E-ISSN: 2664-8857
P-ISSN: 2664-8849
www.anesthesiologyjournal.in
IJAR 2025; 7(1): 42-47
Received: 08-02-2025
Accepted: 09-03-2025

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Comparative study between ultrasound guided serratus anterior plane block, thoracic erector spinae plane block and thoracic paravertebral block for postoperative analgesia in thoracotomy

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DOI: https://www.doi.org/10.33545/26648849.2025.v7.i1a.55

Abstract
Background: Ultrasonography is frequently used in conjunction with a variety of blocks to reduce opioid use and postoperative pain after thoracotomy. The study compared SAPB, ESPB, and TPVB for postoperative pain relief in thoracotomy patients. It assessed the effectiveness of each technique in managing pain after surgery.
Methods: This double-blind, randomized study included 90 patients, aged 21 to 65, undergoing thoracotomy. All participants were classified as ASA I or II. The study aimed to assess their clinical outcomes. Three equal groups of participants were chosen at random: Group 1: patients underwent US guided TPVB, Group 2: patients underwent US guided ESPB and Group 3: patients underwent SAPB.
Results: No significant differences in VAS (Visual Analog Scale) scores were observed within the first six hours of observation. However, at the 12-hour and 24-hour marks, both Groups I and II exhibited lower VAS scores compared to Group III. By the 24-hour point, Group III demonstrated a significant reduction in both Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1) when compared to Groups I and II, indicating notable differences in respiratory function between the groups.
Conclusions: ESPB is ideal and can be utilized as a secure and efficient substitute to TPVB due to it is easy to perform and has less block associated complication.

Keywords: Serratus anterior plane block, thoracic erector spinae plane block, thoracic paravertebral block, ultrasound, thoracotomy

Introduction
Thoracotomy, a surgical operation that induces significant pain, leads to considerable harm to various pain-sensitive tissues, including the skin, muscle layers, fascia, neurovascular bundles, bone, joints, and parietal pleura [1].
Post-thoracotomy pain management is essential for both patient comfort and successful recovery. Inadequate relief of acute pain can negatively affect respiratory function and increase the likelihood of chronic pain following the surgery [2].
Following a thoracotomy, pain management options include regional blocks, NSAIDs, and systemic opioids. Opioids can cause respiratory depression, and NSAIDs can increase the risk of kidney problems and bleeding. Although regional methods like nerve blocks, TPVB, and thoracic epidural are useful for reducing pain, they carry risks like nerve damage and hypotension [3].
The last two decades have seen immense popularity and interest in using ultrasound (US) in the practice of regional anesthesia (RA) for performing regional nerve blocks, fascial plane blocks, and even for central neuraxial blocks. Use of US in RA not only increased the success rate, it also reduced the complications and also facilitated several new blocks especially the fascial plane blocks in recent years [4].
In a thoracic paravertebral block (TPVB), regional anesthesia is achieved by injecting a local anesthetic near the spine in the thoracic region. This approach blocks pain signals from the sympathetic trunk and thoracic spinal nerves, offering targeted pain relief. It is commonly used for different surgeries and chronic pain management, and is comparable in action to a

thoracic epidural block [5].

The Erector Spinae Plane Block (ESPB) provides analgesia for both the anterolateral and posterior chest walls through the inhibition of the dorsal and ventral rami. It is gaining popularity for thoracotomy pain relief because of its straightforward technique and safety. In a similar fashion, the Serratus Anterior Plane Block (SAPB) is an effective and safe method of pain management, using local anesthetics to target the lateral chest wall through diffusion between fascial planes [6-9].

This study compared the analgesic efficacy of ultrasound-guided TPVB, SAPB, and ESPB in patients having thoracotomies.

Patients and Methods

The study involved ninety patients, aged 21 to 65 years and classified as ASA I and II, who were scheduled for thoracotomy at Tanta University Hospitals in Egypt. Conducted from September 2023 to September 2024, the prospective, randomized, double-blind trial ensured that all participants provided informed consent. Ethical approval was obtained to uphold the required medical and research standards.

Exclusion criteria were known hypersensitivity to LA, ocal infection where the block is located, coagulation abnormalities, unclear anatomy such as morbid obese patient, severe chest wall deformity and scoliosis, psychiatric illness, communication difficulties, history of chronic pain, regular medication with analgesics and history of drug abuse.

