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Optimal Point Of Needle Insertion And Angle Of Entry For Successful Paraspinous Lumbar Subarachnoid Block At L3-L4 By Landmark Technique: A Comparative Pilot Study

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Abstract
Background: *Landmark based spinal anesthesia remains common where ultrasound is not routinely available. Midline access may become difficult when the interspinous pathway is narrow or poorly palpable. A standardized paraspinous entry point may provide a reproducible route to the L3-L4 subarachnoid space.*
Objective: *The study assessed final horizontal and vertical needle angles required for successful paraspinous lumbar subarachnoid block at L3-L4 from three defined entry points.*
Methods: *This randomized comparative pilot study included 90 adult ASA physical status I or II patients with BMI below 30 kg/m2. Participants were allocated equally to entry points 0.5 cm lateral and 0.5 cm caudal, 0.5 cm lateral and 0.75 cm caudal or 0.75 cm lateral and 0.75 cm caudal from the inferior tip of the L3 spinous process. Angles, attempts, redirections, depth, success, rescue methods and complications were recorded.*
Results: *Horizontal angulation increased from 2.10 ± 0.92 degrees to 6.20 ± 1.19 degrees and 13.60 ± 1.73 degrees across the three groups. Vertical angulation increased from 1.77 ± 0.77 degrees to 5.10 ± 1.03 degrees and 13.20 ± 1.67 degrees. Both angle comparisons were significant with $p<0.001$. Needle insertion attempts and redirections also increased across groups. Skin to subarachnoid distance remained similar among groups with $p=0.730$. All 90 procedures were successful without rescue technique or recorded complication.*
Conclusion: *The closest paraspinous entry point, 0.5 cm lateral and 0.5 cm caudal to the inferior tip of the L3 spinous process, achieved successful L3-L4 subarachnoid access with the smallest horizontal and vertical angulation and fewer needle manipulations. The findings support this entry point as a simple landmark based option for non obese adults with clinically normal spines.*
Keywords: *spinal anesthesia; subarachnoid block; paraspinous approach; paramedian approach; lumbar spine; landmark technique*

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I. Introduction

Spinal anesthesia provides dense sensory and motor block for lower abdominal, pelvic and lower limb surgery. Its reliability depends on accurate identification of the lumbar interspace, appropriate patient position and controlled advancement of the needle into the subarachnoid space. Lumbar neuraxial ultrasound has improved anatomical understanding of these steps and has shown that surface landmarks may not always predict the true interspace or needle depth.[1]

The midline route remains the conventional approach. It is familiar, quick in patients with favorable anatomy and easy to teach. Technical failure becomes more likely when the interspinous gap is narrow, spinal flexion is limited or the spinous processes are poorly palpable. Chin et al. described an ultrasound assisted paraspinous method that bypasses midline ligaments and targets the interlaminar window from a lateral entry point.[2]

Real time ultrasound guided and ultrasound assisted spinal techniques show that needle trajectory can be planned with greater precision when the interlaminar window and expected depth are known. These methods are valuable but they need equipment, training and added procedural time. Landmark guided spinal anesthesia therefore remains important in many operating rooms.[3]

Patients with distorted spinal anatomy can make the midline route difficult because bone contact, repeated redirection and failed dural puncture occur more often. Bowens et al. showed that severe scoliosis demands an adapted neuraxial strategy rather than repeated midline attempts.[4]

Needle depth is also influenced by patient habitus. Mahmoudi et al. reported a positive relation between BMI and skin to spinal canal distance. Their finding is clinically relevant because insufficient needle length or poor estimation of depth may increase manipulation and tissue trauma.[5]

The geometric relation among puncture point, entry angle and target window is central to procedural success. Vogt et al. described how insertion point and angle can be optimized for neuraxial blockade. Kim et al. also showed that spinal pathology changes the desired angle of needle insertion. These observations support study of a standardized paraspinous point under landmark guidance.[6-7]

Obesity can obscure landmarks and increase technical difficulty. O Donnell et al. described ultrasound assisted spinal anesthesia in obese patients and highlighted the value of anticipating depth and trajectory before puncture. The present pilot study was restricted to patients with BMI below 30 kg/m2 to reduce this source of technical variation.[8]

The present study aimed to determine and compare the final horizontal and vertical angles of needle entry for successful paraspinous lumbar subarachnoid block at L3-L4 using three closely spaced landmark based entry points. Secondary outcomes included insertion attempts, redirections, skin to subarachnoid distance, failure, rescue method, block side and complications.

