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ORIGINAL RESEARCH THORACIC ANESTHESIA

Serratus anterior plane block versus thoracic epidural block in patients undergoing thoracotomy: a randomized double-blind trial

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ABSTRACT

Background & Objective: Standard pain management technique after thoracic surgery is thoracic epidural analgesia, parentral analgesics and nerve blocks. Thoracic epidural analgesia (TEA) has many known complications, including respiratory depression and urinary retention. Serratus anterior plane block (SAPB) is a simple procedure, which provides postoperative pain relief by blocking the lateral cutaneous branches of T2–T9 spinal neurons. We compared the analgesic efficacy of both of these techniques in thoracotomy patients in this randomized trial.

Methodology: The study involved 74 cancer patients scheduled for thoracotomy. The patients were randomly divided into two groups. The patients in Group SAPB underwent ultrasound-guided serratus anterior plan block (SAPB) with catheter insertion. The second group (Group TEA) underwent TEA with preoperative indwelling catheter insertion. In both groups blocks were activated before induction of routine general anesthesia (GA) by a bupivacaine bolus dose, then continued as bupivacaine infusion in ICU for postoperative analgesia. Hemodynamic monitoring was started. Intraoperative fentanyl consumption, postoperative morphine consumption, and time to first request for analgesic were noted including MAP in the two groups.

Results: Both groups were statistically comparable regarding intraoperative fentanyl consumption, postoperative morphine consumption, and time to first request for analgesia in the two groups. Hypotensive episodes were significantly more frequent ($P < 0.001$) in the TEA group (n = 17; 45.9%) compared to the Group SAPB (n = 2; 5.4%). Ramsey sedation scores (RSS) were comparable in the two groups immediately postoperatively and after 2 h. After 4 h after recovery all patients in both groups had an RSS of 2.

Conclusion: Ultrasound-guided serratus anterior plane block is associated with reduced intraoperative and postoperative fentanyl consumption, but the Ramsey sedation scores were equivalent in the two groups after recovery and upto 4h.

Abbreviations: GA: General Anesthesia; PTPS: Post-Thoracotomy Pain Syndrome: RSS: Ramsey Sedation Score; SAPB: Serratus Anterior Plane Block; TEA: Thoracic Epidural Analgesia; VATS: Video-Assisted Thoracoscopic Surgery

Key words: Pain, Postoperative; Serrataus plane block; Thoracotomy; Ultrasound; Thoracic epidural

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1. INTRODUCTION

Lung cancer ranks second among the most common cancers in men, representing the leading cause of cancer-related mortality in more than 90 countries.[1] Thoracic surgery is the most effective treatment for early-stage lung cancer.[2] Thoracotomy is considered the most painful surgical procedure characterized by a severe stress response and respiratory complications.[3] Besides, up to 65% of patients may develop chronic post-thoracotomy pain syndrome (PTPS).[4]

Standard pain management techniques after thoracic surgery are epidural analgesia, systemic opioids, and nerve blocks.[5] Epidural analgesia is considered the gold standard technique for post-thoracotomy pain alleviation.[6] However, thoracic epidural analgesia (TEA) has many contraindications and a risk of several complications, including respiratory depression and urinary retention.[7] Besides, the reported failure rates range from 13% to 32%.[8] Therefore, TEA may not be the best choice for managing post-thoracotomy pain. Thus, in the past decades, the use of regional nerve blocks gained increasing interest for post-thoracotomy analgesia.[9,10] Its success rate has been greatly enhanced with the introduction of ultrasound guidance, which enabled the development of various plane blocks to produce adequate regional analgesia.[11] Serratus anterior plane block (SAPB) is a simple procedure that can provide postoperative dynamic pain relief by blocking the lateral cutaneous branches of T2–T9 spinal nerves by injecting the local anesthetic between the serratus anterior and intercostal muscles.[12] Few studies supported the analgesic efficacy of SAPB after thoracic surgery.[13–15]

The American Pain Society recommended using continuous rather than single-shot regional blocks for postoperative pain management to provide a more prolonged analgesia.[16] The continuous SAPB (cSAPB) with catheter insertion, connected to a patient-controlled device, has been considered recently with inconsistent results.[17]

This study aimed to evaluate the efficacy of cSAPB for perioperative analgesia in thoracic cancer surgeries compared to continuous thoracic epidural block in terms of perioperative opioid consumption and postoperative pain intensity.

