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Comparitive research between ultrasound guided thoracic para vertebral block, serratus anterior plane block and thoracic erector spinae plane block for post-operative pain relief after thoracotomy

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Abstract
Background: Many analgesic modalities have been suggested for management of thoracotomy pain such as peripheral nerve blocks. The purpose of this work was to compare between the post-operative analgesic effect of thoracic paravertebral block (PVB), serratus anterior plane block (SAPB) and erector spinae plane block (ESPB) in cases undergoing thoracotomy.
Methods: This prospective randomized research was done on 75 adult cases aged 21-60 years scheduled for thoracotomy. Cases were categorized into three equal groups regarding the block had before general anesthesia; PVB group: had ultrasound guided thoracic PVB. SAPB group: had ultrasound guided SAPB. ESPB group: had ultrasound guided ESPB. All cases were monitored for heart rate, mean arterial pressure and pulse oximetry. The following parameters were recorded: postoperative visual analogue score (VAS), quantity of postoperative morphine used after the first dose of emergency analgesic, serum cortisol level and postoperative complications.
Results: A significant rise in VAS in group II versus I and III with insignificant difference between I and III. While first time of rescue analgesia was longer in I and III than II with insignificant difference in postoperative complications observed throughout the postoperative period.
Conclusions: In cases planned for thoracotomy, the ultrasound-guided technique of performing TPVB and ESPB provide effective intraoperative and prolonged postoperative analgesia versus SAPB as observed by stable hemodynamics and delayed first time of rescue analgesia. Results showed less postoperative morphine dose with superiority toward ESPB regarding simplicity and shorter duration, so it is an effective and safe alternative to TPVB.

Keywords: Thoracic para vertebral block, serratus anterior plane block, erector spinae plane block, thoracotomy

Introduction
Thoracotomy is a common cause of sever acute pain. This pain may lead to hypoxia, atelectasis, chest infection and ventilation perfusion mismatch since the lungs' mechanical properties changes [1, 2]. Numerous approaches to treating post-thoracotomy agony have been proposed. Pharmacological management such as systemic opioids which with rised doses may lead to respiratory depression, sedation, pruritis, constipation, nausea and vomiting. Also, non-steroidal anti-inflammatory drugs have a role but may lead to bleeding tendency and nephropathy with rised doses. Also, regional analgesic techniques such as thoracic epidural analgesia (TEA) and peripheral nerve blocks. [4, 5].
The rised use of ultrasonography has allowed for a wider variety of plane blocks to be used in regional anaesthetic and this decreases the Time to treatment, start time, and total local anaesthetic dosage decreased and decreases the possibility of injury of nerves, vessels and viscera. [6] Compared to thoracic epidural anaesthesia (TEA), thoracic peripheral nerve block (PVB) has been shown to have same efficacy. PVB causes ipsilateral somatosensory and sympathetic block with excellent analgesia so it is an attractive and good alternative to TEA for thoracotomy pain control [7, 8]
The Serratus Anterior Plane Block (SAPB) is a straightforward fascial plane block that is performed either above or below the serratus anterior muscle (SAM) along the medial underarm line. By cutting off the supply to the peripheral branches of the intercostal nerves,

it supposedly renders the affected side of the chest pain-free. Complication involving the pleura and the neuro-axis should be avoided with the help of this block [9].

ESPB, has rapidly gained popularity because of its ease of application and relatively safer block area. Typically, the thoracic spinal nerve (dorsal and ventral rami) are blocked, and then Subsequently, the local anaesthetic is injected into the fascial plane, directly beneath the erector spinae muscle (ESM), at the end of the transverse process of the spine, effectively numbing the majority of the thoracic cavity. This is accomplished by targeting the dermatomes on the anterior, lateral, and posterior thoracic wall. [10].

The purpose of this work was to compare between the post-operative analgesic effect of thoracic PVB, SAPB and ESPB in cases undergoing thoracotomy.

Patients and Methods

This prospective randomized research was done on 75 adult cases aged 21-60 years, American Society of Anesthesiologsts (ASA) class II and III scheduled to undergo elective thoracic surgeries via thoracotomy. Tanta University Hospitals' Medical Council gave their permission to the study. Cases or their legal guardians provided signed permission. Exclusion criteria were history of neurological, neuromuscular, psychiatric or dementia problems preventing proper comprehension, history of allergy to local analgesics, infection at the site of injection, spine or chest wall deformity, coagulopathy and bleeding disorders, disturbed serum cortisol levels (Cushing syndrome, Adrenal insufficiency) and exogenous intake of corticosteroids. Cases were categorized into three equal groups (25 cases each). Group (I): thoracic PVB group had ultrasound guided thoracic PVB before general anesthesia. Group (II): SAPB group had ultrasound guided SAPB before general anesthesia. Group (III): ESPB group had ultrasound guided ESPB before general anesthesia. A complete history, physical examination, and standard laboratory tests were performed on all patients. On arrival to the operative theatre, two 18G peripheral venous cannulae were inserted in all cases. Monitor was attached to display ECG, heart rate (HR), non-invasive mean arterial blood pressure (MAP) and pulse oximetry (SpO2). Each case had intravenous midazolam 0.02 mg/kg before performing the block.

