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Efficacy of ultrasound-guided erector spinae plane block versus retrolaminar block for postoperative analgesia in patients undergoing thoracotomy

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Abstract
Background: Thoracotomy is one of the most painful surgical procedures. The aim of this study is to evaluate the analgesic efficacy of ultrasound-guided erector spinae plane block (ESPB) versus retrolaminar block (RLB) in patients undergoing thoracotomy.
Methods: This prospective randomized controlled double-blind study was carried out on 60 adult patients aged 21-65 years old of both sexes, who were scheduled for elective thoracotomy their American Society of Anesthesiologists (ASA) physical status classification was II-III in Tanta University Hospitals, Anesthesia Department, from June 2021 to June 2022. Patients were randomly allocated into three equal groups (20 patients each) through sealed opaque envelopes. Control group: patients received general anesthesia alone, ESPB group: patients received general anesthesia combined with ultrasound guided ipsilateral ESPB [20 ml (19ml bupivacaine 0.25% plus 1ml dexamethasone 4mg)], RLB group: Patients received general anesthesia combined with ultrasound guided ipsilateral RLB [20 ml (19ml bupivacaine 0.25% plus 1ml dexamethasone 4mg)].
Results: There was a significant decrease in NRS in both ESPB and RLB groups as compared to the control group at different times of measurements with no statistical significant difference in values of NRS between ESPB group and RLB group. There was a significant delay in the time of first analgesic request in both ESPB group and RLB group as compared to the control group with no significant difference between ESPB group and RLB group. The total 24 hr postoperative rescue morphine consumption showed a significant decrease in the total 24 hr postoperative rescue morphine consumption in ESPB group and RLB group than the control group with no difference in morphine consumption between the ESPB group and RLB group.
Conclusions: Ultrasound-guided RLB and ESPB can provide an effective postoperative analgesia after thoracotomy surgery.

Keywords: Ultrasound-guided, erector spinae plane block, retrolaminar block, analgesia, thoracotomy

Introduction
Thoracotomy is one of the most painful surgical procedures [1]. The reported incidence of persistent pain after thoracic surgery (post thoracotomy pain syndrome) has been reported in 20%-70% of patients [1, 2].
Inadequately treated post thoracotomy pain can have several negative consequences. Therefore, pain relief is essential to facilitate coughing and deep breathing and to promote early mobilization [3].
Thoracic epidural analgesia (TEA) and thoracic paravertebral block (TPVB) are strongly recommended techniques for managing post thoracotomy pain to reduce opioid use and their related adverse effects as hypoventilation, depression of cough reflex, nausea and vomiting [1].
However, they can be technically challenging to perform and are associated with up to 15% failure rate in TEA and potential risk of pneumothorax in TPVB [4, 5].
Erector spinae plane block (ESPB) is a relatively novel ultrasound-guided regional technique. Its application in patients with chronic thoracic neuropathic pain and acute surgical pain has been described by Forero *et al*. [6]. Retrolaminar block (RLB) is an easy and safe analgesic technique. It has been reported to be satisfactory for post-operative analgesia after breast surgery [7]. To our knowledge there is no clinical studies, comparing the effectiveness of both blocks on post thoracotomy pain, has been reported.

The aim of this study is to evaluate the analgesic efficacy of ultrasound-guided erector spinae plane block (ESPB) versus retrolaminar block (RLB) in patients undergoing thoracotomy.

Patients and Methods

This prospective randomized controlled double-blind study was carried out on 60 adult patients aged 21-65 years old of both sexes, who were scheduled for elective thoracotomy. their ASA physical status classification was II-III in Tanta University Hospitals, Anesthesia Department, from June 2021 to June 2022. Every patient received an explanation to the purpose of the study after approval of the institutional and regional ethical committee. A written informed consent was taken from all patients.

Exclusion criteria: were patients' refusal, local infection at the site of block, Coagulation abnormalities, sever spinal deformity e.g. scoliosis, known hypersensitivity to local anesthetics, mental dysfunction and cognitive disorders, history of drug abuse and chronic analgesic use.

Randomization and blindness

Patients were randomly allocated into three equal groups (20 patients each) through sealed opaque envelopes. An anesthesiologist performed the block while another one who was blinded obtained the outcome measures to the study groups.

