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Ultrasound Guided Erector Spinae Plane Block as Preemptive Analgesia for Paediatric Thoracotomy

Pramod Bhale[1], Preet Furia[2], Kunda Dhule[3], Mayuri Pore[4], Sanhita Kulkarni[5]
[1]Professor, [2]Junior Resident, [3]Senior Resident, [4]Assistant Professor, [5]Professor and Head of Department of Anaesthesiology, MGM Medical College and Hospital, N-6 CIDCO, Aurangabad, Maharashtra, India.

Abstract:-

- ***Backgrounds and aims :***

Regional anaesthesia is used as a part of multimodal analgesic strategy for post thoracotomy pain. Several techniques have been described for providing post operative analgesia after thoracotomy which include central neuraxial block (epidural analgesia), paravertebral block. These techniques are invasive. It is challenging to perform these modalities in paediatric patients. Ultrasound guided erector spinae plane (ESP) blockis a newly described technique for managing post thoracotomy pain.

- ***Methods :***

A total of 3 paediatric patients belonging to ASA grade 3 received ultrasound guided unilateral ESP block. The primary objective of this study was to assess post operative analgesia in the form of time required to first dose of rescue analgesia and secondary objective was monitoring of intra operative haemodynamic parameters.

- ***Results :***

The duration of post operative analgesia was 480, 420 and 480 minutes respectively of the 3 cases. The haemodynamic parameters of all 3 cases were within normal limits.

- ***Conclusion :***

Ultrasound-guided ESP block provided effective pre emptive analgesia for paediatric thoracotomy.

- ***Hypothesis***

Administration of ultrasound guided single shot erector spinae plane block in paediatric thoracotomy provides effective perioperative analgesia

I. INTRODUCTION

Thoracotomy incisions are extremely painful. Inadequate pain relief increases neurohumoral stress response. It also impairs respiration and mobilisation. It leads to increase in respiratory complications(1). Chronic pain syndrome after thoracic surgery occurs in 25-60% of patients(1). Effective Analgesic techniques include combining paracetamol, NSAIDS, regional block and opioids. Perioperative intercostal nerve blocks or percutaneous paravertebral nerve blocks are useful for thoracoscopic surgeries. Thoracic Epidural and thoracic para vertebral blocks are currently the recommended first line techniques in use for management of post thoracotomy pain. However they can be technically challenging with upto 15% failure rate. (4)The Erector Spinae Plane Block is a newly described technique for managing post thoracotomy pain. It has numerous advantages that makes it an attractive alternative technique. The first report of the successful use of this procedure was in 2016 where the block was used to manage thoracic neuropathic pain in a patient with metastatic disease of the rib and rib fractures. (5)

Erector spinae plane (ESP) block is one of the newer interfascial techniques that can be performed by superficial or deep needle approach. In superficial needle approach technique, the local anaesthetic drug is injected between rhomboid major muscle and erector spinae muscle, whereas in the deep needle approach, drug is injected below erector spinae muscle [Figure 1]. (6) It has been recommended to use the deep needle approach as drug is deposited closer to costotransverse foramina and origin of dorsal and ventral rami.This block serves the purpose of aparavertebral block without risk of pleural injury. It is supposed to work at the origin of spinal nerves based on cadaveric and contrast study. It has emerged as an effective and safe analgesic regional technique. It has a wide variety of applications ranging from control of acute postoperative pain to chronic pain (7). In this study, we report a series of three cases of paediatric thoracotomy who received general anaesthesia with single shot erector spinae plane block for perioperative pain management.