II. Materials And Methods

Study design and setting

This randomized comparative pilot study was conducted in the operation theatres of the Department of Anaesthesiology, School of Medical Sciences & Research and Sharda Hospital, Greater Noida, India. The study evaluated three paraspinous entry coordinates for lumbar subarachnoid block at L3-L4 using a landmark technique.

Participants

Adult patients aged 18 to 60 years who were scheduled for lower abdominal, inguinal, gynecological, genitourinary or lower limb surgery under lumbar subarachnoid block were considered eligible. Participants had ASA physical status I or II and BMI below 30 kg/m2. ASA physical status was recorded as part of baseline assessment.[9]

Patients were excluded if they declined consent or had infection at the puncture site, coagulation disorder, spinal deformity, prior spine surgery, spinal fracture, spinal metastasis, raised intracranial tension, uncontrolled hypertension, hypersensitivity to local anesthetic or BMI of 30 kg/m2 or higher.

Ethical considerations

The institutional ethics committee approved the protocol. Written informed consent was obtained before enrolment. The study was conducted according to institutional requirements and ethical principles for research involving human participants.[10]

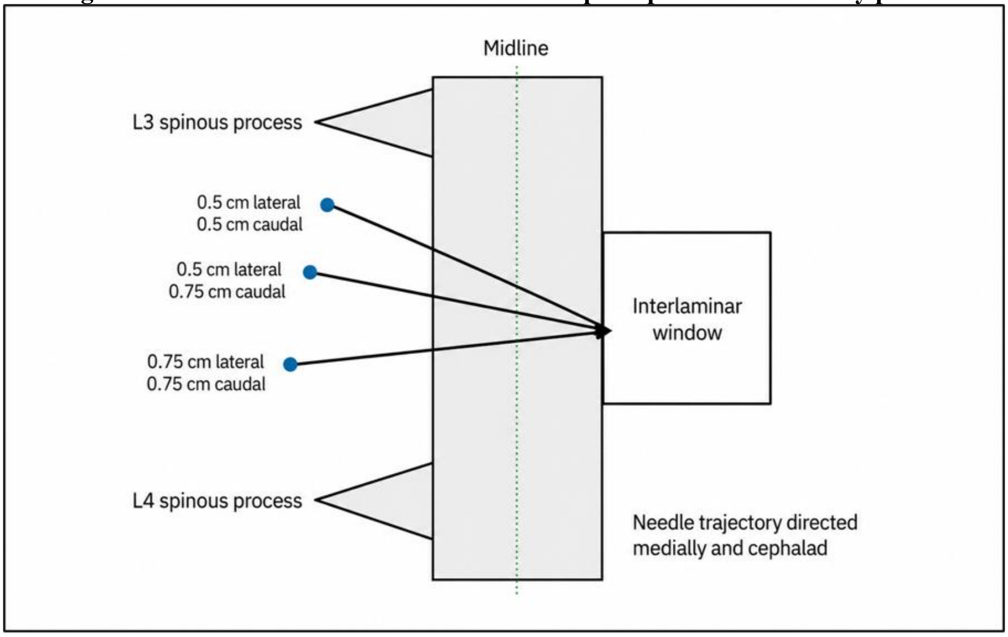
Randomization and study groups

Ninety patients were allocated equally to one of three entry points measured from the inferior tip of the L3 spinous process: 0.5 cm lateral and 0.5 cm caudal, 0.5 cm lateral and 0.75 cm caudal or 0.75 cm lateral and 0.75 cm caudal. Each group included 30 patients.

Procedure

Patients were positioned sitting. The T7, T12 and L4 landmarks were identified and the L3 and L4 spinous processes were marked. The inferior tip of the L3 spinous process served as the reference landmark. Putative right and left entry points were marked for the allocated coordinate. All procedures in the dataset used right sided entry. The needle was advanced toward the L3-L4 interlaminar window. Final horizontal and vertical angulation were recorded after successful entry into the subarachnoid space.

Figure 1. Anatomical schematic of the studied paraspinous L3-L4 entry points.



Legend: The figure shows three lateral and caudal offsets from the inferior tip of the L3 spinous process. The arrows indicate the intended medial and cephalad trajectory toward the interlaminar window. The caption and legend are outside the image.