1. **Control group:** patients received general anesthesia alone.
2. **Erector spinae plane block (ESPB) group:** patients received general anesthesia combined with ultrasound guided ipsilateral ESPB [20 ml (19 ml bupivacaine 0.25% plus 1ml dexamethasone 4mg)].
3. **Retrolaminar block (RLB) group:** Patients received general anesthesia combined with ultrasound guided ipsilateral RLB [20 ml (19 ml bupivacaine 0.25% plus 1 ml dexamethasone 4 mg)].

Preoperative

All patients were subjected to history taking, clinical examination and routine laboratory investigations (complete blood count, bleeding time, clotting time, liver and kidney function tests).

Intraoperative

On entering operating room, peripheral intravenous (IV) line was inserted and routine monitoring were applied to the patients including electrocardiogram (ECG), non-invasive arterial blood pressure and pulse oximetry. Baseline readings of heart rate (HR) and mean arterial blood pressure (MAP) were recorded. Capnogram and temperature probe were applied after induction of anesthesia.

All patients were premedicated with IV midazolam 0.02 mg/kg. After preoxygenation for at least three minutes, anesthesia was induced by fentanyl 2 μg/kg, propofol 1-2 mg/kg and 0.5 mg/kg atracurium. Proper sized endotracheal or double lumen tube was inserted and secured. Maintenance of anesthesia was done by isoflurane 1-2% in 50% oxygen\ air mixture and ventilatory settings were adjusted to keep end-tidal Co_2 between 35-45 mmHg. Incremental doses of atracurium 0.1mg/kg were administered when indicated.

In all patients, the assigned block was performed after induction of anesthesia in the lateral position. Surgery was started 20 minutes after performing the block. Intraoperative fentanyl 1μg/ kg IV was administrated in case of inadequate analgesia that was defined as an increase in HR and /or MAP more than 20% from baseline values and the total amount of intraoperative fentanyl was recorded.

At the end of surgery, isoflurane was switched off and muscle relaxant was reversed by neostigmine 0.05 mg/kg and atropine 0.02 mg/kg. Extubation was done and patient was transferred to post-anesthesia care unit (PACU). All patients received regular analgesia in the form of IV paracetamol (perfalgan) 1gm/6 hours.

Techniques for regional blocks

PHILIPS ultrasound machine (Philips, Bothell, Washington label PN4535619829) and high frequency linear array probe with a frequency of 5-13 MHZ were used for performing the blocks.

Preparation

An informed consent, including risks and benefits of the procedure, was taken before carrying out an ESPB. A peri-procedural assessment was performed to confirm the type of procedure, side, and location of the procedure, and to ensure that there were no contraindications.

Patients were prepared with anti-septic solution. Sterile gloves and surgical cap and mask were dressed, and the ultrasound probe placed into the sterile ultrasound probe cover for imaging.

Technique of ESPB (Erector Spinae Plane Block)

The probe was placed into a longitudinal, parasagittal orientation 3 cm from the midline to visualize the tip of the transverse process of T7. The transverse process appeared in the shape of Tombstone. An 88 mm 22-gauge needle was inserted in plane, in a cranial-to caudal direction using ultrasound imaging until contacting the tip of the transverse process (T7) underneath the fascia of the erector spinae muscle. Two ml of sterile saline 0.9% was injected between the tip of transverse process and erector spinae muscles to confirm needle position, then 20 ml local anesthetic solution (19 ml bupivacaine 0.25% plus 1ml dexamethasone 4 mg) were slowly injected until complete separation of erector spinae muscle from the tip of transverse process. Figures 23 and 24 show the anatomical view of ESPB as well as spread of local anesthetic after the block in one of our patients. Figure 1.

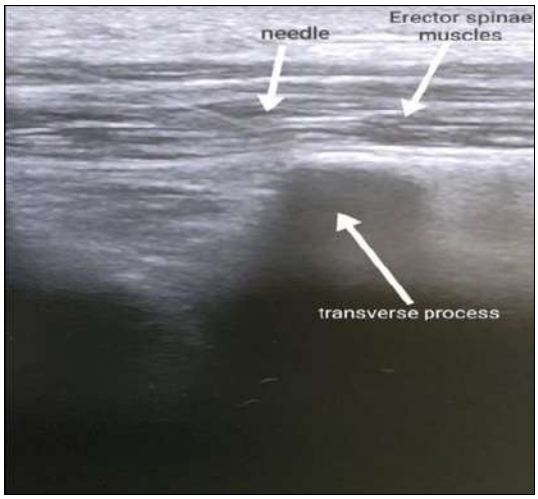


Fig (1a): Anatomical view of ESPB.

