Original Article

# Thoracolumbar curve and Cobb angle in determining spread of spinal anesthesia in Scoliosis. An observational prospective pilot study

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## ABSTRACT

**Background and Aims:** Disparity in spread of spinal anesthesia is a known complication in scoliosis patients. Our primary aim was to compare this disparity based on Cobb Angle and thorocolumbar spine curvature. Secondary aim was to calculate the appropriate lateral angulation of the spinal needle from midline for successful lumbar puncture. **Materials and Methods:** All poliomyelitis patients with scoliosis posted for lower limb orthopedic contracture release surgeries were enrolled into Group A (Cobb Angle <50°), Group B (Cobb Angle >50°), and on thoracolumbar curve into Group R (Right), Group L (Left). Group A, B, R, and L were studied for bilateral spread of spinal anaesthesia. Lateral angle of the spinal needle from midline was noted with Goniometer in groups A and B. Statistical analysis was done using unpaired *t* test and Chi-square test. **Results:** Failures in subarachnoid block (SAB) (unilateral anaesthesia/inadequate/patchy block) was significant in Group B ($P = 0.033$). Segmental disparity in bilateral spread of spinal anaesthesia was significant in Group R with $P$ value of 0.042. Approximate lateral angle for needle in Group A was (4.1 ± 2.45) and in Group B was (9.14 ± 2.45). **Conclusions:** The study showed that there was a strong correlation between right-sided thoracolumbar curve and the spread of spinal anesthesia

**Key words:** Cobb angle, poliomyelitis, quincke needle, spinal anesthesia

## INTRODUCTION

Scoliosis is a deformity of the spine resulting in lateral curvature and rotation of the vertebrae as well as a deformity of the rib cage.[1] It can involve thoracic or lumbar spine or both. Administering spinal anesthesia in scoliotic patients is both challenging and satisfying.[2] Many anesthesiologists are reluctant to administer spinal anesthesia in these patients for the fear of postoperative neurological deficits, multiple attempts required, unpredictability in the level of blockade, and the pattern of blockade during spinal anaesthesia.[3] Data regarding this was scarce. Some case reports mentioned that spinal anaesthesia was safe in these patients compared to general anaesthesia.[4-6] We had little difficulty[7] in providing safe and effective spinal anaesthesia in these patients. We tried to evaluate the placement of spinal needle for spinal anaesthesia using goniometer. This instrument measures lateral angle made by Quincke needle from its midline after noting the free flow of cerebrospinal fluid (CSF). The present study aims at noting the disparity in bilateral spread of spinal anaesthesia in scoliotic patients based on Cobb angle and the curvature of the thoracolumbar spine. We also calculated the appropriate lateral angle



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needed for successful entry into the subarachnoid space in these subset of patients.

## MATERIALS AND METHODS

This is a prospective observational single blinded pilot study. Patients with poliomyelitis with scoliosis, American Society of Anaesthesiologists physical status I/II between 18 and 50 years age, admitted for various lower limb deformity corrective orthopedic surgeries were enrolled in this study over a period of 6 months. After obtaining approval from institutional ethical committee (IEC 861 April 2019 to September 2019), a written informed consent was obtained from all patients enrolled in the study. Cardiovascular and pulmonary assessment including pulmonary function tests were done in all patients as a standard protocol. Lower limb motor power was assessed and noted.

Patients with history of chronic obstructive pulmonary disease (COPD), past history of respiratory failure, prior corrective surgery for scoliosis, cardiac disease like regional wall motion abnormality, congestive cardiac failure, ischaemic heart disease, renal disease like acute or chronic renal failure, raised blood urea and serum creatinine, spinal cord dysfunction, coagulopathy, patient's refusal of regional anesthesia, mentally retarded patients, and pregnant patients were excluded from the study.

