

# Evaluation of thoracic paravertebral block for pain relief in rib fractures

Tarun Yadav<sup>1</sup>, Gunjan Bansal<sup>2</sup>, Mayuri Golhar<sup>1</sup>, Anju Ghai<sup>1</sup>

<sup>1</sup>Department of Anaesthesia and Critical Care, Pandit Bhagwat Dayal Sharma Post Graduate Institute of Medical Sciences, Rohtak, Haryana, India

<sup>2</sup>Department of Health, Haryana Civil Medical Services, Government of Haryana, Haryana, India

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Corresponding author:

Mayuri Golhar.

E-mail: [drmayuriyadav@gmail.com](mailto:drmayuriyadav@gmail.com);

ORCID: 0000-0002-1653-3261

## Abstract

**Introduction:** Fracture of ribs causes severe pain which in turn activates the cascade of respiratory compromise. Pain management with regional blocks is considered one of the promising techniques. Thoracic paravertebral block (TPVB) is a proven technique considered at par with epidural analgesia. But its blind landmark-based technique has a potential risk of pneumothorax. Ultrasound gives advantage of real time visualization which decreases complications and enhance its success rate. So, we conducted this study to gauge the efficacy and utility of ultrasound guided thoracic paravertebral block.

**Material and methods:** Twenty patients were administered TPVB under ultrasound guidance with 15 milliliters of 0.25 % inj bupivacaine and 2 mg per kg fentanyl who had multiple rib fractures of unilateral hemithorax. For prolonged pain relief a catheter was left in place to administer recurring boluses. The parameters noted were superior costotransverse ligament (SCTL), skin to SCTL distance, skin to pleura distance, VAS at rest & at cough, respiratory rate arterial blood gas parameters at various time intervals.

**Results:** Thoracic paravertebral space was easily identified in each patient with ultrasound. We discovered significant pain relief in terms of VAS score at rest & at cough at different time intervals. Respiratory rate and arterial blood gas parameters improved with the use of ultrasound guided thoracic paravertebral block.

**Conclusion:** Sonographic out of plane sagittal thoracic paravertebral block is a successful technique in rib fracture patients to provide effective pain relief and also ameliorates respiratory rate and oxygenation.

**Keywords:** ultrasound, pain relief, rib fracture, thoracic paravertebral block

## Introduction

Majority of rib fractures are consequence of road traffic accidents, and it results in 10 % of total trauma hospitalization. It is an important indicator of severe injury resulting in increased morbidity and mortality [1].

Multiple rib fractures can cause severe pain, which in turn limits the respiratory functions. The mainstay of treatment is to manage pain, airway, oxygenation, intravascular volume support and tube thoracostomy and infection control [2].

Different methods of pain management include nonsteroidal anti-inflammatory agents, narcotics, intercostal nerve blocks, intrapleural catheters and thoracic epidural. NSAIDs and narcotics are rarely effective during the acute phase. Intercostal nerve blocks require frequent repetitions. Thoracic epidurals pose a risk of haemodynamic instability[3].

Thoracic paravertebral block (TPVB) leads to somatic motor and sensory blockage of multiple thoracic dermatomes in ipsilateral hemithorax above and below the block site. Moreover, its analgesic efficacy is equivocal to epidural analgesia [4].

Multiple approaches have been described to the paravertebral space; ultrasound guided paravertebral block is popular now a days due to real time sonographic visualization compared with traditional technique. Due to limited literature availability, we conducted this study with the aim to estimate the efficacy and effectiveness of ultrasound guided out of plane sagittal approach of thoracic paravertebral block in unilateral rib fracture patients for pain relief.

## Material and methods

This prospective randomized study was conducted in Department of Anaesthesia and Critical Care at Pt BDS PGIMS, Rohtak. All procedures performed were within the ethical standards and formal ethical approval was obtained from the institutional board for the same. After written informed consent a total of 20 patients of age group 18 to 75 years who suffered from blunt trauma chest and had unilateral hemithorax fracture ribs with visual analogue score (VAS)  $\geq 3$  received ultrasound guided thoracic paravertebral block. Those who had local

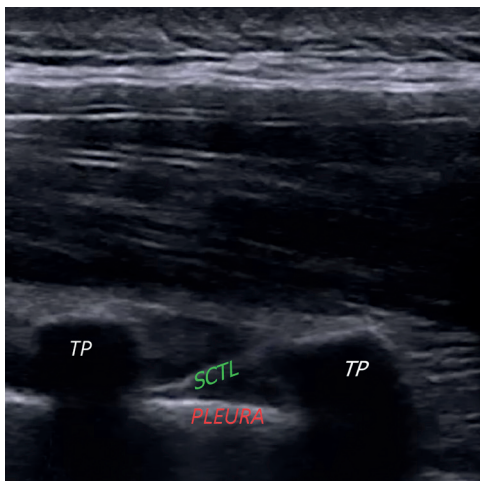
site infection, liver and kidney disease, coagulation disorder and patients who refused to participate in study were excluded.