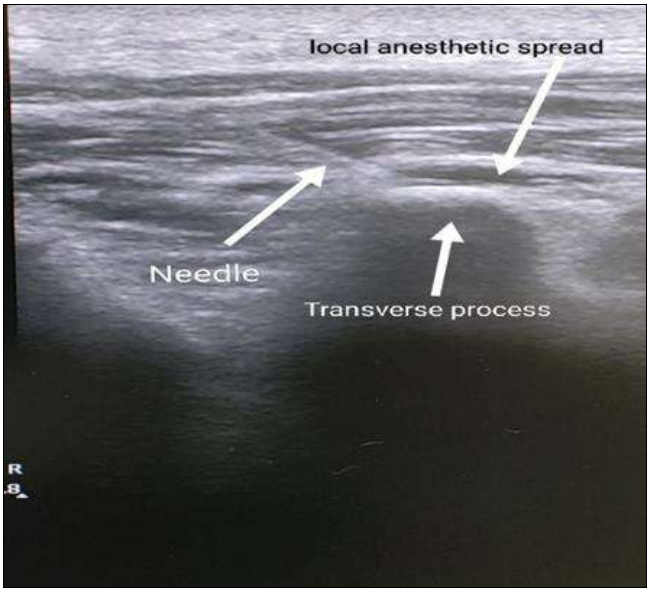


Fig (1b): Local anesthetic spread in ESPB.

Technique of RLB (Retrolaminar Block)

The probe was placed into a longitudinal orientation in the paraspinous line 1cm from the midline. Lamina appeared as a continuous line interrupted by the intra laminar spaces.

An 88 mm 22-gauge needle was inserted in plane 1 cm lateral to the spinous process using ultrasound imaging and advanced caudally or cranially until it contacts the lamina. Figure 2.

Two ml of sterile saline 0.9% was injected to confirm needle position, then 20 ml local anesthetic solution (19 ml bupivacaine 0.25% plus 1ml dexamethasone 4mg) were slowly injected till spread over the lamina. Figures 25 and 26 demonstrate the ultrasound view of retrolaminar space and the propagation of local anesthetic in one of our patients following the block.

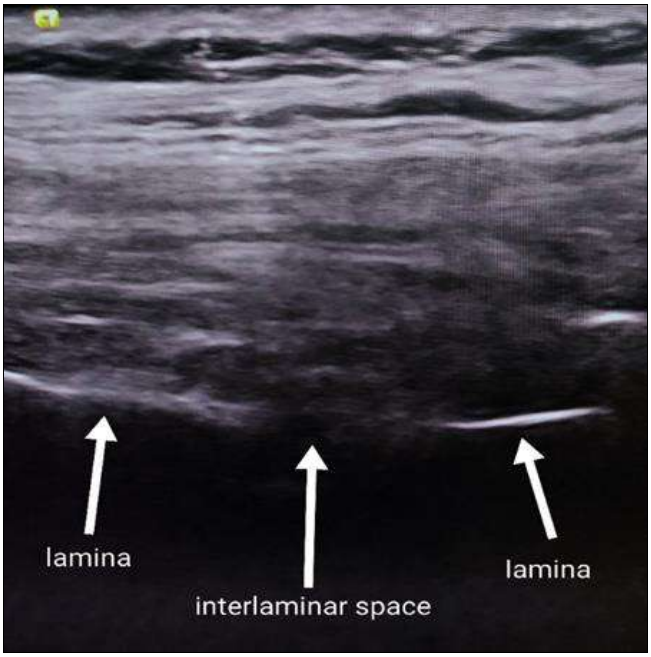


Fig (2a): Ultrasound view of retrolaminar space.