A total of 66 patients were enrolled in the study. Preoperative X-ray of thoracolumbar spine (antero-posterior view) was taken and Cobb angle was calculated. The patients were allocated into two groups based on Cobb angle Group A (Cobb angle $<50°$, $N = 40$) and Group B (Cobb angle $>50°$, $N = 26$). Same patients were grouped based on thoracolumbar curve into two groups curve to left (Group L, $N = 34$) and curve to right (Group R, $N = 32$) where $N$ is number of patients. Group A and Group B were also studied for lateral angulation of spinal needle from midline using goniometer.

After shifting the patients to the operation theatre, non-invasive monitors for recording blood pressure, oxygen saturation (SpO2), and electrocardiogram (ECG) were applied, and their baseline values were recorded. Intravenous (IV) access was established using an 18-gauge cannula. Adequate preloading was done with lactated ringer's solution. Patient was made to sit and positioned for spinal anaesthesia. Under aseptic precautions, thoracolumbar spine parts were cleaned and draped and spinous process was palpated along the curvature of scoliotic spine. The midline of L3-L4/L4-L5 interspace was identified palpating spine from C7 prominence, counting vertebrae down from there, until L3, L4, and L5 vertebrae. This was further confirmed with a line drawn at highest point of iliac crest (Tuffier's line) which corresponds to L4 vertebra lower end or L5 vertebra upper end. With 25 G Quincke spinal needle directed towards the convexity of scoliotic curve and subarachnoid space was entered. If any difficulty was noted, then the needle was redirected upwards or downwards slightly and towards concavity side of the scoliotic curve until loss of resistance was felt. Once free and clear flow of CSF was noted, the stylet of Quincke needle was reintroduced to withhold the flow of CSF and using sterile goniometer, the direction of spinal needle from midline (lateral angulation) was noted.

After noting the spinal needle angle from midline using goniometer, 10 mg (2 ml) of 0.5% hyperbaric Bupivacaine (Sensorcaine 5 mg/ml with Dextrose 80 mg/ml) was administered intrathecally and the patient returned to the supine position immediately. This time was noted as zero time interval. The time taken for bilateral spread of spinal anesthesia and maximum height of sensory block was noted with pinprick technique using 24G blunt needle at 5, 10, 15, and 30 min after injection. Motor power was not recorded. Failed subarachnoid blocks were those in which either sensory block was inadequate (level of the block is below L1 or inguinal region) or the block was patchy or unilateral and converted to general anesthesia. Heart rate, blood pressure, peripheral oxygen saturation (SpO2), and electrocardiogram (ECG) were monitored during the procedure. If either hypotension (blood pressure below 20% of the preoperative value) and or bradycardia (heart rate below 20% of preoperative value) occured it was treated with injection mephenteramine 6 mg IV bolus along with crystalloids and injection atropine 0.6 mg IV, respectively.

Statistical analysis was done using Windows 7. Continuous data was measured using mean and standard deviation and categorical data presented as numbers and percentage. Disparity in spread of spinal anaesthesia based on Cobb angle and thoracolumbar curve was calculated using Chi-square test. Mean needle angle was calculated using Student's *t*-test.

## RESULTS

A total of 66 patients were enrolled for the study. The demographic data such as age and gender were comparable in both groups [$P > 0.05$, Table 1]. A total of 32 patients had thoracolumbar curve deviated to right and 34 patients had the deviation to left which was not statistically significant. The mean Cobb angle was 22.18 in group A and 59.08 in group B.

One to two segment disparity in spread of spinal anesthesia was not statistically significant between group A and group B. Failure of SAB was observed in higher number of patients in group B (26.9%) when compared to group A (7.5%), with statistically significant difference ($P = 0.0330$) [Table 2].

Bilateral equal spread of local anesthetic agent was noted in 52.9% of patients with left sided thoracolumbar curve (group L), while it was noted in only 28.1% patients with right sided thoracolumbar curve (group R) which was statistically significant with $P$ value of 0.042 [Table 3]. The six segments disparity was noted in patients with right sided curves with $P$ value of 0.069 which did not have any statistical significance but may be of clinical relevance. More incidences of failed SAB were noted in patients with right sided curves (21.9%) when compared to left sided curves (8.8%). This was not statistically significant ($P$ value of 0.141) [Table 3].