Randomization and blindness

Using sealed opaque envelopes and computer-generated random numbers, three equal patient groups were assigned at random: Group 1: patients underwent US guided TPVB, Group 2: patients underwent US guided ESPB and Group 3: patients underwent SAPB.Upon opening the envelopes, a blind chief nurse who was not involved in patient care or data collection and determined group assignment during the morning of operation.

Each patient underwent a thorough medical history review, physical examination, and a range of laboratory tests before the procedure. The tests included a complete blood count (CBC), bleeding and clotting time assessments, liver and kidney function tests, as well as pulmonary function tests like forced vital capacity (FVC) and forced expiratory volume in one second (FEV1).

Regular monitoring, including blood pressure, pulse oximetry, and ECG, was instituted in the operating room. An IV line was set up, and baseline vital signs were recorded.

Fentanyl, propofol, and atracurium were used to induce general anesthesia after three minutes of preoxygenation with 100% oxygen. 50% oxygen and isoflurane were used to maintain the anesthesia. Urine output, temperature, CO2, pulse oximetry, blood pressure, and ECG were all used for monitoring. To keep CO2 levels between 30 and 35 mmHg, the respiratory rate was controlled and the tidal volume was set at 6 to 8 ml/kg. After positioning, right atrial access was carried out.

Thoracic paravertebral block

For the US-guided PVB procedure, the patient was positioned laterally, with the affected side facing up. The T5 vertebra was identified by counting downward from C7, utilizing key anatomical landmarks like C7, the scapular spine (T3), and the inferior angle of the scapula (T7). A high-frequency ultrasound probe in both transverse and longitudinal views was used to visualize the T5 transverse process and nearby structures. The needle was positioned toward the paravertebral space, 2-3 cm laterally to T5. Following a saline injection to confirm proper placement, the needle punctured the costotransverse ligament. After that, aliquots of 20 mL of bupivacaine (0.25%) with dexmedetomidine (1 μg/kg) were administered, and the spread was tracked as the pleura moved downward.

Thoracic erector spinae plane block

The patient was positioned laterally with the affected side facing upward for better access to the target region during the US-guided ESPB procedure. The rhomboid major, erector spinae, and trapezius muscles were visualized by positioning the ultrasound probe 3 cm laterally to the fifth thoracic spinous process. With careful in-plane advancement, the needle's tip was positioned just above the fifth thoracic transverse process and deep to the erector spinae muscles. Following a 2 mL saline injection to confirm the needle placement, 20 mL of a 0.25% bupivacaine and 1 μg/kg dexmedetomidine mixture was injected to provide sedation and local anesthetic for the block.

Serratus anterior plane block

The patient was positioned laterally, with the arm abducted and the surgical side up, for the procedure. The serratus anterior was targeted by inserting a needle at the fifth rib along the midaxillary line. After confirming the placement with saline, 20 mL of dexmedetomidine (1 μg/kg) and bupivacaine (0.25%) were injected. Fentanyl (0.5 μg/kg IV) was used to control heart rate and blood pressure, while atracurium (0.1 mg/kg IV) was used to relax muscles. Analgesics like diclofenac and paracetamol were given, as well as prophylactic drugs for PONV, such as ondansetron and dexamethasone. Neostigmine and atropine were used to reverse muscle relaxation, and extubation was the next step. IV paracetamol, ketorolac, and pethidine were used to treat postoperative pain, and patients with VAS scores higher than three were subjected to a 2-hour lockout.

Measurements

Demographic and surgical details, along with heart rate and mean arterial pressure, were recorded at several time points: baseline, skin incision, 1-hour post-induction, end of surgery, and at 30 minutes, 2, 4, 6, 12, and 24 hours following anesthesia. Intraoperative fentanyl dose, pain intensity (VAS at rest and coughing), and time to first analgesic request was noted. Pulmonary function (FVC, FEV1) was assessed preoperatively, at 2 hours, and 24 hours' post-surgery. Complications such as PONV, respiratory depression, local anesthetic toxicity, hematoma, and hemodynamic instability were tracked for up to 24 hours after the surgery.

