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RESEARCH PAPER

Ultrasound-guided serratus anterior plane block for post-thoracotomy pain

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Background and aims: *Thoracotomy is widely recognized as one of the most painful surgical procedures.This form of intensified pain is a matter of high concern to prevent pulmonary complications. Opiates and other weaker analgesics are not sufficiently effective in controlling post-thoracotomy pain. Now, presently there has been an increased interest in the use of regional nerve block. Serratus Anterior Plane Block (USG SAPB) is an interfascial block providing paresthesia of T2 to T9 dermatomes of the anterolateral thorax* ***Materials and methods****: In this single hospital-based, patient and observer-blinded study, 60 patients scheduled for elective thoracotomy were randomized to receive "USG SAPB"(n=30) with 0.2% Ropivacaine after induction and 20 minutes before incision or Standard control group "(n=30) that received standard postoperative pain control with intravenous opioids, NSAIDs and acetaminophen (paracetamol).We compared the postoperative pain assessment, hemodynamic parameters and complications,if any, of both the groups at 2nd, 4th, 6th, 8th, 12th, 24th hours. The statistical analyses were done by using the PSW software version 21.0. Data were compared using the Chi-square test, Unpaired t-test and Mann-Whitney U test.* ***Results****: The Visual Analogue Scale score was significantly lower in the USG SAPB group than the Standard pain control group at rest and coughing (p<0.001) at 8, 12 and 24th postoperative hours and 6,8,12 and 24th hours, respectively. The need for rescue analgesia was significantly lower in USG SAPB (p=0.046). The hemodynamic parameters were comparable in both groups.* ***Conclusion****: The USG SAPB provided prolonged and adequate analgesia and can be used as an adjuvant treatment option for post-thoracotomy.*

Keywords*: Visual analogue score; serratus anterior plane block, complications, rescue analgesia.*

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INTRODUCTION

Thoracotomy is widely recognized as one of the most painful surgical procedures.[1] Post thoracotomy pain (PTP) is mediated through multiple nociceptive and neuropathic mechanisms, which originate from somatic and visceral afferents.[2] The primary source of pain are intercostal nerves, the vagus nerve and phrenic nerve in the pleura, the superficial

cervical plexus, the brachial plexus in the ipsilateral side.[3] The thoracotomy incision involves cutting through several muscle layers of the chest wall and resection of the ribs.[4] This form of intensified pain is a matter of great concern, and pain relief becomes essential not only for the patient's comfort but also to prevent pulmonary complications.[5] In addition to this, inadequate analgesia may result in delayed mobilization of the Patient with increased chances of deep vein thrombosis and pulmonary embolism.[6] Furthermore, if untreated, acute post-thoracotomy pain may lead to chronic post-thoracotomy pain, which has a severe negative impact on the quality of life.[7]

The most acceptable methods for treating post-thoracotomy pain are opioid and thoracic epidural anaesthesia (TEA), associated with severe side effects. Opiates can cause respiratory depression, frequently requiring reintubation and reventilation, while TEA is technically challenging to perform and has the risk for accidental intravascular injection and pneumothorax. Weaker analgesics, such as NSAIDs, are not effective in controlling severe pain and are also complicated by gastrointestinal bleeding. With the introduction of ultrasound guidance, it has facilitated various plane block to achieve adequate regional anaesthesia. In our present study, we used Ultrasound-guided Serratus Anterior Plane Block (SAPB). SAPB was 1st described by Blanco at al.[8] The study's objective was to compare the postoperative pain assessment, hemodynamic parameters and complications,if any, of both the groups at 2nd,4th,6th,8th,12th,24th hours.

MATERIAL AND METHODS

The Institutional Ethics Committee provided ethical approval of this study under the Department of Anaesthesiology and Critical Care, Gauhati Medical College and Hospital, Guwahati, with reference number MC/190/2007/Pt-11/MAR-2019/PG/29. This randomized, Patient and observer-blinded, single hospital study was conducted in the Cardio-Thoracic and Vascular Surgery operation theatre from 1st June 2019 to 31st January 2020 on the patients aged 18-65 years undergoing elective Thoracotomy with American Society of Anaesthesiologists (ASA) Physical Status class I and II under general anaesthesia. Exclusion criteria were allergy to the study drugs, contraindications to Serratus anterior plane block, systemic infections or patients having local sepsis at the site of injection, Cardiovascular diseases- hypertension (blood pressure more than 140/90), tachycardia, congestive heart failure, and coronary artery disease), chronic obstructive pulmonary disease, renal insufficiency, liver dysfunction, the disorder of homeostasis, patients having chronic pain, redo–Thoracotomy. Written and informed consent was obtained from all the patients.