In our study we observed that Quincke needle had to be inserted at a lateral angle of 4.1° ± 2.45° in patients of group A and at an angle of 9.14° ± 2.45° in group B patients from midline [Table 4].

**Table 1: Demographic data**

| Variables | Group A (Cobb angle <50) | Group B (Cobb angle >50) |
|---|---|---|
| Age (years) (Mean) | 22.75 | 23.62 |
| Male:Female ratio (*n*) | 20/20 | 15/11 |
| TL Curve (R/L) (*n*) | 17/23 | 15/11 |
| Cobb angle (Mean) | 22.18 | 59.08 |

Data are represented as mean±SD or number of patients. SD – Standard deviation

**Table 2: Disparity in bilateral spread of spinal anaesthesia based on Cobb angle described in percentages**

| Disparity | Group A (*n*=40) | Group B (*n*=26) | Chi-square value | *P* |
|---|---|---|---|---|
| No segment | 18 (45) | 10 (38.5) | 0.268 | 0.604 |
| 1-2 segment | 16 (40) | 5 (19.2) | 3.095 | 0.079 |
| 3-5 segment | 2 (5) | 2 (7.7) | 0.199 | 0.656 |
| ≥6 segment | 1 (2.5) | 2 (7.7) | 0.967 | 0.326 |
| Failed SAB | 3 (7.5) | 7 (26.9) | 4.545 | 0.033 |

Values are expressed as number (percentage). SAB – Subarachnoid block

**Table 3: Disparity in bilateral spread of spinal anaesthesia based on thoracolumbar curve shown in percentages**

| Disparity | Group R (*n*=32) | Group L curve (*n*=34) | Chi-square test | *P* |
|---|---|---|---|---|
| No segment | 9 (28.1) | 18 (52.9) | 4.132 | 0.042 |
| 1-2 segment | 10 (31.3) | 12 (35.3) | 0.117 | 0.733 |
| 3-5 segment | 3 (9.4) | 1 (2.9) | 1.206 | 0.272 |
| ≥6 segment | 3 (9.4) | 0 (0) | 3.298 | 0.069 |
| Failed SAB | 7 (21.9) | 3 (8.8) | 2.167 | 0.141 |

Values are expressed as number (percentage). SAB – Subarachnoid block

**Table 4: Mean Quinkieneedle angle from midline based on Cobb angle**

| Variable | Group A (*n*=40) | Group B (*n*=26) | *t*-Statistics | *P* |
|---|---|---|---|---|
| Mean needle angle | 4.1°±2.45° | 9.14°±2.45° | 2.056 | 0.04 |

Values are expressed as mean±SD. SD – Standard deviation

## DISCUSSION

Scoliotic curve can be either left or right sided. Most right sided curves are thoracic and are seen in female population. Left sided curves are less common and are usually at the lumbar level. Though surgery is performed when the Cobb angle exceeds 50° in the thoracic spine and 40° in the lumbar spine, patients with poliomyelitis with scoliosis can tolerate even more significant degrees of angulation without the need for surgical correction. Studies have shown that this is the angle at which respiratory insufficiency occurs.[8,9]

The salient feature of our study was the required angulation for a successful intrathecal puncture was derived. Investigators have suggested techniques like use of high-tech imaging modalities to assess the depth and intervertebral space identification to guide the needle angulation for a successful lumbar puncture.[10] In our study, with the use of simple instrument (Goniometer), we found that an acute angulation of 4° ± 2.45° for Cobb angle <50° and 9.14° ± 2.45° for Cobb angle >50° was noted for successful SAB. This was easier and the best way to approximate needle angle for successful SAB based on severity of scoliotic curve. As with Collier's study we chose to give through median approach and our success rate was 100%.[11] We hope that this would guide the anesthesiologists in performing spinal anesthesia in a better way.