Regional analgesic technique

Thoracic PVB

On the side of the operation, in sitting posture with the neck and back of the case flexed and the case supported, under strict aseptic technique, the spinous process of T6 was identified and a linear transducer was applied longitudinal at the level of T6 2.5-3cm lateral to the midline with its orientation directed cranially. After identification of the rounded ribs and the parietal pleura underneath, the transducer was moved medially till the transition of ribs to transverse processes marked by a change in shape (ribs more convex versus transverse processes). The transduser was then slightly tilted laterally so that the transverse process is located superiorly, and the lower rib located inferiorly on the screen. In this position; paravertebral space, pleura and lung tissue were obtained. The pleura and intercostal membrane were hyperechoic, while the costotransverse ligament was hypoechoic, defining the paravertebral area. Skin infiltration was done using 3 ml lidocaine 2% and a 22-G needle was advanced using the in-plane approach craniocaudally. Once the costotransverse ligament is reached, negative aspiration of blood and air was confirmed, and 20 ml of 0.25% bupivacaine was deposited in the paravertebral space leading to downward displacement of the pleura.

SAPB

under sterile conditions, while the case in the lateral position with the diseased side up, using the in-plane approach, the SAPB was performed with the position of the linear transducer oblique in mid axillary line at the level of the fifth rib. Muscles covering the fifth rib include the latissimus dorsi (superficial and posterior), teres major (superior), and SAM (anterior) (deep and inferior), skin infiltration was done using 3 ml lidocaine 2% and a 22-G needle was inserted cephalocaudally. The needle tip target was the inter-fascial plane on the superficial surface of SAM; confirmation was done by proper hydro dissection of the tissue plane by local analgesic (10 ml bupivacaine 0.25%). Advancement of the needle to the plane below the SAM and the fifth rib was done followed by injection of 10 ml bupivacaine 0.25%.

ESPB

On the side of the operation, in sitting posture with the neck and back of the case flexed and the case supported, under strict aseptic technique, the spinous process of T5 was identified and Three centimetres laterally of the T5 spinous process, a linear sensor was attached. Superficial to the hyperechoic transverse process shade, we located the trapezius, rhomboid major, and ESM.

Skin infilteration was done using 3 ml lidocaine 2% and a 22-G needle was inserted using the in-plane approach in cephalic to caudal direction until the tip is seen lying within the fascial plane deep to the ESM at the apex of the transverse process. Total volume of 20 ml of 0.25% bupivacaine was injected lifting the belly of the ESM away from the transverse process.

Anesthesia

All cases had general anesthesia. Preoxygenation was done by 80% oxygen for 3 min. Induction was done by fentanyl 1-2 ug/kg iv, propofol 2 mg/kg iv, and atracurium 0.5 mg/kg iv to facilitate endotracheal intubation. Anesthesia was maintained by isoflurane 1 MAC in an air-oxygen mixture (60% O2, 40% air). Muscle relaxation was maintained with atracurium 0.1 mg/kg iv intermittent boulses until the end of operation. One gm of paracetamol iv infusion was given to all cases. Continuous monitoring of HR, SpO2, ETCO2 and ECG was done until the end of operation. NIBP monitoring was measured every 5 min till the end of operation.

Bradycardia was defiend as heart rate <50 beats/min and received 0.5 mg of intravenous atropine. [11] Hypotension was defined as fall in systolic blood pressure to more than 20% of the baseline value and received intravenous fluids and ephedrine 5 mg /dose slow IV push and repeated as needed to maintain blood pressure.[12]

Neostigmine and Atropine were used to reverse postoperative muscle weakness. After recovery of all reflexes and muscle power, cases were extubated and transferred to the post anesthesia care unit (PACU). Post-operative pain was assessed by VAS at 30 min, 2, 6, 12, 18 and 24 hrs and the rescue analgesia (3-5 mg morphine) were used when VAS >4.

The primary outcome was post-operative analgesic effect of the three blocks using VAS. Secondary outcomes were the effect of the three blocks on hemodynamics, serum cortisol level and post-operative complications.