Based on a previous study,[9] considering the mean (standard deviation) VAS of 2.6 (1.93), to detect a difference of 1.5 in VAS, 26 samples were required in each group with a power of 80% at the significance level of alpha value 0.05 and confidence interval of 95%. Considering an attrition rate of 15%, 30 patients in each group were required in this study. Thus, a sample size of 60 patients was obtained for the study.

After that, random allocation of patients via a computer-generated random selection was done into two equal groups-Group A (SAPB=30) who received Ultrasound-guided Serratus Plane Block with 0.2% Ropivacaine after induction and 20 mins before skin incision and Group B (Standard control=30) who received postoperative analgesic regime comprising of opioids, NSAIDs and acetaminophen.

General anaesthesia was administered comprising of Inj Fentanyl (1-2 mcg/kg), inj Propofol (2-3 mg/kg), inj Vecuronium bromide (0.08-0.1mg/kg) and maintenance with Sevoflurane at titrated dose. Unilateral postero-lateral thoracotomy was carried out at the space between the 4th–5th ribs.

A designated resident, who was not involved in the study, performed the SAPB. Decoding of data was done only after the analysis phase was over.

For SAPB, the Patient was turned laterally with the operative side upwards. Under all aseptic and antiseptic precautions, a -frequency linear probe was placed in a sagittal plane over the patient's midaxillary line at the level between the 4th and 5th rib. With the rib, pleura and the overlying serratus anterior and latissimus dorsi muscle visualized (**Figure 1**), a 22-gauge 50-mm insulated short bevel needle was advanced in-plane technique at 45 degrees. On reaching the appropriate plane, i.e. the plane between latissimus dorsi above and serratus anterior below, 1-2 ml of normal saline was injected after negative aspiration, and hydro-dissection of fascia was seen for confirmation (**Figure 2**). 20 ml of 0.2% Ropivacaine 3ml/kg was injected into the plane.

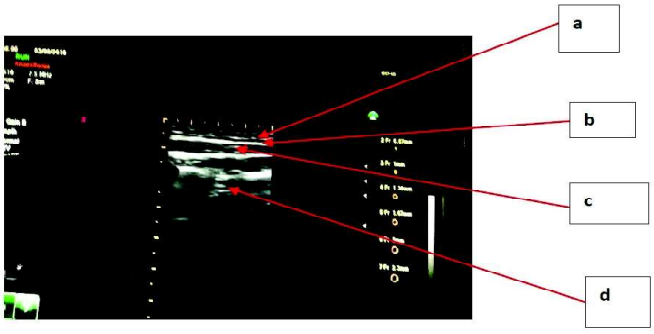


Figure 1 a) Latissimus dorsi muscle b) the plane for drug deposit c) Serratus anterior muscled) pleura

After the completion of the surgery, patients were assessed at an interval of 2, 4, 6, 8, 12 and 24 postoperative hours, respectively, using a Visual Analogue Scale (VAS:0cm = no pain and 10cm = worst pain imaginable,[10]) both at rest and during coughing by the attending nurse blinded to the allotment. Duration of analgesia, side effects and

