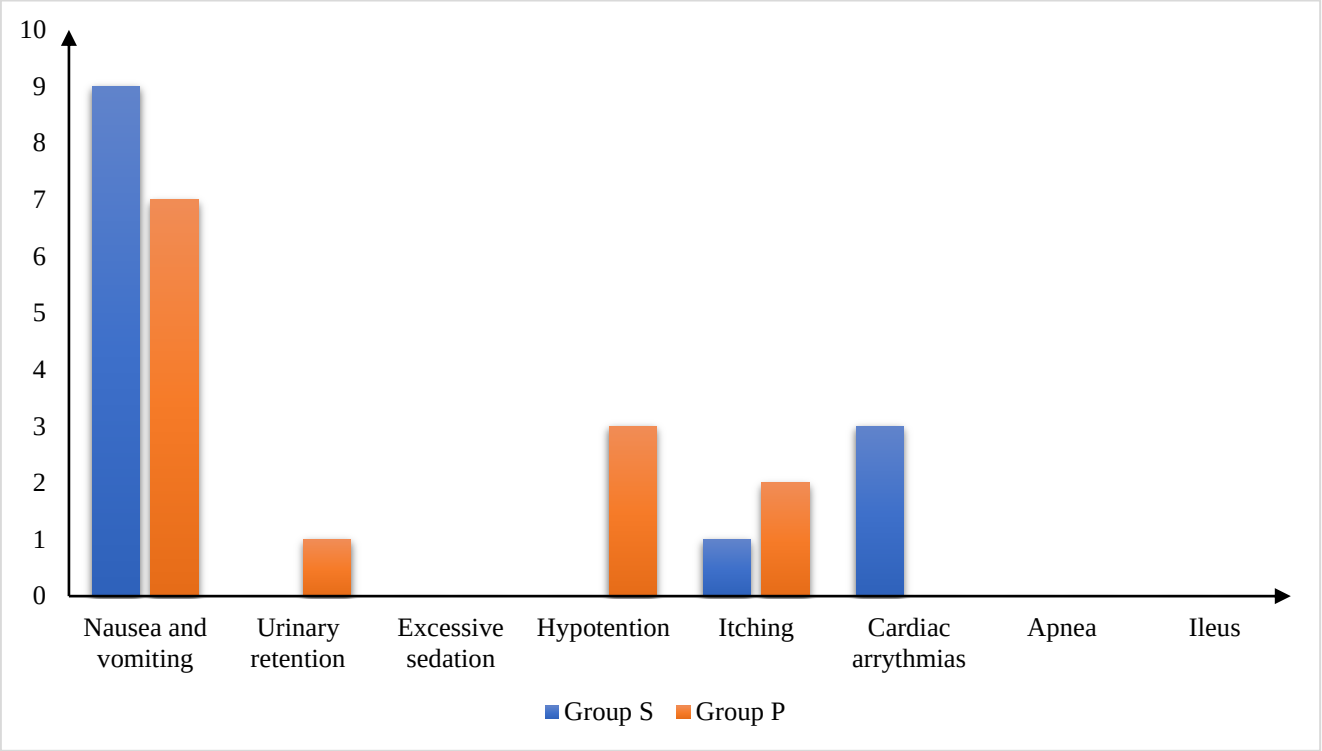

Figure (5): Side effects in both groups

DISCUSSION

In our study, block duration was significantly less in group S than group P (P= 0.003), which is comparable to the result of **Gupta *et al.*** [7], **Aly and Abd Ellatif** [8], **Saad *et al.*** [9] and **Ökmen and Ökmen** [10].

In the present study, VAS at rest was significantly higher in group S than group P at 0, 3, 6, 9, 12, 24, 48 and 72 hours while VAS at cough was significantly increased in group S than group P at 0, 3, 6, 9, 12, 24, 48 and 72 hours. This was in line with **Aly and Abd Ellatif** [8] who found that VAS at rest and coughing were insignificantly different in at all times of measurement but they were significantly increased with SPB compared to PVB at 12 and 18 hours postoperatively.

In accordance to our results, **Moll *et al.*** [11] found that VAS was significantly higher in SPB than PVB after robotic-assisted coronary artery bypass grafting. They used single injection in PVB by 20 ml of 0.5% ropivacaine and in SPB some cases had single injection of 20 – 30 ml of bupivacaine with epinephrine and some cases had catheter infusion by 0.2% ropivacaine at 8 – 12 ml/h.

In contrast to our study, **Gupta *et al.*** [7] found that VAS scores in PVB and SPB groups were similar after mastectomy by using single injection of 20 ml bupivacaine 0.5 % in both blocks. This difference may be due to the different type of the incision (anterior chest wall incision).

Our data were not comparable to the results of **Wang *et al.*** [12] who found that the both SPB or thoracic PVB decreased the uniportal postoperative morphine use and pain ratings in video-assisted thoracic surgery (VATS) under general anesthesia. As this is simpler maneuver than open thoracotomy.