Statistical analysis

SPSS 25 was used for statistical research (IBM Inc., Chicago, IL, USA). Histograms and the Shapiro-Wilks normalcy test were used to determine whether parametric or nonparametric statistical testing was appropriate for the data. The ANOVA test was used to compare all groups, with the post hoc (Tukey) test used to compare the means of each pair of groups. The Kruskal-Wallis test was used to evaluate non-parametric variables stated as median and IQR, and the Mann-Whitney (U) test was used to compare the two groups. Chi-square analysis was performed on categorical factors represented as frequencies and percentages. The cutoff for statistical significance was set at a two-tailed P value of less than 0.05.

Results

There were insignificant difference between all groups regarding to age, sex and weight. (Table 1)

Table 1: Comparison between all groups regarding age, sex and weight

	Group I (n=25)	Group II (n=25)	Group III (n=25)
Age			
Mean ± SD	42.32 ± 10.49	43.36 ± 10.39	43.00 ± 10.79
p. value	0.939		
Weight			
Mean ± SD	78.68 ± 6.43	79.28 ± 5.26	78.32 ± 4.96
p. value	0.829		
Sex			
Male	16 (64.0%)	19 (76.0%)	17 (68.0%)
Female	9 (36.0%)	6 (24.0%)	8 (32.0%)
P-value	0.645		

Data are presented as mean ± SD or frequency (%). P ≤ 0.05 was statistically significant

There were insignificant difference in HR, MAP and SPO2 at preoperative period, after anaesthesia induction, and all throughout the intraoperative and postoperative periods. (Table 2)

Table 2: Comparison between all groups regarding HR (beats/minutes), MAP (mmhg) and SPO2 (%)

		HR	MAP	Peripheral oxygen saturation
		Mean ± S. D	Mean ± S. D	Mean ± S. D
Basal	Group I	80.56 ± 7.79	98.00 ± 6.69	95.92 ± 0.76
	Group II	79.60 ± 7.01	97.64 ± 6.62	96.12 ± 0.73
	Group III	80.48 ± 7.12	98.20 ± 6.09	96.16 ± 0.75
	P value	0.876	0.953	0.477
10 m. after block	Group I	79.08 ± 7.38	99.12 ± 6.08	96.56 ± 0.58
	Group II	78.68 ± 6.86	97.12 ± 6.32	96.36 ± 0.81
	Group III	79.76 ± 7.04	97.44 ± 6.04	96.52 ± 0.71
	P value	0.863	0.470	0.575
Skin inc.	Group I	76.32 ± 7.24	97.00 ± 5.60	97.88 ± 0.83
	Group II	76.44 ± 6.61	95.32 ± 6.24	98.04 ± 0.89
	Group III	77.80 ± 6.76	96.08 ± 5.89	98.04 ± 0.93
	P value	0.701	0.605	0.763
Intra operative 60 m.	Group I	72.76 ± 6.58	94.96 ± 5.37	98.04 ± 0.73
	Group II	74.28 ± 6.19	94.64 ± 6.07	98.28 ± 0.74
	Group III	76.12 ± 6.35	95.20 ± 5.82	98.20 ± 0.71
	P value	0.183	0.942	0.496
Intra operative 120 m.	Group I	76.08 ± 7.03	96.52 ± 4.97	98.24 ± 0.66
	Group II	76.36 ± 5.89	92.84 ± 18.25	98.44 ± 0.71
	Group III	76.92 ± 6.32	96.40 ± 5.54	98.28 ± 0.61
	P value	0.895	0.434	0.533
Intra operative 180 m.	Group I	76.00 ± 9.09	98.71 ± 5.91	98.14 ± 0.69
	Group II	78.60 ± 6.73	100.60 ± 4.67	98.20 ± 0.45
	Group III	75.50 ± 5.21	98.83 ± 3.87	98.50 ± 0.55
	P value	0.764	0.786	0.531
Postoperative 0 hr.	Group I	81.16 ± 7.33	99.48 ± 6.26	95.04 ± 1.10
	Group II	81.00 ± 6.79	98.28 ± 5.94	94.56 ± 1.23
	Group III	81.88 ± 6.84	98.72 ± 5.61	95.40 ± 1.08
	P value	0.894	0.771	0.138
Postoperative 6 hr.	Group I	80.40 ± 7.20	97.68 ± 6.19	95.60 ± 0.91
	Group II	79.80 ± 6.44	97.88 ± 6.20	95.44 ± 0.87
	Group III	79.80 ± 6.83	97.56 ± 5.26	95.88 ± 0.93
	P value	0.938	0.981	0.226
Postoperative 12 hr.	Group I	80.16 ± 7.29	98.28 ± 6.05	95.72 ± 0.98
	Group II	84.32 ± 6.34	99.28 ± 6.31	95.00 ± 0.91
	Group III	79.40 ± 6.88	97.88 ± 5.18	95.76 ± 0.78
	P value	0.098	0.687	0.105
Postoperative 18 hr.	Group I	82.68 ± 7.05	99.32 ± 6.24	95.60 ± 1.00
	Group II	85.20 ± 6.23	98.48 ± 6.06	95.48 ± 1.00
	Group III	81.48 ± 6.80	99.52 ± 5.05	95.56 ± 0.87
	P value	0.142	0.799	0.904