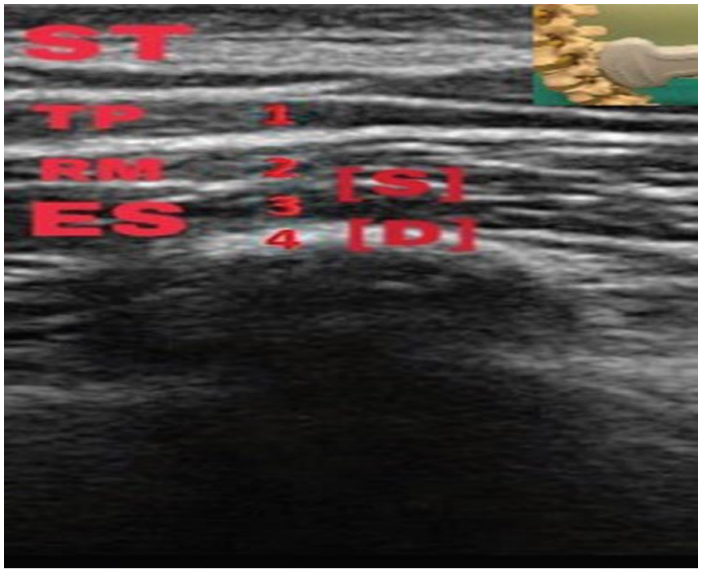

Fig 1: Longitudinal view at transverse process. ST - subcutaneous tissue , 1 (TP) - Trapezius, 2(RM) - Rhomboid Major, 3(ES) - Erector Spinae, 4 - Transverse process, [S] - Superficial needle approach, [D] - Deep needle approach

❖ *Technique*

After securing valid informed consent of the patient's parents, the position of the patient for the block was in lateral position and under the effects of general anesthesia. The technique of the block was guided by ultrasound. A high-frequency linear ultrasound transducer was used to block the thoracic level. (8)After identifying the level of the intervertebral space, the probe was placed in a transverse orientation to identify the spinous process and lamina. The transverse process was identified as a hyperechoic curvilinear structure with pronounced finger-like acoustic shadowing beneath (trident sign) with lamina (sawtooth pattern) and spinous process medially and costochondral junction laterally. The transverse process has a square contour as compared to rib with rounded contour.(9) Then the three muscles were identified from superficial todeep as trapezius, rhomboid major, and erector spinae with simmering pleura in between the transverse processes. The probe was rotated 90 degrees on the transverse process by placing it in a parasagittal plane.(8) Three muscles must be identified as superficial to the hyperechoic transverse process shadow, and they include the trapezius, rhomboid major, and erector spinae (Fig. 2). These three muscles were visualized at the level of the fifth thoracic vertebra (standard level for a thoracic block). The needle was inserted in the plane and the procedure was performed in caudad to cephalad direction as a single shot injection of 0.2% Ropivacaine with volume of 0.5ml/kg.The local anesthetic was deposited in the fascial plane, deeper than Erector Spinae muscle at the tip of the transverse process of the vertebra.(9)

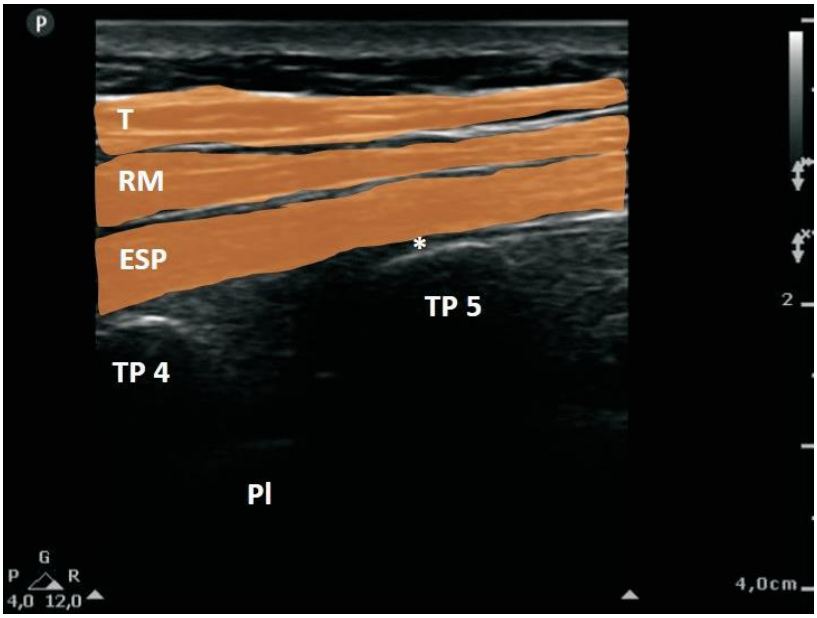

Fig 2.Sonoanatomy of the ESP block at T5 level. TP: transverse process, T: trapezius, RM: Rhomboid major, ESP: erector spinae, Pl: Pleura. *Needle tip place. TP: Transverse process