Routine investigations including haemoglobin, bleeding and clotting time, X ray chest and electrocardiography were done. The number of rib fractured, arterial blood gas analysis and respiratory rate were noted. All the participating patients were explained about the use of Visual analogue score (VAS). VAS was noted at rest and at cough. The ability to cuff and breathe deeply was noted and graded as one - no difficulty, two - mild difficulty, three - moderate difficulty and four who had severe difficulty.

The thoracic paravertebral block was performed in preoperative area. Intravenous access was established and midazolam 2 mg/kg and fentanyl 2 µg/kg were administered. Monitoring included ECG, Spo2 and non-invasive BP. After cleaning and draping of thoracic vertebral, paravertebral area and the ultrasound probe, Initial ultrasound scanning of required vertebral and paravertebral region was done. Patient position was either sitting or lateral according to patients convenience with affected side up.

Site of injection was chosen two segment below the most cephalad fractured rib.

Linear ultrasound probe of 6-13 MHz probe (Sonosite M Turbo) was used for all sonographic assessments. The appropriate thoracic level was identified by cephalad to caudal ultrasound scanning starting from first rib onwards. Afterwards the spinous process and the transverse process of the appropriate thoracic vertebrae and the rib were identified. The midpoint of the transducer was placed in a longitudinal paramedian plane between two transverse processes of chosen vertebral level. Both transverse processes were visualized with the superior costotransverse ligament (SCTL) and the pleura in between (Figure 1).



**Figure 1** - Ultrasonographic anatomy for thoracic paravertebral block

The image was frozen and the distance of transverse process to the skin was noted.

The following measurements were noted at the appropriate vertebral levels.

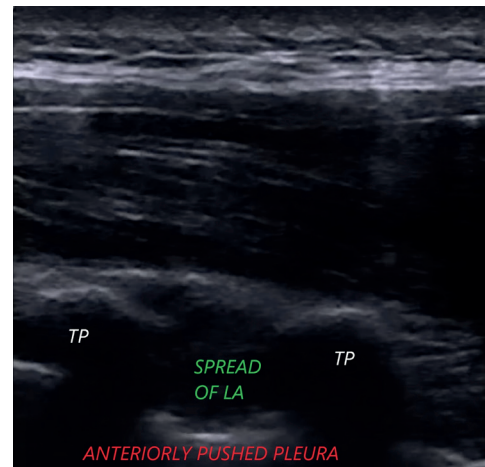
i) Ultrasound appearance of the SCTL in percentage visibility [5]:

1	No visibility	0 % Visibility
2	Poor	<25 % Visibility
3	Moderate	26-50 % Visibility
4	Good	51-75 % Visibility
5	Excellent	>75 % Visibility

ii) Skin to SCTL distance in mm from lateral border of upper transverse process.

iii) Skin to pleura distance in mm from lateral border of upper transverse process.

An 18 G needle was introduced using out of plane technique. The tip of the needle was advanced under direct visualization till it pieces the SCTL. 5 ml of bupivacaine 0.25% was injected after negative aspiration, while the spread of local anaesthetic and simultaneously anterior pushing of the pleura was observed (Figure 2).



**Figure 2** - Thoracic paravertebral block with spread of local anaesthetic and anteriorly pushed pleura

Afterwards an additional 10 ml bupivacaine 0.25% with one µg per kg of fentanyl was injected. A catheter was threaded 2-3 cm into the paravertebral space after the block and was secured with adhesive dressing. The threading of the catheter was graded as easy, some resistance, difficult and not possible. The distance travelled by needle was noted.

Haemodynamic parameters were noted at 3 minutes interval for the first 15 minutes up to 45 minutes. Block was defined successful at loss of cold sensation in greater than or equal to three homolateral dermatomes.