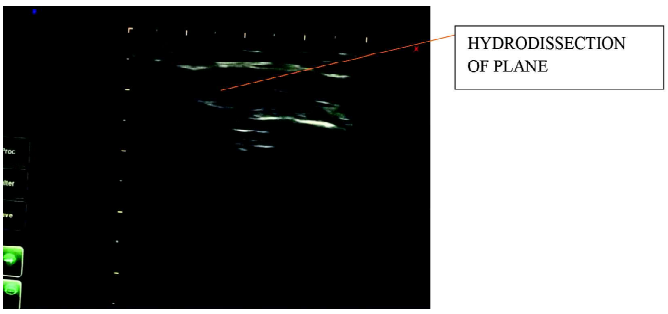


Figure 2 Ultrasonographic image of the drug spread

complications, if any, were also recorded. Intravenous (i.v) tramadol 50 mg stat was used as rescue analgesic, when VAS >4 or at 'Patient's request, up to a maximum of 3 doses in the first 24 hours postoperatively. Beyond that, intramuscular injection of diclofenac 75 mg was used. The time of administration of the rescue analgesics was noted. Hemodynamic parameters, including blood pressure, heart rate and respiratory rate,were monitored. Adverse events comprised hypotension, bradycardia, hypoxemia (SpO_2<90%) or nausea and vomiting.

The statistical analyses were done by using the PSW software version 21.0.

A Chi-square test was used to evaluate the difference between categorical variables. Data rechecked for normality using Kolmogorov-Smirnova test. Unpaired t-test and alternative non-parametric Mann-Whitney U test were used depending on the normality assumption's fulfilment. Probability if less than 0.05 was considered to be significant.

RESULTS

The flow of patients in the trial is shown in the Consort flow diagram (**Figure 3**).