2. METHODOLOGY

This randomized,double-blind,controlled trial was conducted at the National Cancer Institute (NCI), Cairo University, Cairo, from June 2020 to March 2022. The study involved 74 cancer patients scheduled for thoracotomy for lung cancer surgery. The ethical committee of the NCI approved the study. All patients provided informed consent after adequate information regarding the study requirements, purposes, and risks.

Inclusion criteria were all patients, ages 18−65 y, ASA physical status I and II, and body mass index (BMI) < 40 kg/m^2, in patients undergoing lobectomy, pneumonectomy, or decortication due to malignant growths. Patients with known sensitivity or contraindication to local anesthetics, a history of psychological disorders, localized infection at the block site, or coagulopathies (platelet count < 50,000 or an INR > 1.5) were excluded from the study. Also, patients who needed prolonged postoperative mechanical ventilation and cases of failed blocks were excluded.

All patients and anesthesiologists who collected the data and staff members other than the anesthesiologist who applied the block were blinded to the catheter insertion site. All patients had catheters covered by a sterile dressing extended to a similar area in both groups. The selected patients were randomized into two equal groups based on computer-generated numbers using an online randomization program (Research Randomizer).

All patients who met the inclusion criteria were subjected to a complete history taking, targeted physical examination, and routine laboratory investigations. Radiological investigations were done according to the medical condition of the patients.

Premedication was administered as lactated ringer solution 500 ml, midazolam 2 mg, Nexium 20 mg, and 10 mg metoclopramide. Using the numerical rating scale (NRS) for pain assessment was explained to all patients. Clinical monitoring included electrocardiography, pulse oximetry, noninvasive arterial blood pressure, and capnography. All the baseline parameters were recorded. Before induction of anesthesia, the patient allocation was determined for only the anesthesiologist inserting the catheter.

The Group SAPB (n = 37) underwent ultrasound-guided Serratus Anterior Plane Block (SAPB) with catheter insertion using a bupivacaine bolus dose before induction and then continuous infusion in the intensive care unit (ICU) for postoperative analgesia. The TEA Group (n = 37) underwent thoracic epidural with preoperative catheter insertion, activated before induction by a bupivacaine bolus dose, then continued as an infusion in the epidural catheter in ICU for postoperative analgesia.

2.1. Serratus anterior plane block

Patients were placed in the lateral position with the diseased side up. A linear ultrasound transducer (10−12 MHz, M-Turbo Ultrasound, USA) was placed over the midclavicular region of the thoracic cage in a sagittal plane. The fifth rib was identified in the mid-axillary line. The following muscles were identified overlying the fifth rib: latissimus dorsi (superficial and posterior), teres major (superior), and serratus muscle (deep and inferior). The thoracodorsal artery was used to identify the plane superficial to the serratus muscle. A 22G, 50-mm Tuohy needle was introduced in-plane concerning the ultrasound probe targeting the plane superficial to the serratus muscle. Under continuous ultrasound guidance, a local anesthetic solution was injected, then a catheter was threaded, and the spread of analgesic was checked by cold and pinprick test of the chest wall between T2 and T8−9 by an on-duty ICU resident blinded about the study. The patients received a bolus of 30 ml bupivacaine 0.25% followed by a continuous infusion of 0.125% bupivacaine at a rate of 7−12 ml/h according to the patients' response, in the ICU until the end of the first 24 h postoperatively.

2.2. Thoracic epidural block

The block was done to the patient while sitting, and a Tuohy needle was used to identify the epidural space by the loss of resistance, the injectate was injected after a negative aspiration and a test dose (3 ml of 1.5% lidocaine with 1: 200,000 epinephrine). Then, a continuous epidural block was done through the epidural catheter with 5 ml increments of 0.25% bupivacaine was titrated until the block of the required segments was achieved (10−15 ml). Sensory testing was done via pinprick and cold test to detect sympathetic block. An hourly injection of 5 ml 0.25% bupivacaine was done for maintenance.