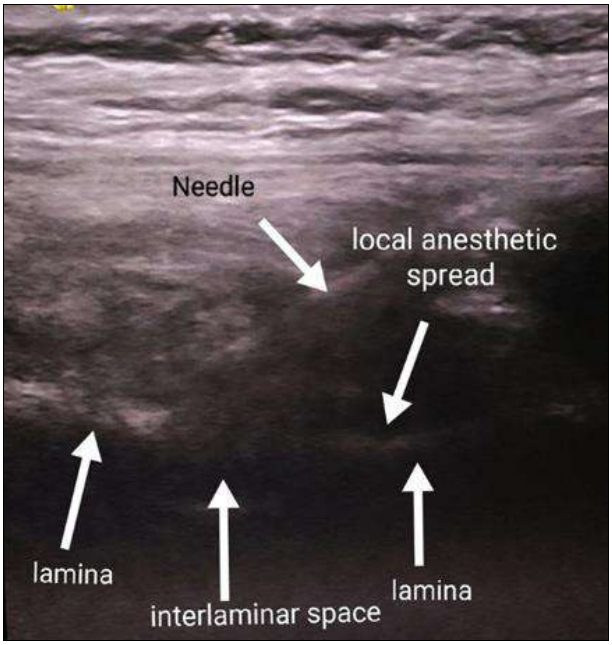


Fig (2b): Local anesthetic spread in RLB.

Measurements

The following data was recorded

- Demographic data: (Age - sex – weight – type of surgery- duration of surgery)
- Pain assessment: Numeric Rating Scale (NRS) is a valid and simple approach to pain assessment (0= no pain and 10= worst possible pain). Postoperative pain was assessed at emergence (the patient's progression from the unconsciousness status to wakefulness and restoration of consciousness), 2nd, 4th, 8th, 12th, 18th and 24th hour postoperatively. IV morphine sulphate 0.05 mg/kg was administered postoperatively as rescue analgesic if NRS is ≥ 4.
- The total amount of morphine consumption in the first 24 hours.
- The time of first analgesic request (period from the injection of the local anesthetic drug of the block to the first request made by the patient for rescue analgesics.
- Any complications or undesirable side effects related to the performed block such as infection, hematoma and local anesthetic toxicity were recorded.

Our primary outcome was total postoperative rescue analgesic requirements in the first 24 hours. The secondary outcomes were the postoperative pain score in the first 24 hours using numeric rating scale (NRS), the time of first rescue analgesic, and incidence of any complication as hematoma, pneumothorax, or local anesthetic toxicity.

Sample size calculation:

Sample size calculation suggested a minimum of 18 patients in each group based on the results of a previous study (9) to detect a significant reduction in total opioid consumption of 7mg at α error of 0.05, standard deviation of 6.23 and 90% power of the study. So we enrolled 20 patients in each group to compensate for possible dropouts.

Statistical analysis

Statistical analysis was done by SPSS v27 (IBM©, Armonk, NY, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD) and were analysed by ANOVA (F) test with post hoc test (Tukey). Quantitative non-parametric data were presented as median and interquartile range (IQR) and were analysed by Kruskal-Wallis test with Mann Whitney-test to compare each group. Qualitative variables were presented as frequency and percentage (%) and were analysed utilizing the Chi-square test. A two tailed P value < 0.05 was considered statistically significant.

Results

In this study, seventy-four patients were assessed for eligibility, five patients did not meet the inclusion criteria (one patient had infection at injection site, two patient had coagulation disorder, one had spinal deformity and one chronic analgesic abuse) and nine patients refused to participate in the study. The remaining 60 patients were randomly allocated into three groups (20 patients in each one). All the 60 patients were followed-up and their data were analyzed statistically. Figure 3.