Sample Size Calculation

Sample size calculation was done using Epi-Info 2002 software by WHO and CDC. Based on previous studies, 25 patients per group were needed to detect a 1.36 difference in pain scores with 95% power and confidence. To account for

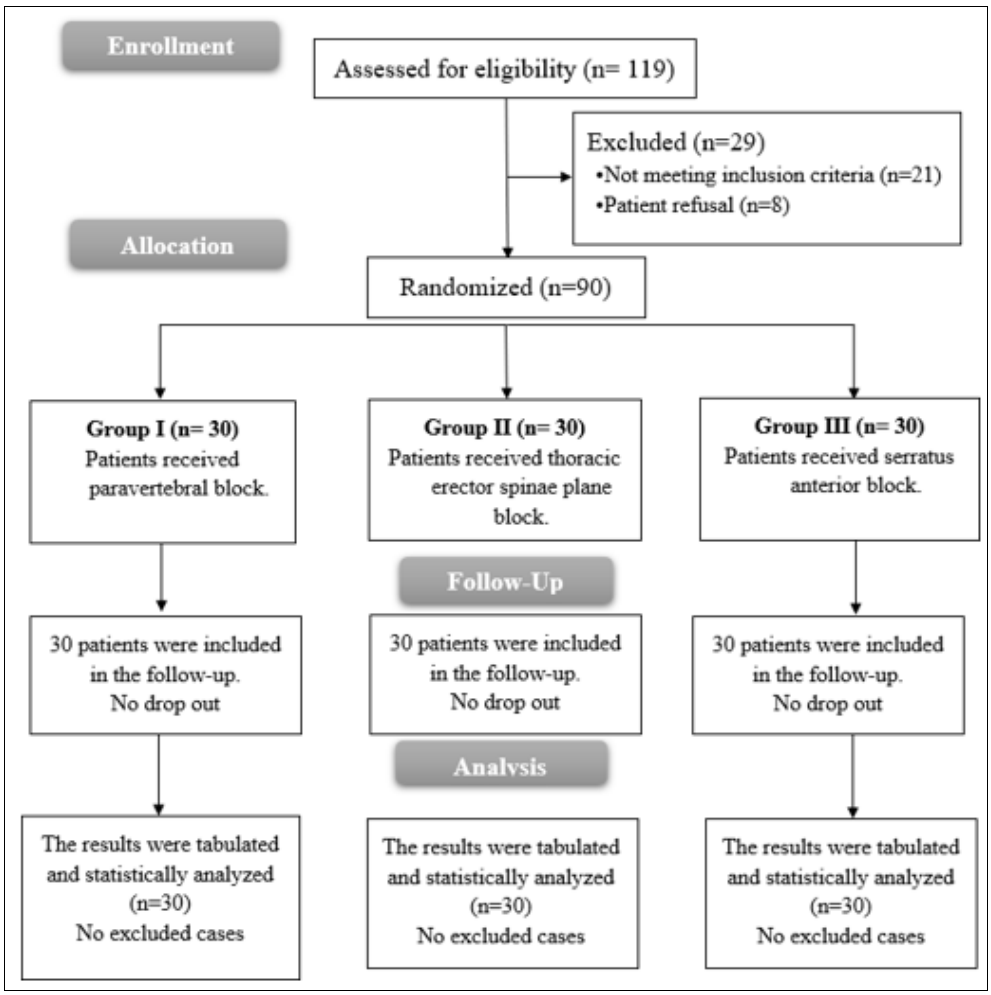
potential dropouts, 30 patients per group were included.

Statistical analysis

SPSS v27 was used to statistically analyze the data, and the Shapiro-Wilks test and histograms were used to assess normality. ANOVA with Tukey's post hoc test (mean ± SD) was used to analyze parametric data, and the Kruskal-Wallis and Mann-Whitney tests were used to analyze non-parametric data (median and IQR). For qualitative variables (frequency and percentage), the Chi-square test was employed. P-values below 0.05 were regarded as statistically significant.

Results

Out of the 119 patients whose eligibility was evaluated, 21 did not fit the requirements, and 8 declined to take part. Three groups of thirty people each were randomly selected from the remaining patients. In the study, all were observed and examined. Figure 1.



There were no significant differences in demographic data, surgery duration, surgery type, or intraoperative fentanyl usage across the three groups. Table 1.