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➢ *Case Number 1*

A 2 months old, ASA III, male child weighing 5 kg presented with breathlessness since15 days. It was not associated with fever, cough, cyanosis.On examination he was conscious, Irritable and crying with heart rate of 168 beats/min, respiratory rate of 48 breaths/min and SpO_2 90% on room air at the time of admission. On nasal prongs it was 99% with 2 Litres of Oxygen. On respiratory system examination, air entry was decreased on left upper zone with no adventitious sounds. Examination of rest of systems were within normal limits.Laboratory Investigations were within normal limits.Chest Xray showed presence of left upper lobe emphysematous changes. HRCT Thorax showed multiple large thin walled cysts in the region of left upper lobe and lingual lobe. Largest cyst measures 6.0x4.4x6.3cm causing compression of underlying lung parenchyma with shift of heart and mediastinal structures towards right side. He was diagnosed as a case of congenital cystic adematoid malformation (CCAM).

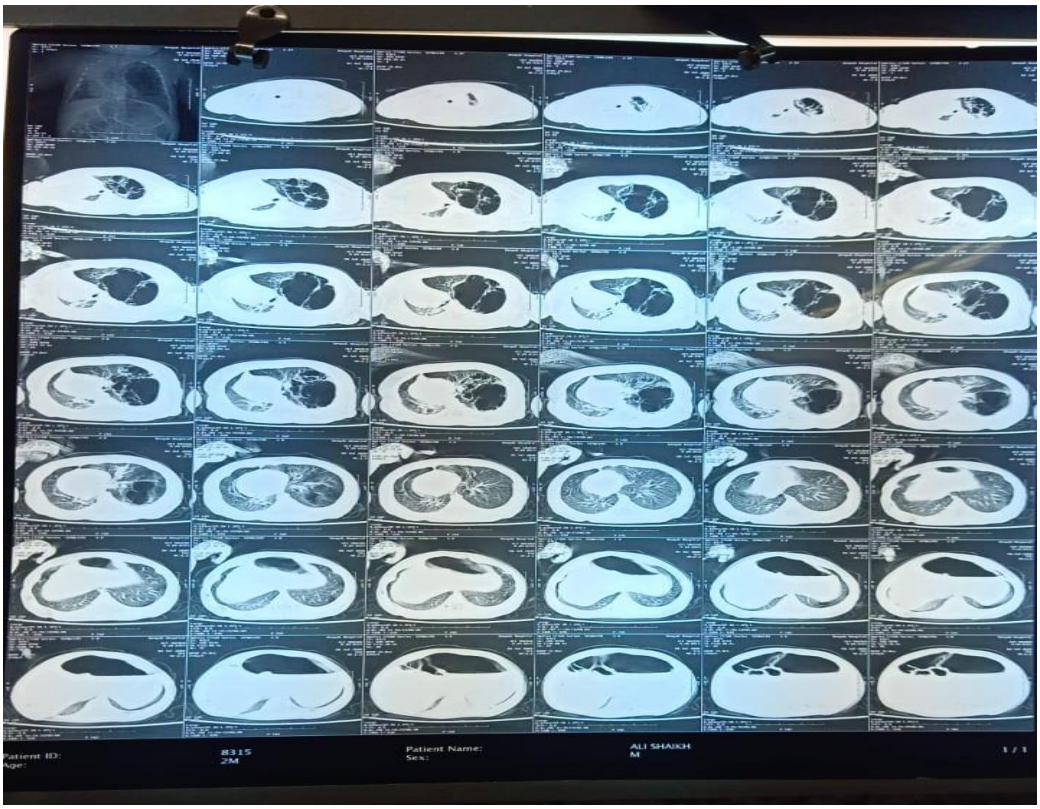

Fig 3 :- HRCT scan of Case number 1 showing CCAM

Plan of Anaesthesia – GA + Unilateral Erector Spinae Plane Block. He was shifted to the operating roomand standard monitoring was attached after obtaining valid written consent from the parents. Two 24-G IV cannulae werealready secured by paediatrician. He was premedicated with Glycopyrolate 25mcg + Midazolam 0.25mg + Fentanyl 10mcg IV.Induction was with Ketamine 10mg +Succinyl Choline 10mg IV and intubated with 3.5 Uncuffed Endotracheal tube following which throat packing was done. Patient was then positioned right lateral positionand USG guided Left sided Erector Spinae Plane Block (ESPB) was administered at T5 Thoracic vertebra level using 24G needle with Ropivacaine 0.2% 2.5ml in plane from cauded to cephalad direction under aseptic precautions.Paracetamol 45mg was administered as intravenous infusion. Anaesthesia was maintained with Sevoflurane and atracurium 2.5mg as a bolus dose followed by 0.5mg IV incremental doses. Patient's vitals were maintained throughout the procedure with heart rate in the range of 130 – 140 / minute. Surgery lasted for 120 minutes. After reversal of the neuromuscular blockade,the trachea was extubated and patient was shifted to ICU. In ICU, the child remained comfortable with a Face, Legs, Activity, Cry, Consolability (FLACC) score of 0. The child was reassessed at 3h, 4h, 5h, 6h, 7h and 8h post operatively since the time of administration of block.When the FLACC score was 4, first dose of rescue analgesia in the form of Paracetamol 45mgIV was given 8 hours after the block post operatively.

Fig 4 : Position of Case number 1 for ESPB

Fig 5 : Position of Case Number 1 for ESPB

Fig 6 : Intra operative Findings of Case 1

➢ *Case Number 2*