GA was induced with propofol 2−3 mg/kg. Then, 200 µg IV fentanyl was titrated to maintain hemodynamics within 20% of the baseline, followed by 0.5−0.8 mg/kg rocuronium to facilitate endotracheal intubation. Anesthesia was maintained with 1−2% isoflurane and 50% air in oxygen mixture, and a top-up dose of rocuronium 0.1 mg/kg was administered every 45 min. All patients were intubated and mechanically ventilated using volume-controlled positive-pressure ventilation with 6−8 ml/kg tidal volume and 1:2 I/E ratio to maintain end-tidal carbon dioxide tension around 35 mmHg. At the end of the surgical procedure, the residual neuromuscular block was reversed using 2 mg/kg sugammadex, and extubation was performed after complete recovery of the airway reflexes. All patients were extubated and transferred to the post-anesthesia care unit (PACU).

All patients received 1 g of IV paracetamol intraoperatively. Inj fentanyl 0.05−0.1 µg/kg titrating doses of were given if the mean arterial blood pressure (MAP) or heart rate (HR) raised above 20% of the baseline levels. Ringer acetate solution was infused to replace fluid deficit, maintenance, and losses. Readings of MAP and HR were recorded before induction of anesthesia, immediately before surgical incision, and then at 30 min intervals intraoperatively.

In the PACU, pain scores, MAP, and HR were recorded immediately on arrival and after 2, 4, 6, 12, and 24 h . Patients rated their pain on an NRS 0−10 scale, with 0 representing no pain and 10 representing the worst imaginable pain. All patients were infused paracetamol every 8 h . Rescue analgesia was provided in the form of 3−5 mg IV doses of morphine to keep the NRS score < 3. The total morphine consumption was recorded. PONV was rated on a four-point verbal scale (none = no nausea, mild = nausea with no vomiting, moderate = one episode of vomiting, and severe = vomiting more than one episode). Ondansetron 0.1 mg/kg IV was given to patients with moderate to severe PONV. Sedation was assessed with Ramsay sedation score.

The primary outcome measure was the total intraoperative fentanyl and postoperative morphine consumption. The secondary outcomes were analgesia duration, postoperative pain during the first 24 h during rest and with movement, hemodynamic stability, and adverse effects.

2.3. Sample size calculation

Using power and sample size calculator for an intervention study, with 0.05 alpha error and power of the study 0.80 and −0.5 non-inferiority margin to calculate the minimal sample size needed forthe efficacy of perioperative US-guided SAPB versus Group TEA. According to the literature, the total 24 h morphine consumption was 10.3 ± 3.0 mg/24 h in SAPB and 9.6 ± 4.3 mg/24 h in TEA. The sample size calculated was 74 persons, with 37 in each group of the study.[16]

2.4. Statistical Analysis

Statistical analysis was done using IBM© SPSS© Statistics version 23 (IBM© Corp., Armonk, NY, USA). Numerical data are expressed as mean and standard deviation or median and range as appropriate. Qualitative data are expressed as frequency and percentage. Chi-square test (Fisher's exact test) was used to examine the relation between qualitative variables. The distribution of numerical data was tested using Kolmogorov-Smirnov test. For quantitative data, comparison between the two groups was made using independent sample t-test or Mann-Whitney test. Comparison of repeated measures was made using

Table 1: Baseline characteristics of the two studied groups

Parameter	Group SAPB (n = 37)	Group TEA (n = 37)	P-value
Age (y)	49.5 ± 10.4	46.2 ± 9	0.157
Side of thoracotomy (Right/Left)	21/16	17/20	0.485
Weight (kg)	77.5 ± 12.8	78.1 ± 9.6	0.846
Height (m)	1.7 ± 0.1	1.7 ± 0.1	0.442
Body mass index (kg/m^2)	27.6 ± 4.7	27.5 ± 3.5	0.861
ASA physical status (I/II)	33/4	34/3	1.000
Type of surgery			
Lobectomy	22 (59.5)	25 (67.6)	0.469
Pleuropneumonectomy	15 (40.5)	12 (32.4)	

Data presented as mean ± SD, or number (%); ASA = American Society of Anesthesiologists

ANOVA for repeated measures. A $P < 0.05$ was considered significant.

3. RESULTS

There were no significant differences in the baseline characteristics between the two study groups (Table 1).

The analgesic profile is shown in Table 2. The two groups were comparable regarding intraoperative fentanyl consumption, postoperative morphine consumption, and time of 1st request of analgesia.There was no significant difference in NRS between the two groups at rest and with movement at all measurement times (Table 3).