VAS was evaluated at rest and at cough on baseline, 1<sup>st</sup> hour, 2<sup>nd</sup> hour, 4<sup>th</sup> hour, 8<sup>th</sup> hour, 24<sup>th</sup> hour, 36<sup>th</sup> hour, 48<sup>th</sup> hour, 60<sup>th</sup> and 72<sup>th</sup> hour post procedure. If VAS ≥ 3 patient were administered 15 ml of 0.25% bupivacaine with 1 µg per kg fentanyl with lock in period of 4 hours. Total number of top-ups doses were noted. During the study if VAS ≥ 3 even after top-ups i.v. inj tramadol 100 mg was given as rescue analgesic. Patients were actively stimulated to perform deep breathing exercises. Arterial blood gas analysis was done on day 2 and 3. Catheter was removed after 72 hours.

## Discussion and Results

Our study was a male dominated study where 95% of patents were males with a mean age of 47±15.61 years. The mean number of ribs fractured were 3±0.56. Road side trauma was the cause of injury in all the patients. Patients characteristics are depicted in Table 1.

Table 1		Patients' characteristics
Age (Mean ±SD)		47±15.61
Range		18-83 years
Sex (F/M)		1 (5%) / 19 (95 %)
Number of rib fractures (Mean ±SD)		3±0.56
Site involved (Left/Right)		9 (45 %) / 11(55 %)

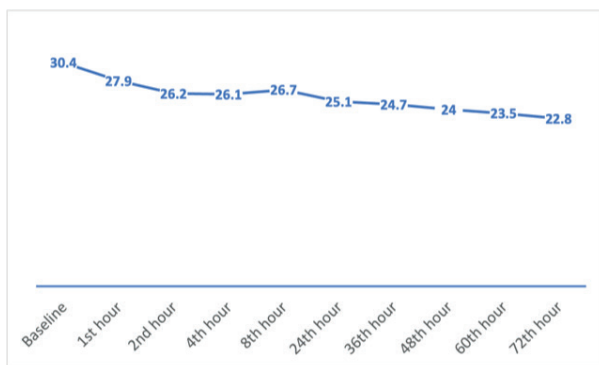
The technical parameters are depicted in Table 2. Block was performed at T5-T6 in 9 patients and T3-T4 in 6 patient. Superior costotransverse ligament visibility was excellent in seven patients and it was graded as good in thirteen patients. The mean depth from skin to SCTL was 2.99±0.51 cm (range 2.32-4.1 cm). Grade of catheter insertion was easy in ten patients while some resistance was faced in seven patients and it was impossible in three patients.

**Table 2** Technical parameters of block

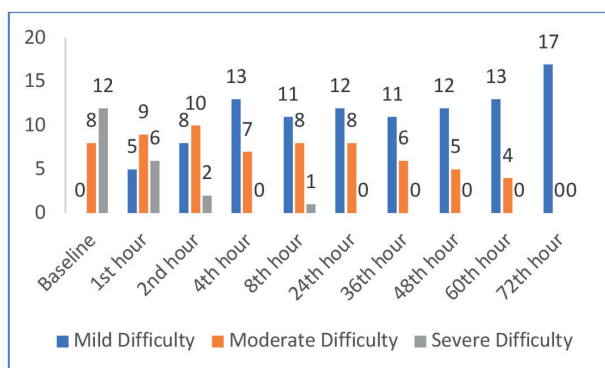
Technical Parameters	
Level of thoracic paravertebral block	
T2-T3	3 (15%)
T3-T4	6 (30%)
T4-T5	2 (10%)
T5-T6	9 (45%)
Mean depth of Needle insertion (Range 2.8- 4.2 cm)	3.42±0.44 cm
Visibility of SCTL	
Excellent	7 (35%)
Good	13(65%)
Distance between skin to transverse process (Range 1.45-3.91 cm)	2.32 ± 0.65 cm
Distance between skin to parietal pleura (Range 3.04-4.4 cm)	3.66± 0.42 cm
Skin to SCTL distance (Range 2.3-4.1 cm)	2.99± 0.51 cm
Grading of catheter insertion	
Easy	10 (50%)
Some resistance encountered	7 (35%)
Not possible	3 (15%)