A 4 years old, ASA III, male child weighing 16kgpresented with breathlessness since 10 days. It was not associated with fever, cough, cyanosis.

On examination he was conscious, Irritable and crying with heart rate of 134 beats/min, respiratory rate of 26 breaths/min and SpO_2 92% on room air at the time of admission. On nasal prongs it was 99% with 2 Litresof Oxygen. On respiratory system examination, air entry was decreased on right lower zone with no adventitious sounds. Examination of rest of systems were within normal limits.His total leucocyte counts were 15,160. Rest of the laboratory investigations were within normal limits. Chest Xray was suggestive of right sided pleural effusion.USG Chest showed mild collection on right side (50ml) with underlying soft tissue component with underlying consolidation with septae within drainage tube in situ.CECT Chest showed moderate right sided pleural and fissural effusion with smooth interlobular septal thickening. ICD in 5^{th} Intercostal space on right side with its tip abutting lung parenchyma. Consolidation involving apical and posterior segments of right upper lobe, lateral segment of right middle lobe and superior segment of right lower lobe suggestive of infective etiology. He was diagnosed as a case of right sided empyema with a collection of 50ml. He was posted for thoracotomy. Plan of Anaesthesia – GA + Unilateral Erector Spinae Plane Block. He was shifted to the operating room and standard monitoring was attached after obtaining valid written consent from the parents. Two 22-G IV cannulae werealready secured by paediatrician. He was premedicated with Glycopyrolate 75mcg + Midazolam 0.5mg + Fentanyl 30mcg IV. Induction was withKetamine 30mg +Succinyl Choline 30mg IV and intubated with 5.5 Uncuffed Endotracheal tube following which throat packing was done. Patient was then positioned left lateral position and USG guided Right sided Erector Spinae Plane Block (ESPB) was administered at T5 Thoracic vertebral level using 24G needle with Ropivacaine 0.2% 8mlin plane from cauded to cephalad direction under aseptic precautions. Paracetamol 225mg was administered as intravenous infusion. Anaesthesia was maintained with Sevoflurane and atracurium 8mg as a bolus dose followed by 1.5mg IV incremental doses.Patient's vitals were maintained throughout the procedure with heart rate in the range of 100 – 110 / minutes and BP 100 -110mmHg /50-60mmHg. Surgery lasted for 140 minutes. After reversal of the neuromuscular blockade, the trachea was extubated and the child shifted to ICU. In ICU, the child remained comfortable with a Face, Legs, Activity, Cry, Consolability (FLACC) score of 0. The child was reassessed at 3h, 4h, 5h, 6h, 7h and 8h post operatively since the time of administration of block. First dose of analgesia in the form of Paracetamol 225mg IV in the post operative period was given 7 hours after the block.