Heart rate and MAP changes during surgery and in the postoperative period are shown in Figures 1 and 2. There was some fluctuation of HR and MAP in the two groups. Hypotensive episodes were significantly more frequent ($P < 0.001$) in the Group TEA (n = 17, 45.9%) compared to the Group SAPB (n = 2; 5.4%). Ramsey sedation score was comparable in the two groups immediately postoperatively and after 2 h (Table 4). Starting from 4 h , all patients in both groups had an RSS of 2.

PONV was encountered in 18 (48.6%) patients of the Group SAPB and 16 (43.2%) of the Group TEA ($P = 0.553$). Three patients in the Group TEA experienced mild shoulder pain, and a few patients had urine retention. There were no incidents of respiratory depression (RR < 10) or pruritus (Table 5). Most patients in the two groups were satisfied with the analgesic technique ($P = 0.356$).

4. DISCUSSION

Thoracotomy infers a long anterior or posterolateral incision with muscle division and sometimes resection of ribs. Most surgeries involve the T3−T10 dermatomes; thus, T4–5 TEA is usually practiced.[18] TEA has numerous advantages; however, several complications have been reported in the perioperative period raising an increasing debate about its role. Serious complications are usually rare, but minor complications are relatively common, such as hypotension, catheter removal, disconnection or occlusion, and postoperative nausea and vomiting.[19] Besides, thoracic epidural catheter placement can be technically difficult and stressful for awake patients. Non-functioning block was reported to occur in up to 30% of cases following TEA placement.[20]

Table 2: Intraoperative and postoperative analgesic profile of the two studied groups

Variable	Group SAPB (n = 37)	Group TEA (n = 37)	P-value
Intraoperative fentanyl consumption (µg)	153 ± 53	140 ± 48	0.274
Total postoperative morphine consumption in (mg)	6 (0−9)	6 (0−9)	0.623
Patients requesting for postoperative morphine	28 (75.7)	30 (81.1)	0.572
Time to 1st analgesia request (h)	6 (0−24)	8 (0−24)	0.671

Data presented as mean ± SD, median (range), or number (%)

SAPB: serratus anterior plane block, TEA: thoracic epidural block.

Table 3: Numerical Rating Scale at rest and on movement in the two study groups

Measuring time		Group SAPB (n = 37)	Group TEA (n = 37)	P-value
NRS at Rest	Immediate	1 (0−6)	1 (0−5)	0.987
	After 2 h	2 (0−5)	2 (0−5)	0.938
	After 4 h	2 (0−5)	2 (0−5)	0.862
	After 8 h	2 (0−5)	1 (0−5)	0.337
	After 12 h	2 (0−6)	2 (0−4)	0.919
	After 16 h	2 (0−4)	2 (0−4)	0.464
	After 20 h	2 (0−4)	2 (0−4)	0.110
	After 24 h	2 (0−5)	2 (0−4)	0.269
NRS on movement	Immediate	2 (0−7)	2 (0−6)	0.489
	After 2 h	2 (0−6)	2 (0−6)	0.620
	After 4 h	2 (0−6)	2 (0−5)	0.818
	After 8 h	2 (0−6)	2 (0−6)	0.934
	After 12 h	2 (0−7)	2 (0−5)	0.859
	After 16 h	2 (0−6)	2 (0−5)	0.783
	After 20 h	2 (0−6)	2 (0−6)	0.878
	After 24 h	2 (0−6)	2 (0−6)	0.981

Data are expected as median (range)

Table 4: Ramsey sedation score in the two study groups

Time	Group SAPB (n = 37)	Group TEA (n = 37)	P−value
Immediate	3 (1−3)	2 (2−3)	0.281
After 2 h	2 (2−3)	2 (2−2)	0.317

Data are expected as median (range)

Table 5: Postoperative adverse effects and patient satisfaction in the two studied groups

Adverse effects	Group SAPB (n = 37)	Group TEA (n = 37)	P-value
No PONV	19 (51.4)	9 (24.4)	
Mild PONV	12 (32.4)	7 (19.0)	0.553
Moderate PONV	6 (16.2)	8 (21.6)	
Urine retention	1 (2.7)	4 (10.8)	0.358
Shoulder pain	0 (0)	3 (8.1)	0.240
Patient Satisfaction	29 (78.4)	32 (86.5)	0.356