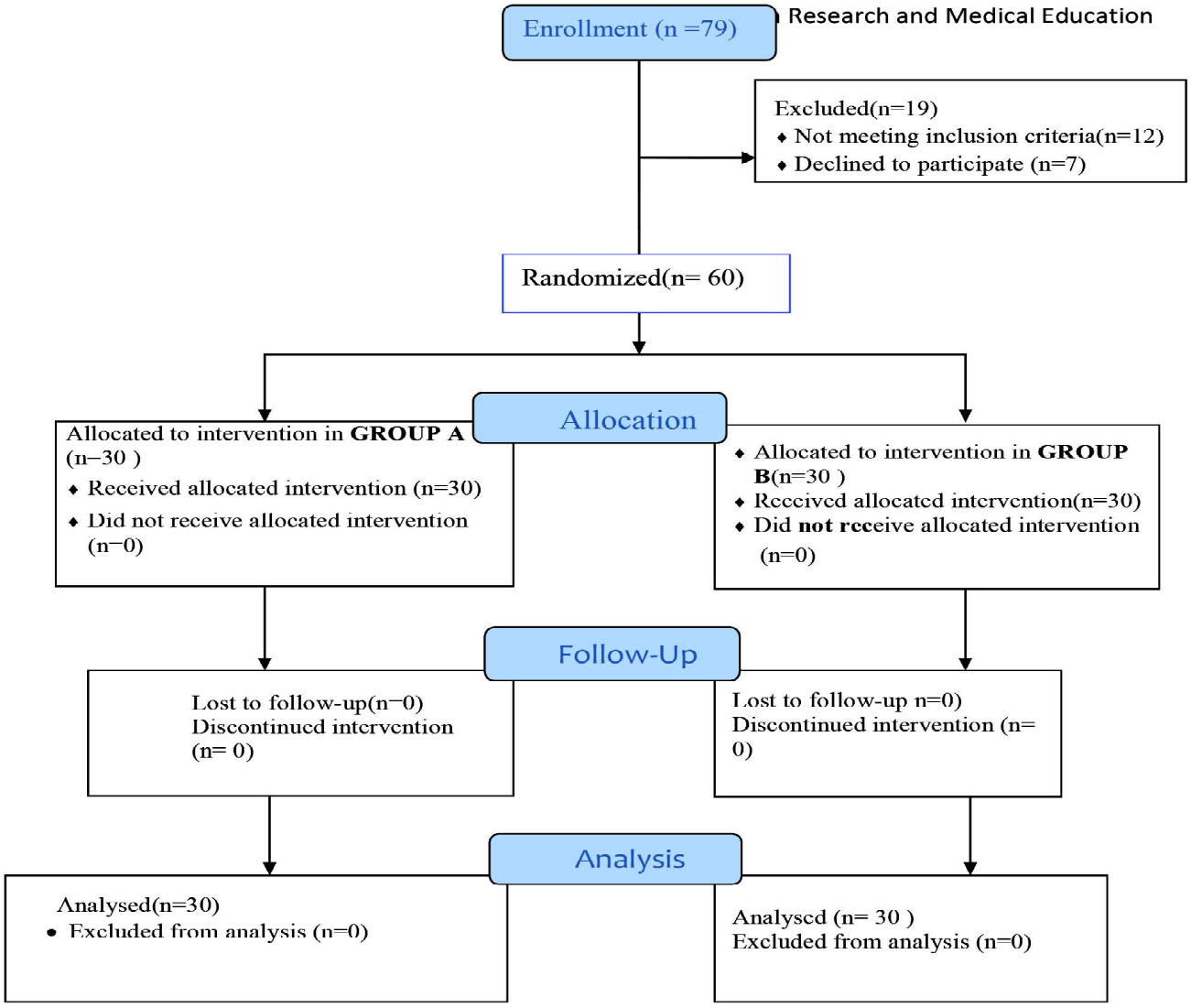


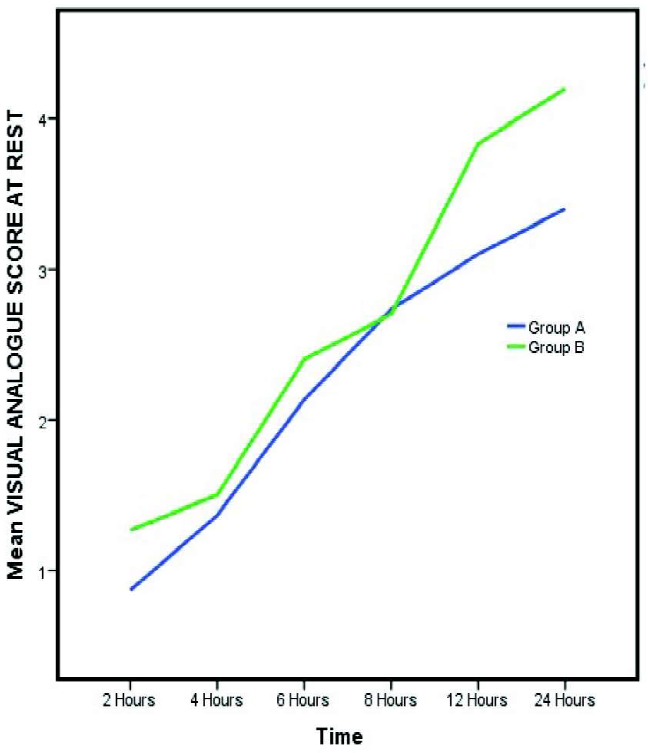
Figure 3 Consort flow diagram

The patient's demographics (**Table 1**) were similar, with no significant differences among both groups regarding age, weight, gender, height and operative time.

Table 1 Demographic and other data

Variables		N	Mean	Std. Deviation	Minimum	Maximum	P-value
AGE (years)	Group A	30	38.9	15.193	18	64	0.412
	Group B	30	4073	11.687	24	60	
Height (cm)	Group A	30	162.1	6.91	150	170	0.200
	Group B	30	159.6	7.76	145	170	
Weight (kg)	Group A	30	55.73	8.598	42	70	0.530
	Group B	30	54.32	8.918	40	70	
Duration of Surgery (min)	Group A	30	97.00	17.30	70	135	0.725
	Group B	30	98.67	19.21	60	130	

The VAS score was significantly lower in the USG SAPB group (Group A) than the Standard control group (Group B) both at rest and coughing ($p< 0.001$) at 8,12 and 24th postoperative hours and 6,8,12 and 24th hours respectively (**Figure 4a** and **4b**).