Fig 7 : Position and Application of Ultrasound Probe on case number 2 for ESPB

➢ *Case Report 3*

A 3 years, ASA III, female childweighing 10kg presented with chief complaints of fever, cough since 15 days and breathlessness since 12 days. It was not associated with vomiting, cyanosis and convulsions.On examination she was conscious, Irritable and crying with heart rate of 138/min, respiratory rate of 28 breaths /min and SpO_2 of 92% on room air at the time of admission. On nasal prongs it was 99% with 2 Litres of Oxygen. On respiratory system examination, air entry was decreased on left lower zone with no adventitious sounds. Examination of rest of systems were within normal limits.Her total leucocyte counts were 17,110. Rest of the laboratory investigationswere within normal limits.Chest Xray was suggestive of left sided pleural effusion.CECT chest showed moderate Left sided loculated pleural effusion with thick enhancement of underlying lung collapse suggestive of empyema.She was diagnosed as a case of right sided empyema with a collection of 90 -100ml. She was posted for thoracotomy. Plan of Anaesthesia – GA + Unilateral Erector Spinae Plane Block. She was shifted to the operating room and standard monitoring was attached after obtaining valid written consent from the parents. Two 24-G IV cannulae werealready secured by paediatrician. She was premedicated with Glycopyrolate 50mcg + Midazolam 0.3mg + Fentanyl 20mcg IV. Induction

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was withKetamine 20mg +Succinyl Choline 20mg IV and intubated with 4.5 Uncuffed Endotracheal tube following which throat packing was done.Patient was then positioned left lateral position and USG guided Right sided Erector Spinae Plane Block (ESPB) T5 Thoracic vertebral level using 24G needle with Ropivacaine 0.2% 5mlin plane from cauded to cephalad direction under aseptic precautions. Anaesthesia was maintained with Sevoflurane and atracurium 5mg as a bolus dose followed by 1mg IV incremental doses.Patient's vitals were maintained throughout the procedure with heart rate in the range of 100 – 110 / minutes and BP 100 -110mmHg /60-70mmHg. Surgery lasted for 130 minutes. After reversal of the neuromuscular blockade, the trachea was extubated and shifted to ICU. In ICU, the child remained comfortable with a Face, Legs, Activity, Cry, Consolability (FLACC) score of 0. The child was reassessed at 3h, 4h, 5h, 6h, 7h and 8h post operatively since the time of administration of block. First dose of analgesia in the form of Paracetamol 150mg IV in the post operative period was given 8 hours after the block.

Fig 7: Ultrasound Image showing the needle and spread of Local anaesthetic agent.

HR At	**Difference**	**Percentage Change (%)**
0 Min(160)Vs 30 Min(152)	08	5.00
0 Min(160)Vs 60 Min(150)	10	6.25
0 Min(160)Vs 120 Min148)	12	7.50
0 Min(160)Vs 300 Min(144)	16	10.00
0 Min(160)Vs 480 Min(184)	24	15

Table 1: Showing the comparison of Heart Rate (HR) changes in First Case compared to basal HR

Maximum increase in heart rate at 480 minutes
Maximum decresase in heart rate at 30 minutes
Mean change in heart rate :8.75%

HR At	**Difference**	**Percentage Change (%)**
0 Min(132)Vs 30 Min(118)	14	10.61
0 Min(132)Vs 60 Min(108)	14	10.61
0 Min(132)Vs 120 Min(126)	06	4.55
0 Min(132)Vs 300 Min(156)	16	12.12
0 Min(132)Vs 480 Min(156)	24	18.18

Table 2: Showing the comparison of Heart Rate (HR) changes in Second Case compared to basal HR

Maximum increase in heart rate at 480 minutes
Maximum decresase in heart rate at 120 minutes
Mean change in heart rate : 11.2%

HR At	**Difference**	**Percentage Change (%)**
0 Min(136)Vs 30 Min(120)	16	11.76
0 Min(136)Vs 60 Min(110)	14	10.29
0 Min(136)Vs 120 Min(118)	18	13.24
0 Min(136)Vs 300 Min(118)	18	13.24
0 Min(136)Vs 480 Min(156)	20	19.12

Table 3: Showing the comparison of Heart Rate (HR) changes in Third Case compared to basal HR

Maximum increase in heart rate at 480 minutes
Maximum decresase in heart rate at 60 minutes
Mean change in heart rate : 13.53%

SBP At	**Difference**	**Percentage Change (%)**
0 Min(84)Vs 30 Min(84)	00	0.00
0 Min(84)Vs 60 Min(80)	4	4.76
0 Min(84)Vs 120 Min(94)	10	11.90
0 Min(84)Vs 300 Min(86)	2	2.38
0 Min(84)Vs 480 Min(92)	8	9.52

Table 4: Showing the comparison of Systolic Blood Pressure (SBP) changes in First Case compared to basal SBP

Maximum increase in systolic blood pressure at 120 minutes
Maximum decrease in systolic blood pressure at 60 minutes
Mean change in systolic blood pressure : 5.71