Data are expected as number (%); PONV: Postoperative nausea and vomiting

Alternative approaches to TEA were paravertebral and intercostal blocks.[21,22] However, in recent years, ultrasound-guided fascial plane blocks have been introduced to replace TEA. One of these block techniques is the SAPB, which blocks T2–9 intercostal nerves and dorsal thoracic nerves offering analgesia to the anterolateral chest wall. Moreover, it was shown to be effective in blocking the long thoracic nerve, which regulates pain due to serratus muscle injury. The long thoracic nerve is also involved in afferent nociception through sensory innervation and connection.[23]

This study was designed to investigate cSAPB as an alternative to TEA in patients subjected to lung cancer surgery through open thoracotomy incisions. The study demonstrated a comparable perioperative analgesic profile for the two techniques regarding intraoperative fentanyl consumption, postoperative morphine consumption, duration of analgesia, and pain intensity. Hemodynamically, both methods were safe along the intraoperative and postoperative periods. SAPB has the advantage of a significantly lower frequency of hypotensive episodes. Adverse effects were limited to mild PONV, mild shoulder pain, and urine retention in a few cases, with no significant difference between the two groups.

The origin of acute pain after lung resection appears to be complex and multifactorial, caused by incision, pleural inflammation, damaged lung parenchyma, and placement of chest tube.[24] SAPB is believed to provide efficient thoracotomy pain relief as it blocks the lateral cutaneous branch of T2 to T9 intercostal nerves.[25] Intercostal nerves convey the nociceptive somatic component of thoracotomy pain to the limbic system and somatosensory cortex.[3]

Few previous studies have reported that SAPB has an adequate analgesic effect in patients having thoracic surgery. A retrospective analysis of patients undergoing thoracotomy tested the effect of adding SAPB to patient-controlled analgesia with morphine.

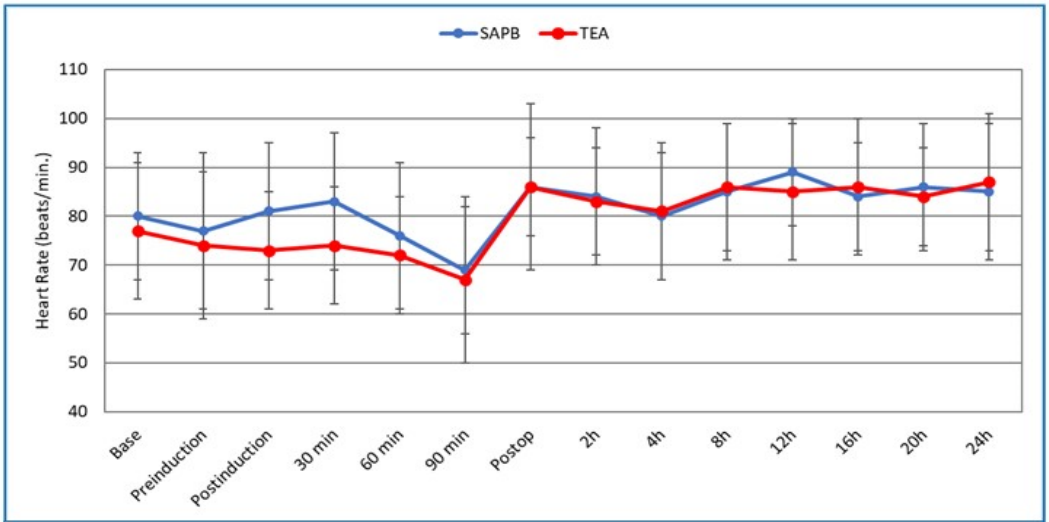

Figure 1: Intraoperative and postoperative changes in the heart rate in the two studied groups