Second finding, Cobb angle >50 increases the risk of failed spinal arachnoid blocks. In our earlier studies we had noted that the patient with scoliotic spine had higher disparity in spread of spinal anesthesia compared to normal patients. Out of 21 patients in scoliotic group one case had inadequate block and was converted to general anesthesia.[7] However, we had neither measured the Cobb angle nor the side of thoracolumbar curve in scoliotic group.

Hence in the present study we wanted to find the effect of Cobb angle and thoracolumbar curve in causing the disparity in the spread of spinal anesthesia. However, we found that a significant number of patients (7 out of 26; having *P* value of 0.033) had failed subarachnoid block necessitating supplemental anesthesia with Cobb angle >50°. Other case reports also had unilateral block with Cobb angle >45°.[12] In our earlier study we also reported a case of unilateral block in scoliotic group.[11]

The reason for greater association of failed SABs with higher Cobb angle could be explained by several theories:-

Bozeman had reported unilateral anesthesia even with second epidural bolus dose and further gave spinal anesthesia which was also unilatera. He explained that the possible reason could be presence of anomalous congenital midline diffusion barrier in both the epidural and subarachnoid spaces.[13]

Lund PC postulated that the pia mater is a thin vascular membrane that closely invests the spinal cord and extends four ligamentous projections to dura. It is conceivable that if these ligaments were over developed and unbroken, this may interfere with the subarachnoid spread of local anaesthetics and result in unilateral subarachnoid block.[14]

Several remedies have been tried to overcome this unilateral blockade, such as placing the patient on the side less blocked, and a technique using a large-volume/low-concentration local anesthetic solution.[15] Augmentation of an asymmetric block by placement of an additional epidural catheter at the level of the unblocked dermatome had also been described.[16] However, this technique confers the theoretical risk of catheter intertwining with shearing, or avulsing the *in situ* catheter.

Third finding was that spread of spinal anesthesia depends on the curvature of the scoliotic spine. In our study one interesting finding was that disparity in the spread of spinal anesthesia was more in right sided curve when compared to left sided thoracolumbar curve (Table 3, no segment disparity, *P* value = 0.042).

To our knowledge, this is the first study evaluating the effect of thoracolumbar curve on the spread of spinal anesthesia, although few case reports have described on the spread of spinal anesthesia based on Cobb angle.[17,18] There is another case report in pediatric age describing epidural anesthesia as a safe mode with Cobb angle >90° but side of thoracolumbar curve is not observed.[19]

Our study result shows that failed SAB is more common in patients with Cobb angle of more than 50°. This may necessitate a clinician to consider using advanced technique like ultrasound-assisted neuraxial block in patients with higher Cobb angle to reduce the failure rate. In addition more number of patients with right sided thoracolumbar curve had more than six segment disparity in spread of local anesthesia compared to none in left sided thoracolumbar curve. Though this difference did not reach statistical significance, it may have some implication while giving hemispinal and the patients positioning after SAB for optimal blockade of the pain pathways for the required surgery.

From our study we could infer that there could be a strong correlation between right sided scoliotic curve and spread of spinal anesthesia and probable reason we could find was adhesion of pia mater to the spinal cord at maximum vertebral rotation of spine leading to disparity in right sided curve.

The main limitation of our study was unavailability of the imaging modalities to know intra-thecal spread of drug based on thoracolumbar curve and also to find which side (convex or concave side) of curve is blocked higher, This needs extrapolation to a large population for better results.

## CONCLUSIONS

We conclude that significant disparities in spread of spinal anesthesia were noted due to curvature of thoracolumbar curve to right and number of failed spinal blocks was due to higher Cobb angle (Cobb angle >50°). So one should keep in mind curvature of thoracolumbar spine along with Cobb angle in performing and assessing sensory block. We hope that this study will guide the anesthesiologists in proper planning of spinal anesthesia and to find possible techniques to minimise the disparities in spread of spinal anaesthesia in this subset of patients.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.


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Nil.


### Conflicts of interest

There are no conflicts of interest.

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