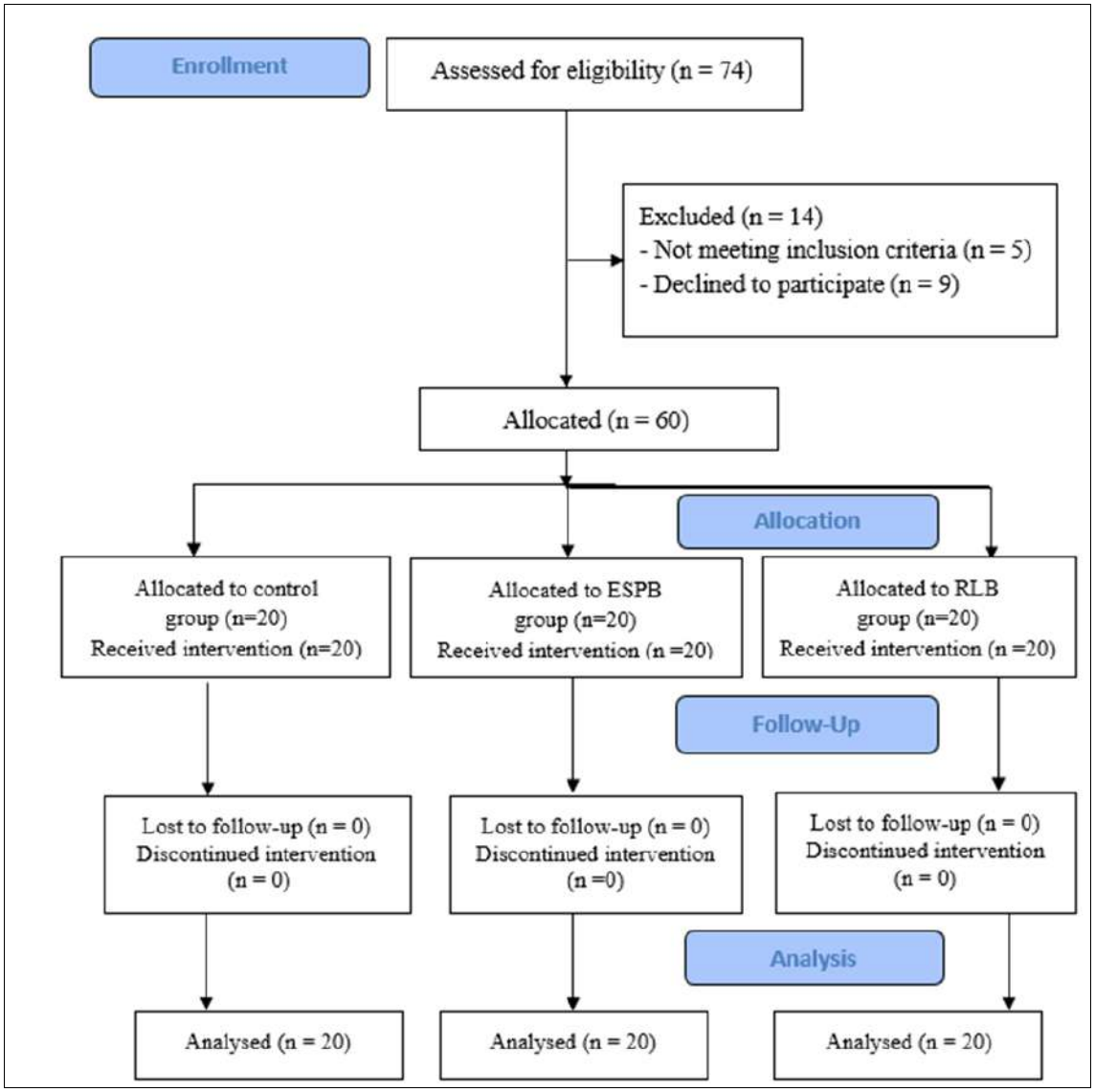


Fig 3: CONSORT flow diagram of the participants through each stage of the randomized trial.

Table (1) showed that The three groups (control, ESPB and RLB) were compared regarding age, sex, weight, type and duration of surgery. There was no significant statistical difference between all groups

Table 1: Comparison between the three studied groups according to demographic and surgical data:

	Control (n = 20)	ESPB (n = 20)	RLB (n = 20)	Test of Sig.	p
Age (years)					
Range	21−60	21 −58	21 −57	F= 0.975	0.384
Mean ± SD.	36.60 ≠12.73	40.95 ≠11.89	41.25 ≠10.65		
Sex					
Male	17 (85%)	15 (75%)	14 (70%)	χ^2= 1.337	^{MC}p= 0.638
Female	3 (15%)	5 (25%)	6 (30%)		

Weight (kg)					
Range	59 – 80	58 – 80	62 – 85	F= 0.435	0.649
Mean ± SD.	71.6 ± 5.47	73.1 ± 5.65	73.15 ± 6.72		
Duration of surgery (minutes)					
Range	120 – 240	120 – 240	120 – 250	F= 0.596	0.554
Mean ± SD.	187.5 ± 29	180.5 ± 35.31	192.5 ± 39.59		
Type of surgery [Count (%)]					
Pneumonectomy	1 (5%)	0 (0%)	0 (0%)	χ^2= 2.383	0.994
Bullectomy	4 (20%)	3 (15%)	4 (20%)		
Decortication	10 (50%)	12 (60%)	11 (55%)		
Lobectomy	5 (25%)	5 (25%)	5 (25%)		