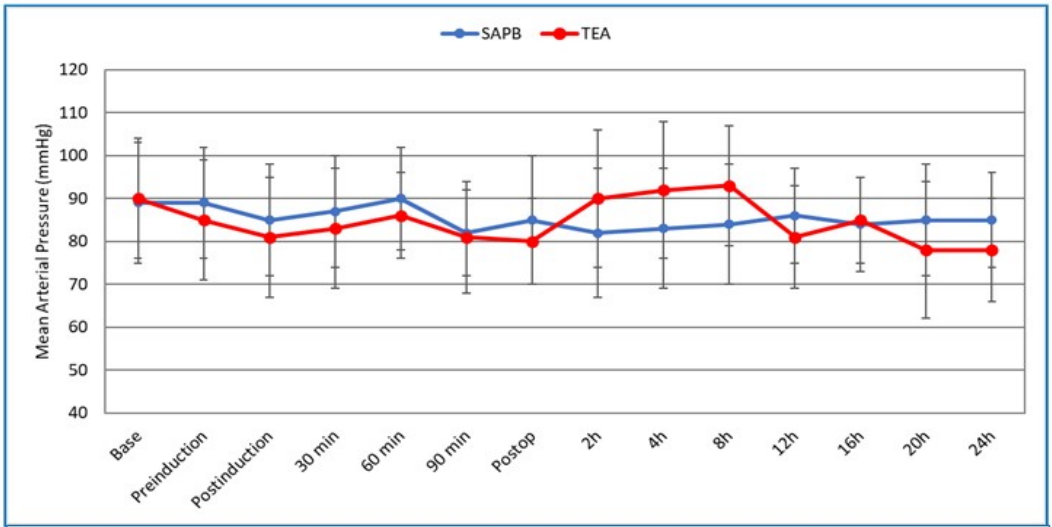

Figure 2: Comparative intraoperative and postoperative changes in the mean arterial pressure

SAPB was investigated in patients undergoing thoracoscopic surgery compared to no block. SAPB reduced intraoperative remifentanil and postoperative fentanyl consumption, and pain scores were reported in the first 24 postoperative hours.[27] Another prospective, randomized trial compared single-injection SAPB with standard pain control with intravenous opioids, NSAIDs, and acetaminophen in patients undergoing video-assisted thoracoscopic surgery (VATS). SAPB was associated with significantly lower pain intensity and less morphine and tramadol consumption.[28]

In a non-randomized prospective study, a multimodal approach of SAPB, morphine-patient controlled analgesia, and paracetamol was compared with intercostal nerve block (ICNB) in patients subjected to lobectomy using VATS. The two techniques had comparable safe and effective analgesic results in these patients.[29]

Hanely et al. compared cSAPB with continuous thoracic paravertebral block (cTPVB) in patients undergoing VATS in a randomized, non-inferiority study. Opioid consumption was non-inferior with cSAPB compared with cTPVB. SAPB was associated with lower postoperative pain scores at rest and with cough and on movement. Also, there was no difference in hemodynamics or opioid side effects.[30] Gao et al. reported adequate pain relief in lung cancer patients undergoing VATS with cSAPB in combination with flurbiprofen.[31] Compared to infiltration block, SAPB was more effective postoperative analgesic in patients undergoing VATS. However, opioid consumption and intraoperative hemodynamics were comparable between

the two groups.[32]

The previous studies included patients undergoing thoracoscopic surgery. On the other hand, the current study confirmed the effectiveness of cSAPB in patients subjected to open thoracic surgery in patients with lung cancer. In patients subjected to lung cancer surgical procedures via thoracotomy, SAPB was associated with a good analgesic effect compared to TEA for acute postoperative pain.[33] This study used a continuous infusion of 5 ml/h of 0.125% levobupivacaine. In the current study, the infusion rate was adjusted according to the patient response between 7 and 12 ml/h.

On the contrary, SAPB was less effective than TEA for patients with lung cancer undergoing posterolateral thoracotomy.[34] Another study compared cSAPB with cTEA in patients undergoing open lung resection. cSAPB was less effective than cTEA for postoperative analgesia with similar adverse events.[35] Adding dexmedetomidine to levobupivacaine during cSAPB enhanced its analgesic efficacy in patients undergoing thoracic surgery.[36] In children undergoing thoracotomies, SAPB was associated with reduced intraoperative and postoperative fentanyl consumption and pain scores with a prolongation of analgesic duration.[37]

5. CONCLUSION

Ultrasound-guided serratus anterior plane block is associated with reduced intraoperative and postoperative fentanyl consumption when compared to thoracic epidural analgesia for thoracotomies, but the Ramsey sedation scores were equivalent in the two groups after recovery and upto four hours.

6. Data availability

Numerical data generated in this study are available with the corresponding author.

7. Conflict of interest

The authors declare no conflicts of interest, and no external or industry funding was involved in this study.

8. Authors' contribution

RMG: Collection of data.

SSB: Statistical analysis of data.

ARA: Supervise, and revision of data

SFS: Registration of clinical trial

NES: Consents and ethical committee approval

HIA: Review and results.

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