Outcomes

The primary outcomes were final horizontal and vertical needle angles required for successful subarachnoid entry. Secondary outcomes were number of needle insertion attempts, number of redirections, distance from skin to the subarachnoid space, success, failure, rescue method, side of successful block and recorded complications.

Statistical analysis

Continuous variables were summarized as mean ± standard deviation and range. Categorical variables were summarized as frequency and percentage. Between group comparisons used one way analysis of variance for continuous variables and chi square testing for categorical variables. A p value below 0.05 was considered statistically significant.

III. Results

The study included 90 patients with equal allocation to the three entry point groups. Each group included 30 participants. Baseline BMI was similar across groups. Age, weight and height differed statistically across groups but all participants met the planned eligibility limits.

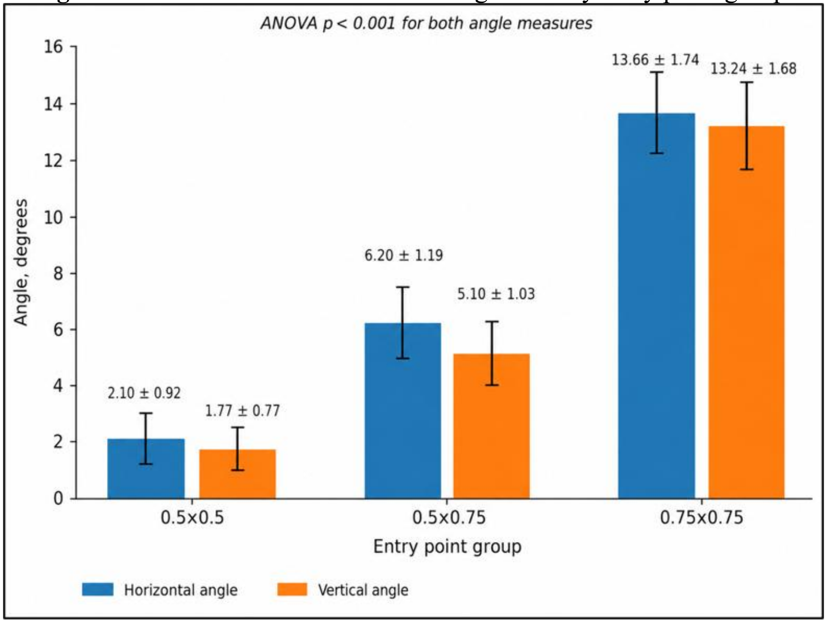
Table 1. Baseline demographic and clinical characteristics by entry point group.

Variable	0.5x0.5	0.5x0.75	0.75x0.75	p value
Age, years	41.90 ± 9.58	46.23 ± 9.02	36.60 ± 11.49	0.002
Weight, kg	59.13 ± 6.27	62.00 ± 4.99	66.97 ± 4.37	<0.001
Height, cm	156.03 ± 7.82	161.10 ± 7.08	166.50 ± 5.38	<0.001
BMI, kg/m2	24.28 ± 1.54	23.92 ± 1.68	24.12 ± 1.57	0.681
Sex F, n (%)	19 (63.3%)	18 (60.0%)	8 (26.7%)	0.007
Sex M, n (%)	11 (36.7%)	12 (40.0%)	22 (73.3%)	
ASA physical status I, n (%)	22 (73.3%)	19 (63.3%)	25 (83.3%)	0.216
ASA physical status II, n (%)	8 (26.7%)	11 (36.7%)	5 (16.7%)	
MMP class I, n (%)	16 (53.3%)	16 (53.3%)	24 (80.0%)	0.049
MMP class II, n (%)	14 (46.7%)	14 (46.7%)	6 (20.0%)	

Values are mean ± SD or n (%). MMP: Modified Mallampati classification; ASA: American Society of Anesthesiologists physical status.

Horizontal and vertical angulation increased as the puncture point moved farther lateral and caudal from the L3 reference point. The 0.5x0.5 group required the smallest angles. The 0.75x0.75 group required the greatest horizontal and vertical angulation. Both comparisons were significant.

Figure 2. Final horizontal and vertical angulation by entry point group.



Legend: Blue bars represent horizontal angulation and orange bars represent vertical angulation. Error bars indicate standard deviation. Both angle measures differed significantly among groups by analysis of variance.