SBP At	**Difference**	**Percentage Change (%)**
0 Min(96)Vs 30 Min(104)	8	8.33
0 Min(96)Vs 60 Min(88)	8	8.33
0 Min(96)Vs 120 Min(98)	2	2.08
0 Min(96)Vs 300 Min(94)	2	2.08
0 Min(96)Vs 480 Min(96)	00	0.00

Table 5: Showing the comparison of Systolic Blood Pressure (SBP) changes in Second Case compared to basal SBP

Maximum increase in systolic blood pressure at 30 minutes
Maximum decrease in systolic blood pressure at 60 minutes
Mean change in systolic blood pressure : 4.164

SBP At	**Difference**	**Percentage Change (%)**
0 Min(98)Vs 30 Min(96)	02	2.04
0 Min(98)Vs 60 Min(98)	00	0.00
0 Min(98)Vs 120 Min(98)	00	0.00
0 Min(98)Vs 300 Min(92)	06	6.12
0 Min(98)Vs 480 Min(102)	04	4.08

Table 6: Showing the comparison of Systolic Blood Pressure (SBP) changes in Third Case compared to basal SBP

Maximum increase in systolic blood pressure at 480 minutes
Maximum decrease in systolic blood pressure at 300 minutes
Mean change in systolic blood pressure : 2.44

DBP At	**Difference**	**Percentage Change (%)**
0 Min(52)Vs 30 Min(54)	02	3.85
0 Min(52)Vs 60 Min(50)	2	-3.85
0 Min(52) Vs 120Min(66)	14	-26.92
0 Min(52)Vs 300 Min(60)	8	-15.38
0 Min(52)Vs 480 Min(60)	8	-15.38

Table 7: Showing the comparison of Diastolic Blood Pressure (DBP) changes in First Case compared to basal DBP

Maximum increase in diastolic blood pressure at 120 minutes
Maximum decrease in diastolic blood pressure at 60 minutes
Mean change in diastolic blood pressure : 13.07

DBP At	**Difference**	**Percentage Change (%)**
0 Min(68)Vs 30 Min(64)	04	5.88
0 Min(68)Vs 60 Min(56)	12	17.65
0 Min(68)Vs 120 Min(68)	00	00
0 Min(68)Vs 300 Min(76)	08	11.76
0 Min(68)Vs 480 Min(64)	04	5.88

Table 8: Showing the comparison of Diastolic Blood Pressure (DBP) changes in Second Case compared to basal DBP

Maximum increase in diastolic blood pressure at 300 minutes
Maximum decrease in diastolic blood pressure at 60 minutes
Mean change in diastolic blood pressure : 8.23

DBP At	**Difference**	**Percentage Change (%)**
0 Min(72)Vs 30 Min(64)	08	11.11
0 Min(72)Vs 60 Min(58)	14	19.44
0 Min(72)Vs 120 Min(66)	06	8.33
0 Min(72)Vs 300 Min(64)	08	11.11
0 Min(72)Vs 480 Min(86)	14	19.44

Table 9: Showing the comparison of Diastolic Blood Pressure (DBP) changes in Third Case compared to basal DBP

Maximum increase in diastolic blood pressure at 300 and 480 minutes
Maximum decrease in diastolic blood pressure at 60 minutes
Mean change in diastolic blood pressure : 13.88

Mean Duration of Surgery (Mins.) - 133.33

Parameter	**Case 1**	**Case 2**	**Case 3**
Age (months)	2	48	36
Weight (kg)	5	16	10
Duration of Surgery (Minutes)	120	140	130
Duration of Post Operative Analgesia (Minutes)	480	420	480

Table 10 : Showing demographic characteristics, duration of surgery and duration of post operative analgesia

Case Number	**FLACC Score at various time intervals (Minutes)**							
	120	**150**	**180**	**240**	**300**	**360**	**420**	**480**
1	0	1	1	2	3	3	3	4
2	0	0	1	1	2	3	4	2
3	0	0	1	2	2	3	3	4

Table 11: Showing post operative FLACC score of each case.