SD: Standard deviation F: F for One-Way ANOVA test
χ^2: Chi square test MC: Monte Carlo
P value < 0.05 indicates statistical significance

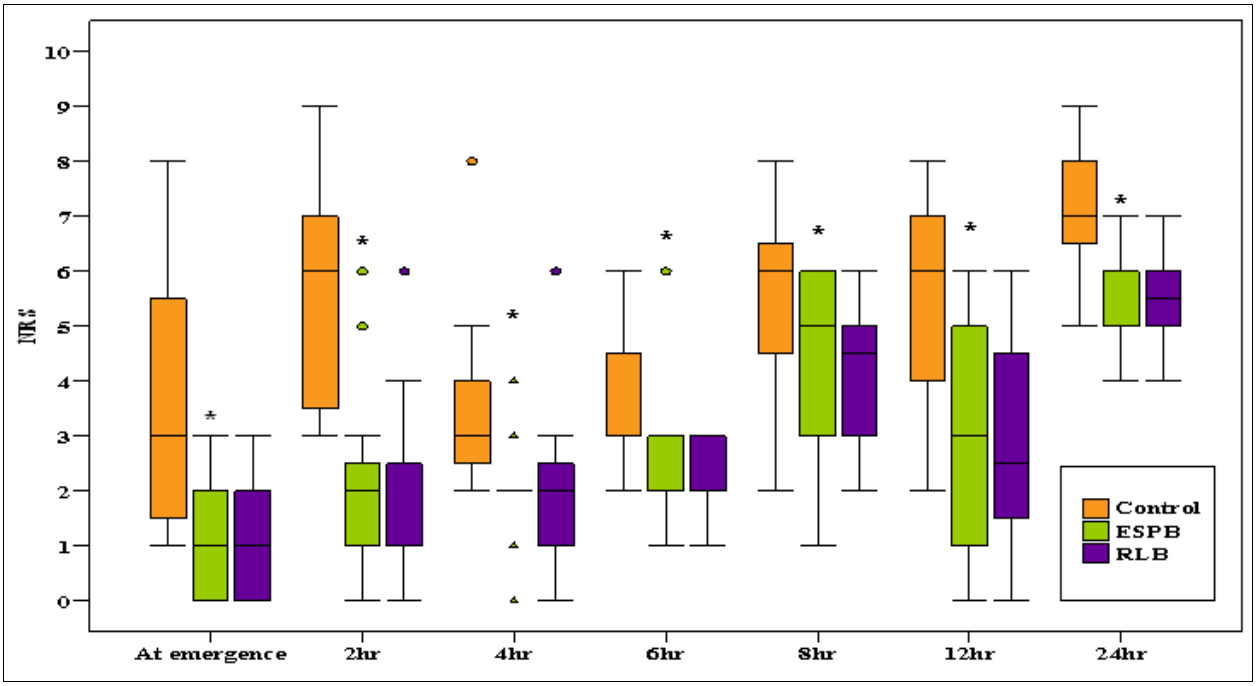
Comparing intraoperative rescue fentanyl consumption between the three studied groups. Table 2 showed a statistically significant decrease in intraoperative rescue fentanyl consumption in ESPB group with a range from 0 to 80 µg, median and interquartile range (0) and RLB group with a range from 0 to 80 µg, median and interquartile range (0) as compared to control group whose range was from 60 to 160 µg, median 75 and interquartile range (70-100), with no significant difference between ESPB and RLB groups as shown in table (6) and figure (30).

Table 2: Comparison between the three studied groups according to intra operative rescue fentanyl (µg)

Cases No.	Intra operative fentanyl (*µg*)		
	Control	**ESPB**	**RLB**
Range	60-160	0-80	0-80
Median (IQR)	75(70-100)	0(0 -0)	0(0-0)
H	34.530		
P	<0.001		
Significance between groups	P_1<0.001, P_2<0.001, P_3=1.000		

Figure (4) showed that Comparing values of NRS in the three studied groups showed that there was a significant decrease in NRS in both ESPB and RLB groups as compared to the control group at different times of measurements with no statistical significant difference in values of NRS between ESPB group and RLB group.

Figure 4: Comparison between the three studied groups according to NRS:



Data are presented as median (IQR).
P value ‹ 0.05 indicates statistical significance
*: denotes statistical significance versus control group.

Fig 4: Box and Whisker Plot showing the distribution of median NRS scores between the three studied groups.