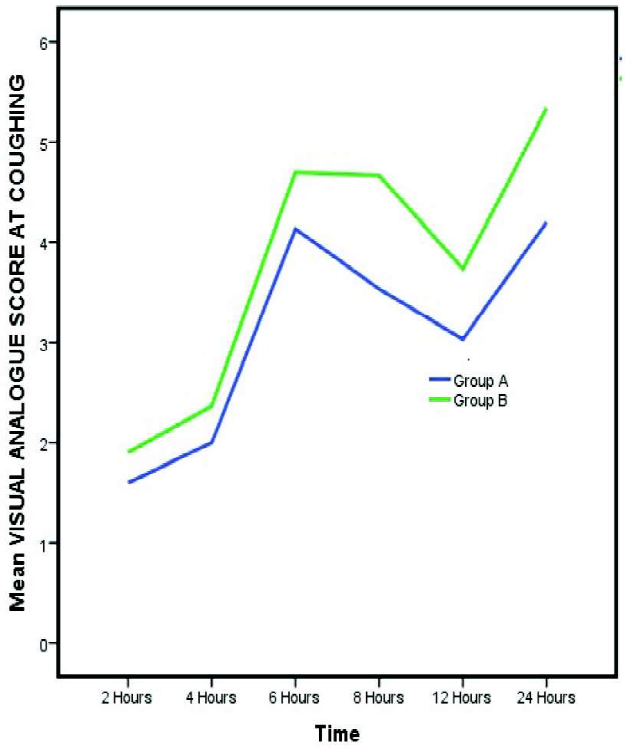


Figure 4a PostoperativeVAS score at rest **Figure 4b** Postoperative VAS score while coughing

The need for rescue analgesia was significantly lower in the USG SAPB ($p= 0.046$) group. However, the analgesia duration was longer in the SAPB group (847.5 ± 55.067 mins) than the standard control group (480.83 ± 50.26 min).

The haemodynamic parameters analysis showed no statistically significant difference in mean heart rate over time between the two groups. Similarly, the mean respiratory rate over different time points was also not found to be significantly different between the two groups (**Table 2**).

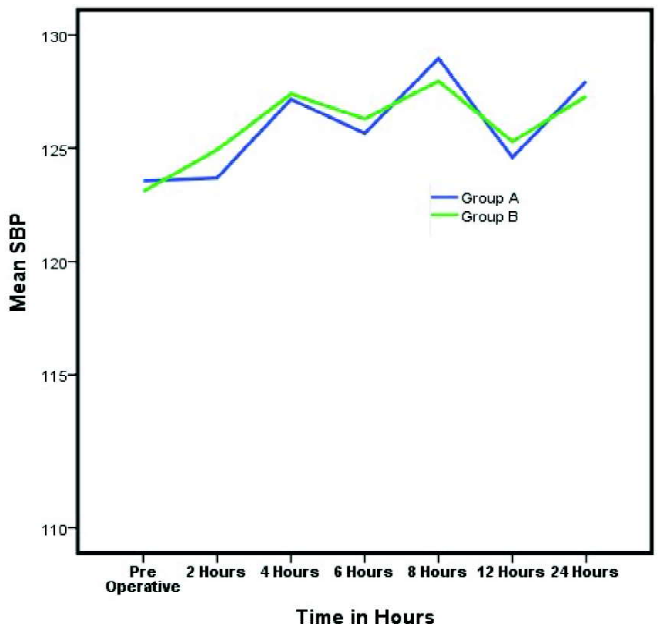
Table 2 Comparision of heart rate and respiratory rate at a different time of observation between the two groups

Time	Groups	N	Heart Rate			Respiratory Rate		
			Mean	SD	p-value	Mean	SD	p-value
Pre-op	Group A	30	77.8	7.42	0.726	14.4	1.61	0.752
	Group B	30	77.13	7.262		14.23	2.388	
2 Hours	Group A	30	77.7	7.183	0.698	13.13	0.9	0.858
	Group B	30	78.47	8.046		13.07	1.818	
4 Hours	Group A	30	77.9	8.117	0.741	13.6	0.932	0.735
	Group B	30	77.27	6.565		13.7	1.317	
6 Hours	Group A	30	77.73	8.538	0.465	13.73	0.98	0.074
	Group B	30	76.17	7.94		13.2	1.27	
8 Hours	Group A	30	77.2	5.839	0.607	14	1.313	0.057
	Group B	30	76.1	10.073		13	1.07	
12 Hours	Group A	30	77.77	9.328	0.724	14.67	1.626	0.872
	Group B	30	77	7.259		14.73	1.552	
24 Hours	Group A	30	76.87	6.837	0.424	14.33	1.295	0.249
	Group B	30	75.23	8.744		14.73	1.363	

The mean arterial pressure at different time points was compared using the Mann- Whitney U test. No significant differences were observed in mean arterial pressure between the two groups (**Table 3**).