Postoperative 24 hr.	Group I	80.96 ± 6.69	98.24 ± 5.99	96.28 ± 0.68
	Group II	80.96 ± 6.48	98.44 ± 5.80	95.96 ± 0.73
	Group III	81.00 ± 6.61	98.84 ± 5.93	96.24 ± 0.66
	P value	0.995	0.935	0.212

Data are presented as mean ± SD or frequency (%); HR: heart rate; MAP: mean arterial blood pressure. $p \leq 0.05$ considered significant.

A significant rise was found in VAS in group II versus I and III and there were insignificant difference between I and III. (Table 3)

Table 3: Comparison between all groups regarding the VAS

VAS		Mean ± S. D	p. value
30 m.	Group I	2.52 ± 0.51	0.690
	Group II	2.64 ± 0.49	
	Group III	2.60 ± 0.50	
2 hr.	Group I	2.56 ± 0.51	0.336
	Group II	2.76 ± 0.44	
	Group III	2.64 ± 0.49	
6 hr.	Group I	2.80 ± 0.65	0.001*
	Group II	3.52 ± 0.51	
	Group III	2.96 ± 0.45	
12 hr.	Group I	3.32 ± 0.56	0.001*
	Group II	4.44 ± 0.51	
	Group III	3.60 ± 0.50	
18 hr.	Group I	4.32 ± 0.48	0.005*
	Group II	4.76 ± 0.44	
	Group III	4.44 ± 0.51	
24 hr.	Group I	4.52 ± 0.59	0.955
	Group II	4.52 ± 0.51	
	Group III	4.56 ± 0.51	

Data are presented as mean ± SD or frequency (%); VAS: visual analogue scale. $p \leq 0.05$ considered significant.

Comparing all groups, first time of rescue analgesia was in different between I and III with p value (0.526). While first time of rescue analgesia was longer in group I than II with p value (0.001) and it was also longer in group III than II with p value (0.001). (Table 4)

Table 4: Comparison between all groups regarding first time of rescue analgesia (hours) and total dose of morphine

	Group I	Group II	Group III
First time of rescue analgesia			
Mean ± SD	21.33±3.07	15.36 ± 3.04	20.70 ± 3.06
p. value	0.001*		
Group I & Group II	Group I & Group III	Group II & Group III	
0.001*	0.526	0.001*	
Total dose of morphine			
Mean ± SD	2.84 ± 2.08	5.64 ± 2.23	3.28 ± 2.11
p. value	0.001*		
Group I & Group II	Group I & Group III	Group II & Group III	
0.001*	0.470	0.001*	

Data are presented as mean ± SD or frequency (%). $p \leq 0.05$ considered significant.

Comparing all groups, there were insignificant difference in serum cortisol level at 2 hours before surgery with p value (0.522) and at 24 hours after surgery with p value (0.239). However, at 2 hours after skin incision the p value was 0.001, which revealed that there was a significant rise in serum cortisol level in group II versus I and III, and there were insignificant difference between I and III. (Table 5)

Table 5: Comparison between all groups regarding serum cortisol level (mcg/dl).

Serum cortisol level		Mean ± S. D	p. value
Pre 2h.	Group I	13.04 ± 2.03	0.522
	Group II	12.92 ± 2.00	
	Group III	12.44 ± 1.85	
After 2h.	Group I	22.48 ± 2.12	0.001*
	Group II	25.04 ± 2.51	
	Group III	23.52 ± 2.28	
After 24h.	Group I	14.12 ± 2.03	0.239
	Group II	14.76 ± 1.67	
	Group III	13.92 ± 1.73	

Data are presented as mean ± SD or frequency (%). $P \leq 0.05$ considered significant.

Comparing all groups, there were insignificant difference in postoperative complications observed throughout the postoperative period. (Table 6)

Table 6: Comparison between all groups regarding postoperative complications.