II. DISCUSSION

The erector spinae muscle (ESM) is a complex formed by thespinalis, longissimusthoracis, and iliocostalis muscles that run vertically in the back.(7) The ESP block is performed by depositing the local anesthetic (LA) in the fascial plane, deeper than the Erector SpinaeMuscle at the tip of the transverse process of the vertebra. Local Anaesthetic is distributed in the caudo-cranialfascial plane.(7) Additionally,it diffuses anteriorly to the paravertebral and epidural spaces, and laterally to the intercostal space at several levels.(8)The local anaesthetic agent exerts its effect on the ventral and dorsal ramus of the spinal nerve. The ventral ramus (intercostal nerve) is divided into the anterior and lateral branches. Its terminal branches provide the sensory innervation of the entire anterolateral wall. The dorsal ramus is divided into 2 terminal branches and it gives the sensory innervation to the posterior wall.(7) Furthermore, the diffusion of LA to the paravertebral space through the costotransverseforamina and the intertransverse complex (intertransverseand costotransverse ligaments: levators, rotators, and intercostal muscles) provides both visceral and somatic analgesia.(7)

Erector SpinaePlane block is a technique that has great advantages over conventional techniques such as thoracic epidural and paravertebral blocks performed close to the neuroaxis. First, it is an easy technique to perform as the visualization of the target by ultrasound is very simple and it is not difficult to direct the needle towards it. Second, the technique has a low risk of complications. Important structures (such as main vessels, pleura, or medulla) whose injury can cause serious complications, are far from the target of blockage.Given that this procedure is easy to perform and is relatively safe, several authors have expressed the opinion that it could be part of the multimodal analgesia of the enhanced recovery after surgery programs. However, being such a novel blockade technique, the lack of more well-designed prospective studies makes recommending its use in these programs has not yet occurred. Therefore, we can conclude that ESP block seems to be an effective analgesic technique at many levels. This offers us the opportunity to utilize it in many clinical situations. Although it is not the technique of first choice in most situations, it is a suitable alternative, especially in scenarios in which the technique of first choice constitutes an important risk or is directly contraindicated. Moreover, ESP block has been described as an effective alternative when paravertebral or epidural block are contraindicated.

In this study we found after administration of the block,the mean change in heart rate, systolic blood pressure and diastolic blood pressure was 8.75%, 5.71% and 13.07% respectively. The mean change in heart rate, systolic blood pressure and diastolic blood pressure were 11.21%, 4.16% and 8.23% respectively. The mean change in heart rate, systolic blood pressure and diastolic blood pressure were 11.53%, 2.44% and 13.88% respectively.

In Gupta A et al they gave Erector Spinae Plane block using clonidine as an adjuvant for excisionof chest wall tumour in a paediatric patient where the duration of analgesia was 24 hours.(6) The prolonged effect was probably because they used Ropivacaine 0.375% with clonidine as an additive. This attributes to prolonged duration of post operative analgesia.

In Sobhy et al they did a prospective, randomized observer blind controlled clinical trial on adult patients undergoing thoracotomy where there were 2 groups – one being the study group which received ultrasound guided erector spinae plane block with a volume of 20ml of 0.25% Bupivacaine and the control group received no block. The VAS scores were significantly lower ($p < 0.002$) in the study group.(10) This study was done in adult patients with higher concentration and volume of different drug (20 ml of 0.25% Bupivacaine). Our study was conducted in paediatric age group where the drug, its concentration and volume were different.

In Muñoz F et al they gave ultrasound guided erector spinae plane block in paediatric oncological thoracic surgery for post operative analgesia with Bupivacaine 0.5% 14ml with epinephrine as an additive 5micrograms/ml after the procedure. The duration of post operative analgesia lasted for 32 hours.(11) This delay can be attributed to the fact that the block was given after completion of procedure prior to emergence and the concentration of drug was higher (0.5% Bupivacaine 14ml) with epinephrine as an additive. In our study we administered pre emptive analgesic erector spinae plane block immediately after giving giving general anaesthesia with a different drug, concentration and volume. The duration of analgesia is longer than our study due to addition of epinephrine as an additive to bupivacaine.

In our study, we found that there was prolongation of duration of analgesia along with haedmodynamic stability. The requirement of first analgesic dose was also delayed according to the FLACC score.Thus we prove our hypothesis.

III. CONCLUSION

We conclude that ultrasound-guided Erector SpinaePlane block is an excellent regional analgesicmodality on the horizon.However, more randomized controlled trials are necessary especially in paediatric population toestablish the best indications of Erector SpinaePlaneblock as an analgesic technique in chronic, acute, and postoperative pain.

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