Table 3 Comparison of mean arterial pressure between two groups

Parameter	Mean		S.D.		p-value (U)
	A	B	A	B	
Pre op	91.34	91.38	5.14	6.04	0.98
0 min	91.79	89.00	6.58	7.09	0.08
15 min	90.58	89.11	4.88	4.57	0.18
30 min	90.00	88.62	4.44	3.80	0.15
45 min	89.69	88.12	4.62	3.48	0.11
60 min	89.68	88.46	6.92	5.17	0.46
75 min	90.00	87.32	6.14	7.08	0.17
90 min	87.88	85.77	2.69	3.65	0.08
105 min	88.44	89.00	2.24	3.74	0.71
120 min	89.50	87.83	3.00	2.04	0.32
135 min	85.00	86.00	-	-	-



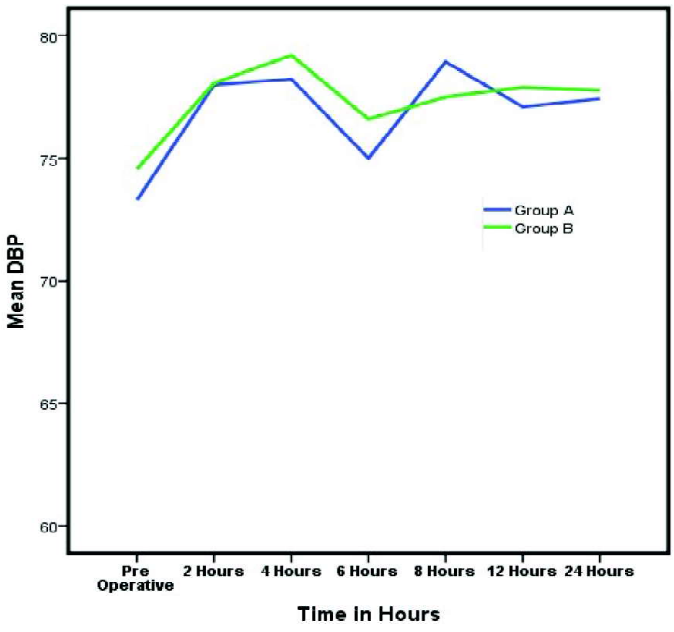


Figure 5a Variation in SBP in the postoperative period

Figure 5b Variation in DBP in the postoperative period

Both the procedures' side effects were found to be minimal and similar between both the groups with no significant differences (**Table 4**).

Table 4 Comparison of adverse effects in both the groups

SIDE EFFECTS	Total	Group A (n=30)	Group B (n=30)	Chi	p-value
Bradycardia	1(1.7%)	0(0%)	1(3.3%)		
Respiratory distress	1(1.7%)	1(3.3%)	0(0%)		
Hypotension	7(11.7%)	4(13.3%)	3(10%)	2.164	0.706
Nausea &vomiting	4(6.7%)	2(6.7%)	2(6.7%)		
None	47(78.3%)	23(76.7%)	24(80%)		

DISCUSSION

The study's main findings were 1) SAPB reported significantly lower levels of pain after thoracic surgery; 2) the amount of rescue analgesia was lower in the SAPB group; 3) the vomiting incidence was lower in SAPB; 4) SAPB was not associated with any complication.

Various modalities to control PTP have been tried with varied success, for example, 1) intrapleural analgesia, 2) cryo-analgesia, 3) thoracic epidural, 4) paravertebral block, 5) intravenous narcotics, NSAIDS.[11,12]

None could be considered ideal either due to systemic side effects or the lack of technical feasibility. Hence, to search for a near-ideal option of PTP relief in terms of simplicity, safety, efficacy and feasibility, regional techniques came into consideration.