Complications	Postoperative			P-value
	group 1	group 2	group 3	
	N (%)	N (%)	N (%)	
Hypotension	1 (4%)	0 (0%)	0 (0%)	0.363
Nausea and vomiting	4 (16%)	1 (4%)	3 (12%)	0.376

$p \leq 0.05$ considered significant.

Discussion

Regarding hemodynamics in the current research, there were insignificant difference in HR and MAP at preoperative period, after anaesthesia induction and all throughout the intraoperative and postoperative periods. Consistent with the results of our reaserch, Moustafa *et al.* [13] compared thoracic PVB and ESP block in 90 cases undergoing modified radical mastectomy with axillary clearance. They found that there were insignificant difference regarding HR or MAP between the PVB group versus the ESP block group before skin incision as well as during the studied periods after skin incision.

Regarding SPO2 in the current research, there were insignificant difference in SPO2 at preoperative period, after anaesthesia induction, and all throughout the intraoperative and postoperative periods. Regarding VAS in this research, there were insignificant difference at 30 minutes and at 2 hours. However, at 6, 12 and at 18 hours there was a significant rise in VAS in group II versus I and III and there were insignificant difference between I and III. This result prove that ESPB and TPVB are equally effective as analgesic measure for postoperative pain relief after thoracotomy and SAPB is less effective than them. Consistent with the results of our reaserch, Fang *et al.* [14] compared between thoracic PVB and ESP block in 91 cases undergoing thoracotomy. They found that there were insignificant difference in postoperative pain scores between the PVB group versus the ESP block group up to 48 hours postoperative.

In contrary to the current research, Chen *et al.* [15] conducted a research on 72 cases undergoing thoracoscopic partial pulmonary resection surgery. The cases were divided into three equal groups, the thoracic PVB group, the ESP block group and the intercostal nerve block group. They found that although VAS at rest and while coughing were low (< 4) at all times in all groups, however, VAS were statistically low for the PVB group versus the ESP block group at 0, 2, 4 and 8 hours postoperatively. The difference between this result and the result in our research may be due to multiple paravertebral injections used in Chen's research.

Regarding first time of rescue analgesia in this research, it was in different between I and III. While, first time of rescue analgesia was longer in group I than II and it was also longer in group III than II. This result indicate that ESPB provide the same duration of analgesia as PVB and SAPB provide shorter analgesia than them. Consistent with the results of our reaserch, Moustafa *et al.* [13] found that the time to first analgesic requirement in the ESP block group showed insignificant difference when versus that required in the PVB group.

Regarding total dose of postoperative morphine dose in this research, it was in different between I and III. While, there was significant decrease in total dose of postoperative morphine dose in group I versus group II and there was also significant decrease in group III versus group II. This result indicated that ESPB and TPVB are equally effective as analgesic measure for postoperative pain after thoracotomy and SAPB is less effective than them. Consistent with the results of our reaserch, Moustafa *et al.* [13] found that the mean postoperative 24 hours morphine dose in the PVB group showed insignificant difference when versus that consumed in the ESP block group.

Regarding serum cortisol level in this research, there were insignificant difference at 2 hours before surgery and at 24 hours after surgery. However, at 2 hours after skin incision there was a significant rise in serum cortisol level in group II versus I and III, and there were insignificant difference between I and III. Which indicate that ESPB and TPVB are equally effective in decreasing stress response and SAPB is less effective in decreasing stress response. Regarding complications in the current research, in the PVB group, one case (4%) developed hypotension which required resuscitation by IV fluids and IV bolus of 5 mg ephedrine. This may be due to unilateral sympathetic blockade caused by PVB. Also, four cases (16%) developed PONV which received 4 mg intravenous ondansetron. While in SAPB group one cases (4%) developed PONV and received 4 mg intravenous ondansetron, while in the ESPB group three cases (12%) developed PONV and received 4 mg intravenous ondansetron. Comparing all groups, there were insignificant difference observed throughout the postoperative period. Consistent with the results of our reaserch, Ciftci *et al.* [16] conducted a research on 60 cases undergoing lobectomy. The cases were divided into two equal groups, the first group had general anesthesia only and the second group had general anesthesia with ESP block. No complications were reported in the ESP block group except nausea and vomiting in five cases.

Conclusions

Ultrasound-guided technique of performing TPVB, ESPB and SAPB helps to achieve a successful block with the least complications and superiority toward TPVB and ESPB as observed by effective intraoperative and prolonged postoperative analgesia without causing significant hemodynamic instability and delayed first time of rescue analgesia with lower total dose of postoperative morphine dose. ESPB is a simple block and performed in shorter duration than TPVB, so it is an effective and safe alternative to TPVB.

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Conflict of Interest
Nil

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