**Table 3** Mean of arterial blood gas analysis at day 1, day2 and day 3.

	Day 1	Day 2	Day 3	P value
pH	7.40±0.10	7.42±0.03	7.41 ±0.04	0.549
Po2 in mm Hg	77.45±24.59	89.82±25.76*	95.96±20.71*	<0.001
PCo2 in mm Hg	40.54±7.08	37.58±5.31	38.77±3.96	0.354
HCo3 in mmol/L	25.41±5.52	25.92±1.76	26.06±2.45	0.991
Spo2 in %	87.66±5.78	91.76±2.63**	92.64±1.93**	0.004

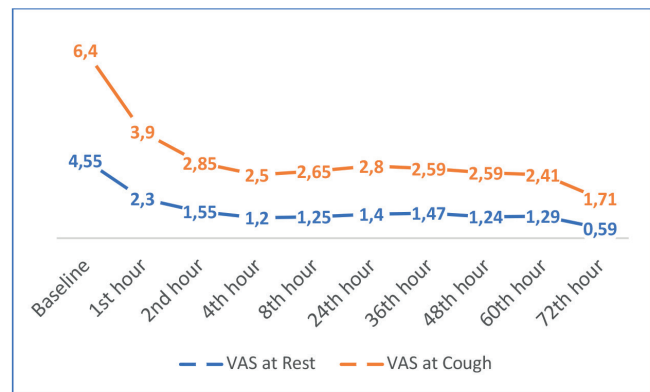


**Figure 4** - Mean comparison of respiratory rate from baseline



**Figure 5** - Ability to breathe and cough deeply

Significant augmentation in pain score was observed both at rest and at cough (p<0.001) during different time intervals when matched to baseline (Figure 3).



**Figure 3** - Comparison of VAS at rest and VAS at cough from baseline

Respiratory function recovered significantly with decrease in respiratory rate (p<0.001) as shown in Figure 4. Blood gas analysis shows significance of Po2 and oxygen saturation at 48 and 72 hours compared to baseline as depicted in Table 3. While mean PaCo2 and pH did not alter much after initial block.

Ability to breathe and cough deeply. Twelve patients had severe difficulty in breathing and eight patients had moderate difficulty in breathing which improved after block, although mild difficulty persisted in few patients as shown in Figure 5.

## Discussion

TPVB commensurate with epidural analgesia in terms of abatement of pain relief with fewer complications [6,7]. The improvement in pain scores, respiratory functions in our study is similar to Mohta et al who used classical landmark guided approach for paravertebral block [4].

In our study we had improvement in respiratory functions and oxygenation till 3 days after continuous paravertebral block, our results are like Karmakar et al who assessed efficacy of continuous infusion of bupivacaine for pain management in unilateral multiple fracture using blind technique [8].

Out of 20 patients catheter insertion was easy in 10 patients (50%), with some resistance 7 (35%) and it was not possible in 3 (15%) patients which can be either due to narrow thoracic paravertebral space or impediment of catheter into endothoracic fascia and these results are similar to Rianin et al [9] and Luyet et al's cadaveric study [10].

An out of plane technique used in our study which had lower needle penetration depth when compared to in plane technique. Once the needle tip penetrated with SCTL and local anaesthetic was administered, the spread of drug was confirmed by the anteriorly pushed pleura.

The ultrasound appearance of SCTL, skin to pleura distance in our study is comparable to the study by Marhofer et al [11] who used out of plane technique for TPVB at T3 and T6 levels in patients with mastectomy.

The use of ultrasound gives great assistance to determine needle insertion site and depth of paravertebral space. Due to superficial location of paravertebral space, TPVB is apt for sonographic assistance. Hence it should be preferred over loss of resistance technique and additional of using ultrasound is avoidance of pleural puncture.

The fundamental step to achieve a successful TPVB using ultrasound guidance by sagittal approach is correct identification of superior costo transverse ligament and pleura. Factors which compromise successful performance in intercostal approach include blood in intercostal space or presence of subcutaneous air due to pneumothorax. During the procedure the practitioner must always view the tip of needle to prevent inadvertent pleural puncture. Small saline infiltration may help in needle localization.

### Limitation of study

Absence of control group, pulmonary functions were not evaluated in detail. More studies are required to assess the effectiveness of the sonographic technique as compared to the conventional loss of resistance technique.

### Conclusion

Ultrasound guided thoracic paravertebral block using sagittal approach in out of plane technique is an easy and applicable method of providing significant pain relief in patients with rib fractures which also helps to improve respiratory functions and oxygenation. The benefit of using ultrasound helps in guidance of needle and visualize the depth of insertion hence prevents the chances of inadvertent pleural puncture.

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