Table 1: Patient Characteristics, Surgical Details, and Fentanyl Use Across Groups

		Group I (n=30)	Group II (n=30)	Group III (n=30)	P
Age (years)		37.6±7.79	38.6±7.7	38±5.51	0.876
Sex	Male	21(70.0%)	22(73.33%)	19(63.33%)	0.696
	Female	9(30.0%)	8(26.67%)	11(36.67%)	
Weight (KG)		81.6±9.92	81.3±11.92	80±11.41	0.839
Duration of surgery (min)		157.2±18.55	148.8±16.33	153.3±18.77	0.203
Type of surgery	Lobectomy	11(36.67%)	10(33.33%)	12(40%)	0.959
	Bullectomy	9(30.0%)	8(26.67%)	6(20%)	
	Pneumonectomy my	3(10.0%)	2(6.67%)	4(13.33%)	
	Decortication	5(16.67%)	8(26.67%)	7(23.33%)	
	Lung biopsy	2(6.67%)	2(6.67%)	1(3.33%)	
Intraoperative fentanyl consumption		97.33±20.83	102±26.18	98±23.25	0.709

Data is presented as mean ± SD or frequency.

Mean arterial blood pressure (MAP) and heart rate did not significantly differ among the three groups prior to anesthesia, during the procedure, or within six hours following it. However, groups I and II had significantly

lower heart rates and MAPs than group III at 12 and 24 hours following the procedure. Furthermore, there were never any differences between groups I and II. Figure 2.

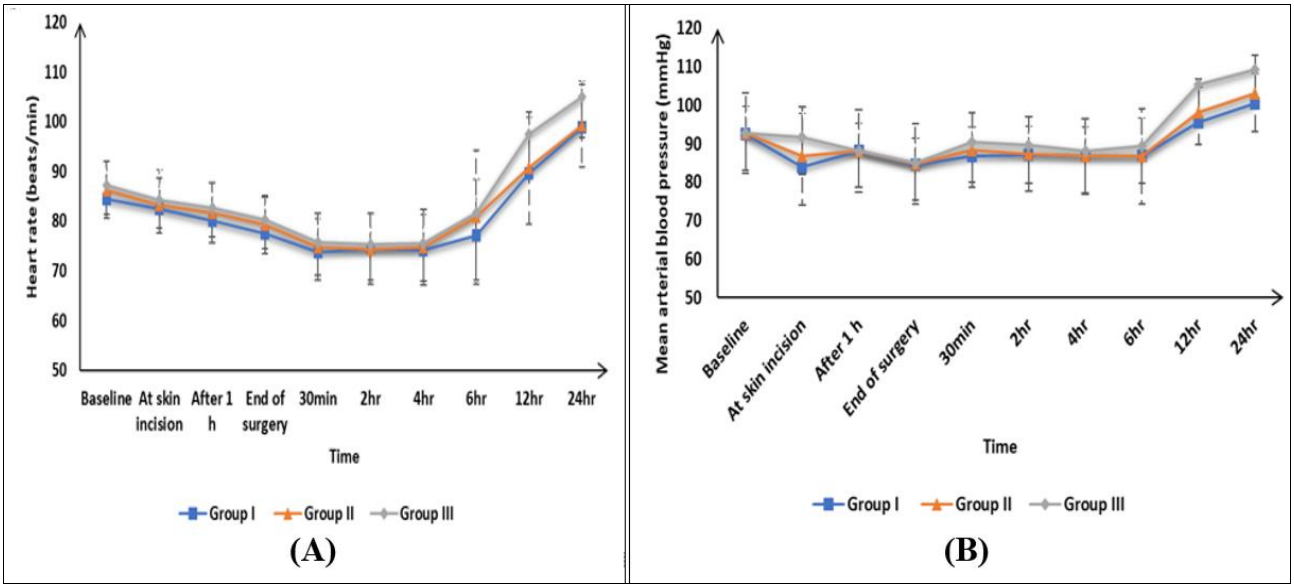


Fig 2: (A) Comparison of Heart Rate and (B) Mean Arterial Pressure Between Groups

In the first 6 hours, there were no significant differences in VAS scores for rest and cough between the groups. Yet, at 12 and 24 hours postoperatively, groups I and II showed significantly lower VAS scores than group III. Group I and group II had comparable VAS scores at all assessment times, with no significant differences between them. Table 2.