Table (4) showed that Comparing the three studied groups as regard the time of first analgesic request revealed that there was a significant delay in the time of first analgesic request in both ESPB group with a range from 95 to 725 minutes, median 475 and IQR (475-720) and RLB group with a range from 100 to 710 minutes, median 480 and IQR (477.5-695) as compared to the control group whose range is from 30 to 120 minutes, median 60 and IQR (30-90), with no significant difference between ESPB group and RLB group.

Comparing the three studied groups regarding the total 24 hr postoperative rescue morphine consumption showed a significant decrease in the total 24 hr postoperative rescue morphine consumption in ESPB group with a range from 7 to 10 mg, Mean ± SD (8.40 ± 1.57) and RLB group with arrange from 6 to 12 mg, Mean ± SD (7.60 ± 1.64) than the control group whose range was from 10-20 mg, Mean ± SD (14.75 ± 2.55) with no difference in morphine consumption between the ESPB group and RLB group.

Table 4: Comparison between the three studied groups according to Time of first analgesic request and total 24hr postoperative rescue morphine consumption

Cases No.	Time of first analgesic request (minutes)		
	Control	ESPB	RLB
Range	30 – 120	95 – 725	100 – 710
Median(IQR)	60 (30 – 90)	475 (475 – 720)	480(477.5 – 695)
H	35.538		
P	<0.001		
Significance between groups	P_1<0.001,P_2<0.001,P_3=0.802		
Total 24hr postoperative rescue morphine consumption (mg):			
Range.	10-20	7 – 12	6 -12
Mean ± SD.	14.75 ± 2.55	8.40 ± 1.57	7.60 ± 1.64
F	79.043		
P	<0.001		
Significance between groups.	P_1<0.001, P_2<0.001, P_3=0.410		

Regarding Intraoperative complications in the three studied groups. No patient in the three groups experienced any adverse effect in terms of infection, local anesthetic toxicity or hematoma.

Discussion

ESPB and RLB are ultrasound-guided techniques for thoracoabdominal wall analgesia involving injection into the musculo-fascial plane between the paraspinal back muscles and underlying thoracic vertebrae. The ESP block targets the tips of the transverse processes, whereas the retrolaminar block targets the lamina [8].

To our knowledge, no clinical studies comparing the effectiveness of ESPB and RLB blocks on post thoracotomy pain have been reported.

Our prospective randomized study aimed to evaluate the analgesic efficacy of ultrasound-guided ESPB versus RLB in patients undergoing thoracotomy. The primary outcome was total postoperative rescue analgesic requirements in the first 24 hours. The secondary outcomes were the postoperative pain score in the first 24 hours using numeric rating scale (NRS), the time of first rescue analgesic, and the incidence of complications.

In the current study, the use of ESPB and RLB in patients undergoing thoracotomy procedures was associated with significant decrease in NRS up to 24 hours postoperative, reduced intraoperative and 24hr postoperative rescue opioid consumption as well as prolonged duration of analgesia as compared to the control group with no significant statistical difference observed between ESPB and RLB groups as regards the outcome parameters. Moreover, no block related complications were detected in our study.

The mechanism of action of ESPB involves injection of local anesthetics between the deep surface of the erector spinae muscle and the tip of the transverse process; thus, it can diffuse anteriorly into the adjacent paravertebral and inter-costal spaces blocking the dorsal and ventral rami of the spinal nerves [9].

In the RLB technique, the needle does not physically enter the paravertebral space and the injectate is placed at the retrolaminar site (the flattened or arched part of the vertebral arch, forming the roof of the spinal canal) [10]. RLB would logically offer the advantage of a lower risk of pleural injury since needle insertion is made at a more medial puncture site, avoiding needle advancement and manipulation close to the pleura. This approach is proposed as not only safe but also an easy, fast, and effective alternative to other described paravertebral analgesic techniques [9, 10].

Our findings showed that both the ESPB group and the RLB group had significantly lower rescue opioid consumption, longer analgesic durations, and significantly lower NRS values over the course of 24 hours than the control group, with no statistically significant differences seen between the two groups.

In agreement with our results, Yao *et al*., [9]. revealed that single-injection of ESPB significantly reduced cumulative opioid consumption compared with the control group who received ESPB with normal saline. In addition, they revealed that preoperative ESPB reduced NRS pain scores both at rest and during coughing in the first postoperative 8 h. However, at 24 and 48 h postoperatively, there was no difference between the groups in regards to NRS pain scores either at rest, or during coughing.