In contrast to our results, **Chu and Jarvis** [13] demonstrated that the SPB was better than PVB for controlling pain related to chest tube. However, the number of patients included in this study was very small and they used a catheter.

Saad *et al.* [9] found that VAS score was insignificantly different between SPB and PVB in cases of lung lobectomy for lung cancer, which wasn't in line with our results. While in agreement with our results, VAS was significantly decreased in PVB compared to SPB at 12 and 24 h. They used single injection by different doses as 20 ml bupivacaine 0.5% in PVB group and 30 ml bupivacaine 0.5% in SPB group.

In contrary to our finding, **Hanley *et al.*** [14] reported that numerical rating scale (NRS) at rest, with

cough and with movement was significantly lower in continuous SPB at 24 hours postoperatively, but not extended to 48 hours postoperatively in video-assisted thoracic surgery (VATS). They used larger volume in SPB group (40 ml levobupivacaine bolus before the surgery) than in the PVB group (20 ml of 0.25% bupivacaine). They also used multimodal rescue analgesia as paracetamol, ibuprofen, gabapentin and oxycodone as required.

In our study, first time to request morphine and ketorolac were significantly lower in group S than group P. Confirming to our finding **Saad *et al.*** [9] found that most cases of PVB group didn't request rescue opioids. Also, **Mahran *et al.*** [15] found that time for first request of morphine was significantly prolonged with PVB compared to SPB. Moreover**, Gupta *et al.*** [7] found that the duration of analgesia was significantly prolonged with PVB than SPB after mastectomy.

In contrast to our results, **Aly and Abd Ellatif** [8] found that no difference in the first time required morphine between PVB and SPB groups. Also, **Chu and Jarvis** [13] reported that the SPB delays the need for rescue analgesia for chest tube-related pain.

In contrast to our results, **Wang *et al.*** [12] found that addition of single-injection SPB and PVB is associated with the same first time of rescue analgesia. **Moll *et al.*** [11] found that patients who received SPB have significantly increased rescue analgesia compared to patients administered PVB. **Amin *et al.*** [16] found that both SPB and PVB were similar in controlling pain after breast surgeries.

In the current study, total morphine in the first 24 hours, total morphine in the second day, total morphine in the first 48 hours, and total morphine in the first 72 hours were substantially greater in group S than in group P, whereas total morphine in the third day was negligible.

In agreement with our result, **Aly and Abd Ellatif** [8] **and Saad *et al.*** [9] demonstrated that PVB group had a lower morphine consumption in the 1st 24 hours compared to SPB group. Also, **Gupta *et al.*** [7] demonstrated that PVB group had a lower morphine consumption in the 1st 24 hours compared to SPB group after mastectomy. **Mahran *et al.*** [15] demonstrated that PVB group had a lower morphine consumption in the 1st 24 hours and 48 hours compared to SPB group. **Moll *et al.*** [11] found that opioid consumption was significantly higher in SPB compared to PVB.

In contrast, **Hanley *et al.*** [14] reported that SPB were similar to PVB in opioid consumption at 1st 48 hours in patients undergoing VATS. **Wang *et al.*** [12] found SPB or PVB had the same total consumption of analgesia in patients undergoing VATS. **Amin *et al.*** [16] found that SPB group had lower opioid consumption in comparison to PVB group.

In our study, side effects were insignificantly different between both groups. In keeping with our findings, **Aly and Abd Ellatif** [8] found that complications were insignificantly different between the two blocks. Also, **Durant *et al.*** [17] reported that SPB effectively managed without any side effects in comparing with conventional analgesia.

In contrast, **Saad *et al.*** [9] demonstrated that complications (especially hypotension and bradycardia) were significantly decreased in SPB compared to PVPB for management of post thoracotomy pain. Also, **Gupta *et al.*** [7] found insignificant difference in side effects between SBP and PVB groups. Moreover, **Madabushi *et al.*** [18] reported utilising the SPB to treat thoracotomy pain well, with no vomiting or nausea.

Limitations of our study were 1) the study was open labelled. 2) Given the relatively limited sample size, more research with a larger sample size may be necessary. The results of our study need to be confirmed by more randomised studies. 3) We didn't record the preoperative VAS as it may have a role in consumption of postoperative analgesics. 4) There were no control cases.

CONCLUSIONS

US-guided SPB is an alternative regional block to PVB for thoracotomy but PVB has a more prolonged analgesia with lower VAS and longer analgesic time till 1st analgesic request, which makes it a useful alternative to the traditional, opioid-based, general anesthetic technique after thoracotomy, but both blocks were equivalent in terms of hemodynamic stability and negative medication side effects.

Supporting and sponsoring financially: Nil.
Competing interests: Nil.

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