One such regional anaesthesia technique is SAPB which provides paresthesia of T2 to T9 dermatomes of the anterolateral thorax.[13]

In our study, pain score was assessed by VAS at 2nd, 4th, 6th, 8th, 12th and 24th-hour postoperatively, both at rest (VASr) and coughing (VASc). VASr in the patients receiving SAPB (group A) were lower and significant (p-value <0.05) as compared to group B at the 8th, 12th and 24th postoperative hour.Till the 8th postoperative hour, there was no difference in the pain scores between the two groups. Analyzing the dynamic VAS scores, pain scores were also lower in the SAPB group (group A), and this difference was significant (p<0.001) at the 6th, 8th, 12th and 24th hour. Till the 6th postoperative hour, there was no difference in the pain scores between the two groups.

The iv opioids are one of the most commonly used multimodal analgesia technique. However, opioids in large doses have significant side effects like nausea, vomiting, respiratory depression, sedation.[14] The result of our study showed that the total amount of tramadol used was lower in the SAPB group. Most likely, the decrease in the incidence of vomiting in SAPB resulted from lower doses of iv opioids administered.

Thoracic epidural block (TEB) is considered to be the gold standard for PTP. However, this technique requires highly trained medical staff. Risks associated include accidental dural puncture, inadvertent high block, local anaesthetic toxicity and total spinal anaesthesia (unintentional spinal injection of an epidural dose of a local anaesthetic). Additional side effects such as hypotension, neuraxial hematoma, vomiting and urinary retention have also been reported.[15] Furthermore, an epidural puncture is contraindicated in patients who have a local infection, a history of previous spinal surgery, coagulation disorders, on concurrent anticoagulant or antiplatelet therapy.[16]

Paravertebral block (PVB) is a technique that involves the injection of local anaesthetic into the paravertebral space to block nerves after they exit the spinal cord. The major potential complications associated with PVB are total spinal block, pneumothorax and neuronal injury.[16]

Due to these technique's side effects and complications, alternative methods for palliation of thoracotomy pain are the subject of much current research.

In 2011, Blanco[13] described a conceptually new type of regional anaesthesia, the PECs and PECs II (modified pectoralis muscle blocks, for pain control after breast surgery.After that, many studies were carried out. Prominent among these studies were descriptions of SAP block for pain relief of the thorax's anteromedial region.[17]

In the present study, we used ultrasound-guided SAP block in the management of post-thoracic surgery acute pain. This block is easy to perform, has a high success rate, and carries minimal complications. In our study, we performed the block when the patients were already anaesthetized, and hence, they did not experience any discomfort or pain. Furthermore, SAP block usually requires only a single injection compared to most other regional blocks that often need multiple injections. Patients were benefited by experiencing significantly less pain during the early postoperative hours and by requiring lower opioid dosage during that period.

The reason for extensive analgesia of upto mean 847.5 mins, as seen with our study, can due to the spread of the drug along the fascial plane and into the paravertebral space, which is filled with adipose tissue and since local tissue perfusion is low in adipose tissue, it results in low absorption speed of local anaesthetic agent into the blood.[17]

The present study has several limitations: 1) the zone of anaesthesia induced by SAP block sometimes requires the concomitant use of another anaesthetic technique and 2) the superficial nature of SAP block does not provide a solution for the reduction of pain due to damage to the visceral pleura caused by intercostal drains.[16] SAP block may interfere with the serratus muscle's integrity, and the fascial plane may be disturbed at the surgical incision site and consequently alter the drug distribution.[18,19] It appears that SAP block has a lower risk of local anaesthetic toxicity because the total dose of local anaesthetic injected during ultrasound-guided SAP is smaller than that used in the other techniques, and also, the local anaesthetic agent is injected into an area that is relatively less vascularized.[16]

In the present study, the postoperative VAS scores during the first 8 hours at rest and 6 hours while coughing were similar in both study groups, signifying that the block's analgesic effect persisted for up to 8 hours patients regained consciousness post-surgery. We suggest future studies to investigate the feasibility of prolonging the sufficient postoperative analgesia period induced by SAP block for up to 24 hours.

CONCLUSION

SAP block is an effective adjuvant treatment option for PTP. Compared to the current methods used for post-thoracic surgery pain relief, SAP block has some significant advantages, mainly its ease of use and its low potential for side effects.

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Contribution of Authors: We declared that this work was done by the authors named in this article, and the authors will bear all liabilities about claims relating to the content of this article.

Ethical Corrections: All data of the cases were treated with confidentiality, following the declaration of Helsinki.

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