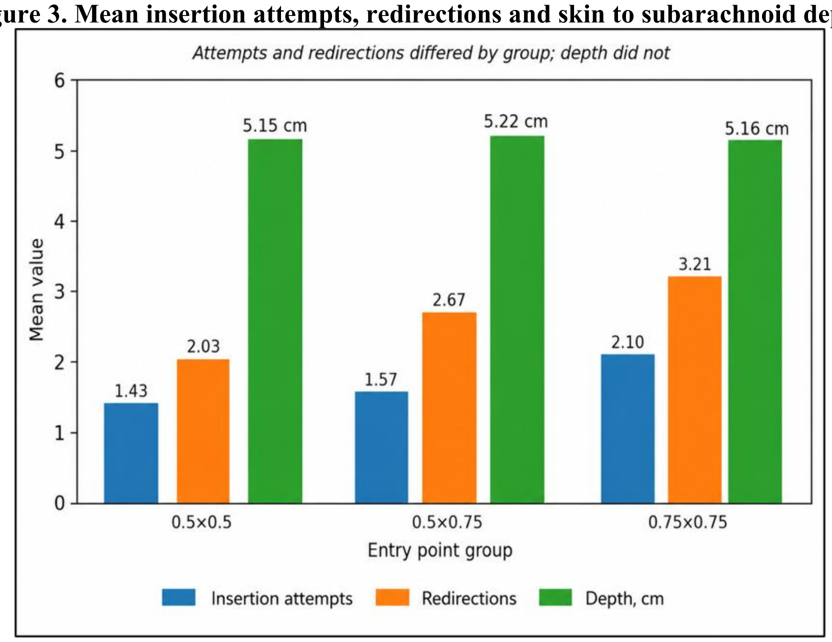
Table 2. Procedural parameters by entry point group.

Measure	0.5x0.5	0.5x0.75	0.75x0.75	p value
Horizontal angulation, degrees	2.10 ± 0.92	6.20 ± 1.19	13.60 ± 1.73	<0.001
Vertical angulation, degrees	1.77 ± 0.77	5.10 ± 1.03	13.20 ± 1.67	<0.001
Needle insertion attempts	1.43 ± 0.50	1.57 ± 0.68	2.13 ± 0.73	<0.001
Needle redirection attempts	2.03 ± 0.72	2.67 ± 0.96	3.20 ± 0.85	<0.001
Skin to subarachnoid distance, cm	5.15 ± 0.36	5.22 ± 0.38	5.15 ± 0.44	0.730

Values are mean ± SD. ANOVA was used for between group comparisons.

Needle insertion attempts and redirections increased across the three entry point groups. Skin to subarachnoid distance stayed similar, which shows that entry point changed trajectory more than final depth.

Figure 3. Mean insertion attempts, redirections and skin to subarachnoid depth.



Legend: Blue bars represent insertion attempts, orange bars represent redirections and green bars represent skin to subarachnoid depth in centimeters. Attempts and redirections increased with more lateral and caudal entry points; depth remained similar among groups.

All surface landmarks were identified and marked in every participant. All 90 blocks were successful using the study technique. No patient required rescue technique. No complication was recorded.

Table 3. Landmark marking, success, rescue method and complications.

Variable	0.5x0.5	0.5x0.75	0.75x0.75	p value
Surface landmarks identified	30 (100.0%)	30 (100.0%)	30 (100.0%)	1.000
Inferior tip of L3 spinous process identified	30 (100.0%)	30 (100.0%)	30 (100.0%)	1.000
Putative entry point marked bilaterally	30 (100.0%)	30 (100.0%)	30 (100.0%)	1.000
Right sided entry used	30 (100.0%)	30 (100.0%)	30 (100.0%)	1.000
Successful block	30 (100.0%)	30 (100.0%)	30 (100.0%)	1.000
Failure encountered	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000
Rescue method required	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000
Recorded complication	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000

Values are n (%). All procedures were performed from the right side.

Depth measurements showed that the ligamentum flavum was identified at a mean depth of 4.24 ± 0.39 cm during a straight trajectory. In the lamina medial trajectory, ipsilateral lamina contact occurred at 3.11 ± 0.19 cm and medial ligamentum flavum identification occurred at 4.94 ± 0.43 cm. BMI correlated positively with skin to subarachnoid distance.

Table 4. Depth landmarks and BMI relation to skin to subarachnoid distance.