Our results were also supported by Ciftci *et al*., [11]. reported that the opioid consumption during 24hrs was statistically reduced in the ESPB group when compared with the control group. In addition, the study revealed that the active and passive visual analog scores (VAS) during 24 hours were statistically lower in the ESPB group at all times of measurements when compared with the control group.

In addition, Sobhy *et al*., [12] found that postoperative morphine consumption, pain scores at rest and during

coughing, morphine-related side effects, and hospital stay. 60 patients were allocated equally into two groups: ESPB (study) group and control group. They concluded that the ESPB group consumed much less postoperative morphine and had significantly better pain scores (VAS) than the control group.

Nobukuni *et al*., [13] reported that there was no significant difference in the rescue dose of analgesic consumption or in the NRS scores between the two groups.

Conversely**,** Sugiyama *et al*., [14] revealed that morphine use in the first 24 and 48 h were non-significantly higher in RLB group. The results indicated that the immediate postoperative analgesic efficacy of PVB was superior as compared to RLB in patients undergoing VATS or limited thoracotomy. One possible explanation for the limited efficacy of RLB is that paravertebral injections made in the dorsal part of the endothoracic fascia resulted in limited longitudinal multi-segmental distribution, whereas injections made in the ventral part of the endothoracic fascia resulted in a more extensive longitudinal distribution.

Up to our knowledge, few studies have compared ESPB and RLB blocks in different operations, but none have compared these techniques on thoracotomy.

Sotome *et al*., [15] observed that There was no significant difference in pain intensity at rest for 24 h postoperatively, between the ESPB and RLB groups. The study revealed that there was no significant difference in the consumption of remifentanil during anesthesia and the median time until the first postoperative rescue analgesic after the block procedure in the ESPB group was not longer than that in the RLB group, which was in agreement with our results.

Liu *et al*., [16] compared the postoperative analgesic effects of ultrasound-guided RLB and ESPB for retroperitoneal laparoscopic surgery. There was no significant difference between the two groups in the postoperative pain scores at both the rest and cough state.

No block related adverse events were noted in our study. The use of direct ultrasonographic visualization significantly improves the outcome of most regional anesthesia techniques. With the help of high-resolution ultrasonography, the anesthetist can directly visualize relevant nerve structures; thus improving the quality of nerve blocks and avoiding complications [17].

In agreement with our results Sotome *et al*., [15] revealed that no complications related to the blocks, such as hematoma or infection at the block site, were observed in ESPB or RLB groups. In addition, Liu *et al*., [16] revealed that no patients in ESPB or RLB groups developed severe adverse event. However, Zhao *et al*., [17] revealed that 6 patients (15%) in RLB group and 11 patients (28%) in ESPB group had postoperative nausea and vomiting, with the incidence of nausea and vomiting in RLB group significantly lower than that in ESPB group. The disagreement may be due to the difference in the study population as they conducted their study on patients with MRF while we performed ours on patients scheduled for thoracotomies.

In line with our findings, Yao *et al*., [9] revealed that there were not any complications due to ultrasound guided ESPB have been reported. As well, Ciftci *et al*., [11] reported that there were no differences in terms of the other adverse effects between ESPB and control groups. Sugiyama *et al*., [14] reported that there was no significant difference between RLB and PVB groups as regard the incidence of complications. Additionally, Nobukuni *et al*., [13] revealed that there were no significant differences in the incidence of adverse effects between the in TEA and RLB group groups.

This study has limitations as First: the nerve blocks were performed after induction of general anesthesia, which made it difficult to assess the extent of skin paresthesia. Second: we performed only single bolus injection of local anesthetic and we did not use the catheter technique; continuous ESPB or RLB could have provided persistent postoperative analgesia after thoracic surgery. Finally, we did not follow up the occurrence of chronic pain up to 3-6 months after the operation.

Conclusions

Ultrasound-guided RLB and ESPB can provide an effective postoperative analgesia after thoracotomy surgery. Both blocks reduce the pain intensity, as assessed by NRS score, and prolong the duration to first analgesic request. Postoperative morphine consumption is reduced as well. Meanwhile, those blocks have not been associated with any known side effects, making them safe procedures.

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Conflict of Interest: Nil

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