Table 2: VAS Scores for the Three Studied Groups

	Group I (n=30)	Group II (n=30)	Group III (n=30)	P
VAS at rest				
30 min	2.5(1-3)	3(1-3)	3(1-3)	0.883
2hr	3(1-3)	3(1-3)	3(1-3)	0.845
4hr	2(1-3)	2.5(1-3)	3(1- 4)	0.149
6hr	2.5(1-3)	2(1-6)	3(2 - 7)	**0.012***
P1=0.876, P2=0.008*, P3=0.013*				
12hr	4(1-7)	4(1 - 7)	5(3 - 8)	**0.007***
P1=0.616, P2=0.003*, P3=0.014*				
24hr	4(1-8)	4(1 - 6)	5(3 - 8)	**0.005***
P1=0.416, P2=0.002*, P3=0.020*				
VAS during cough				
30 min	3(2 - 4)	3(2 - 3)	3(1 - 5)	0.423
2hr	3(1 - 5)	3.5(1 - 5)	4(1 - 7)	0.062
4hr	3(1 - 6)	4(1 - 4)	4.5(2 - 8)	0.055
6hr	3(2 - 6)	4(1 - 7)	4(2 - 7)	0.146
12hr	4(2 -7)	5(3 - 8)	6(2 - 8)	**0.010***
P1=0.680, P2=0.016*, P3=0.005*				
24hr	6(4 - 8)	6(5 - 9)	7(3 - 9)	**<0.001***
P1=0.158, P2<0.001*, P3=0.023*				

Data is presented as median (IQR). * Significant P value < 0.05. VAS: Visual analogue scale.

Table 3 shows that Groups I (16.60±6.44 hours) and II (14.40±6.22 hours) had significantly longer times before requesting rescue analgesia than Group III (9.47±4.20 hours) (P<0.001). Group III required a significantly higher total pethidine dose (184.3±32.24 mg) compared to Groups I (83.66±27.73 mg) and II (92.66±27.03 mg) (P<0.001). Overall, Groups I and II experienced longer pain relief and used less pethidine than Group III. Table 3.

Table 3: Time to First Request for Rescue Analgesia and Total Pethidine Dose Across Groups

	Group I (n=30)	Group II (n=30)	Group III (n=30)	P
Time of first request of rescue analgesia	16.60±6.44	14.40±6.22	9.47±4.20	<0.001*
P1=0.280, P2<0.001*, P3<0.006*				
Total dose of pethidine	83.66±27.73	92.66±27.03	184.3±32.24	<0.001*
P1=0.560, P2<0.001*, P3<0.001*				

Data is presented as mean ± SD. * Significant P value < 0.05.

In all three groups, there were no appreciable variations in FVC or FEV1 before or two hours following surgery. Furthermore, groups I and II did not significantly differ from one another during the evaluation periods. At 24 hours, however, group III's values were significantly lower than those of groups I and II (P<0.05) Table 4.

Table 4: FVC and FEV1of the studied groups

	Group I (n=30)	Group II (n=30)	Group III (n=30)	P
FVC				
Preoperative	69.8±6.6	69.4±7.16	69.1±6.83	0.925
After 2h	59.27±8.28	56.67±9.16	56.77±8.36	0.419
After 24h	55.9±9.17	55.63±8.89	49.37±7.6	0.005*
P1=0.992, P2=0.011*, P3=0.016*				
FEV1				
Preoperative	73.9±7.45	73.5±8.72	74.37±7.14	0.911
After 2h	60.27±8.28	56.67±9.16	57.77±8.36	0.258
After 24h	56.2±9.16	55.63±8.89	48.27±7.75	<0.001*
P1=0.965, P2=0.002*, P3=0.004*				

Data is presented as mean ± SD or frequency. * Significant P value < 0.05. FVC: Forced vital capacity, FEV1: Forced expiratory volume exhaled in the first second.

Table 5 shows no significant difference in the incidence of PONV (P=0.533) and respiratory depression (P=0.770) across the groups. However, Group I had a significantly higher occurrence of hypotension (16.67%) and bradycardia (16.67%) compared to Group II (3.33%) and Group III (0%) (P=0.024). No cases of LA toxicity or hematoma were reported in any group.

Table 5: Complications of the studied groups

	Group I (n=30)	Group II (n=30)	Group III (n=30)	P
PONV	4(13.33%)	3(10.0%)	6 (20%)	0.533
Hypotension	5(16.67%)	1(3.33%)	0 (0%)	0.024*
Bradycardia	5(16.67%)	1(3.33%)	0 (0%)	0.024*
LA toxicity	0(0.0%)	0(0.0%)	0(0.0%)	---
Hematoma	0(0.0%)	0(0.0%)	0(0.0%)	---
Respiratory depression	1(3.33%)	1(3.33%)	2(6.67%)	0.770

Data is presented as frequency (%). * Significant P value < 0.05. PONV: Postoperative nausea and vomiting, LA: Local anesthetic.

Discussion

A thoracotomy is a particularly painful surgery [10]. Because ultrasonography is so widely used, many blocks are performed to relieve pain after surgery and lessen the need for opioids [11].

The three groups' mean arterial blood pressure and heart rate did not differ significantly in the first six hours after anesthesia. But at 12 and 24 hours, Groups I and II showed no difference from Group III, and Groups I and II had much lower values. The results of Said *et al*. [12], who found that the SAPB group had a higher mean arterial blood pressure and postoperative heart rate than the ESPB group after eight hours, are corroborated by these findings. Meanwhile, during the intraoperative and postoperative periods, Saad *et al*. [13] observed notable changes in heart rate and blood pressure, with the PVB group showing lower readings than the SAPB group.

The three groups in this study did not significantly differ in their total intraoperative fentanyl consumption. This is consistent with Soltan *et al*. [14], who discovered no appreciable variations in the amount of fentanyl used by the two groups. Our findings, however, are not in line with those of Hassan *et al*. [15], who noted that the ESPB group required less fentanyl during surgery than the SAPB group.

The three groups' postoperative pain and cough VAS scores at rest during the first six hours after surgery were similar. There was no difference between Groups I and II, but at 12 and 24 hours, Groups I and II reported significantly lower VAS scores than Group III. These results are consistent with those of Duran *et al*. [16], who found no discernible difference in pain scores between coughing and rest, and that both blocks provided efficient analgesia. But according to Soltan *et al*. [14], the ESPB group's VAS scores were noticeably lower than those of the SAPB group, which may suggest that the ESPB is more effective than the SAPB.

The time to first rescue analgesia did not differ significantly between Group I and Group II; however, both groups needed rescue analgesia much later than Group III. Additionally, there was no difference in the total amount of pethidine consumed by Groups I and II compared to Group III during the first 24 hours. Aly *et al*. [17], who discovered that the PVB group consumed less morphine, concur with these findings. But according to Wu *et al*. [18], the SAPB group took longer to receive their first dose of sufentanil than the ESPB group did. This suggests that variations in local anesthetics and surgical techniques could account for these differences.

FEV1 and FVC did not differ significantly either before or two hours after surgery. At 24 hours, however, there was no difference between Groups I and II, and Group III's values were much lower than those of Groups I and II. This is in line with the Hassan *et al*. study, which showed that the ESPB and SAPB groups had better FVC and FEV1 than the control group [15].

No significant differences in complications, PONV, or respiratory issues were observed across the three groups in this study. However, group I had a significantly higher occurrence of hypotension and bradycardia than groups II and III. This is in line with the findings of Fang *et al*., [19] who reported comparable analgesia with ESPB and a reduced incidence of hypotension and bradycardia.

This study was limited by factors such as a small sample size, a single-center design, and a pain assessment that was confined to the first 24 hours after surgery. Although surgery type differences were observed, these did not reach statistical significance. The use of single-shot blocks rather than catheters may have constrained the duration of analgesia, and the extent of the block and failure rates were not evaluated.

Conclusion

TPVB, ESPB, and SAPB are all successful in reducing opioid consumption, relieving postoperative pain, and improving pulmonary function in thoracotomy patients. Although TPVB and ESPB are more effective, SAPB is simple and safe. ESPB stands out as the most promising alternative to TPVB, offering greater ease of use and fewer complications.

Financial support and sponsorship: No funding received

Conflict of Interest: No conflicts to disclose

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How to Cite This Article
Hegazy SH, Mohammed Amr M, Ebrahim AG, Shalaby OM, Abo Elnasr LM. Comparative study between ultrasound guided serratus anterior plane block, thoracic erector spinae plane block and thoracic paravertebral block for postoperative analgesia in thoracotomy. International Journal of Advanced Research in Medicine. 2025;7(1):42-47.