Variable	n	Mean ± SD or effect estimate	Range or p value
Straight trajectory: ligamentum flavum identified	43	4.24 ± 0.39	3.60 to 5.10
Lamina medial trajectory: ipsilateral lamina contact	47	3.11 ± 0.19	2.70 to 3.50
Lamina medial trajectory: medial point of lamina	47	3.74 ± 0.32	3.10 to 4.50
Lamina medial trajectory: ligamentum flavum identified medially	47	4.94 ± 0.43	4.20 to 5.80
BMI versus skin to subarachnoid distance	90	Pearson r = 0.504	<0.001

LF: ligamentum flavum. Correlation row reports Pearson correlation.

IV. Discussion

This pilot study showed that all three paraspinous entry points achieved successful L3-L4 subarachnoid access in non obese adults with clinically normal spines. The closest coordinate, 0.5 cm lateral and 0.5 cm caudal to the inferior tip of L3, required the smallest horizontal and vertical angulation. It also required fewer insertion attempts and fewer redirections. The more lateral and caudal coordinate required steeper angulation and more needle manipulation.

The findings are consistent with technical descriptions of neuraxial ultrasound. Kalagara et al. described how ultrasound can show midline, interspinous level, interlaminar window and estimated depth before central neuraxial blockade. The present data provide a complementary landmark based estimate of trajectory in a restricted patient population.[11]

Park et al. compared ultrasound assisted and landmark guided paramedian spinal anesthesia in elderly patients and found that ultrasound assistance can improve technical performance. The present study differs because it did not use ultrasound during the procedure and focused on non obese adults with normal spinal columns. The similarity lies in the emphasis on a reproducible lateral corridor rather than repeated midline puncture.[12]

Bae et al. showed that interlaminar space varies according to age, laterality, patient position and spinal level. That observation helps explain why a single puncture direction may not suit every patient. The current study held the level and position constant and examined small coordinate changes around one surface landmark.[13]

Zeng et al. reported the use of an ultrasound assisted modified paramedian technique in elderly patients. Chen et al. evaluated modified paramedian technique during residency training. Both studies support the idea that a more standardized lateral route can reduce uncertainty during spinal access. The current study adds measured horizontal and vertical angles for a simple landmark based paraspinous technique.[14-15]

The increase in attempts and redirections at the 0.75x0.75 coordinate may have practical relevance. Chin et al. showed that ultrasound imaging facilitates spinal anesthesia in adults with difficult surface landmarks. Hong et al. showed that needle design affects headache risk. Weji et al. and Lybecker et al. reported that patient and procedural factors influence post dural puncture headache incidence. Reduced manipulation may therefore be desirable even when the final success rate is high.[16-19]

Turnbull and Shepherd described the mechanism of post dural puncture headache in relation to dural defect and cerebrospinal fluid leakage. Multiple punctures and extensive needle manipulation can plausibly increase tissue trauma. No patient in the present cohort had a recorded complication but the sample size was too small to estimate rare events.[20]

The positive relation between BMI and skin to subarachnoid depth in this dataset agrees with studies that link body habitus to spinal needle depth. Kumari et al. also showed how spinal deformity can affect spinal anesthesia. These findings indicate that the present coordinate system should be applied cautiously outside non obese patients with normal spinal anatomy.[21]

Large series and advisory documents show that serious neuraxial complications are uncommon but important. Cook et al. reported major complications after central neuraxial block. Moen et al. described severe neurological complications after neuraxial blockade in Sweden. Neal et al. and Horlocker et al. provided risk reduction guidance for regional and neuraxial practice. The current study was not powered to assess such complications but its focus on reducing attempts is consistent with safer procedural practice.[22-25]

Posterior lumbar anatomy also supports the rationale for a controlled lateral approach. Tran et al. described clinically relevant anatomy of lumbar dorsal rami. Rabelo et al. discussed paraspinal lumbar access through the Wiltse corridor. These anatomical concepts indicate that lateral routes can be systematic rather than improvised when the entry point and trajectory are defined.[26-27]

Bhardwaj et al. compared landmark, preprocedural ultrasound assisted and real time ultrasound guided approaches for paramedian subarachnoid block. Kiaei et al. compared lateral and modified lateral approaches. George and Kakati reported a comparison of median and paramedian spinal anesthesia in elderly patients. These studies show ongoing interest in alternatives to the midline route and support further study of simple paraspinous coordinates.[28-30]

V. Strengths And Limitations

The study used clearly defined entry coordinates, equal group allocation and direct measurement of horizontal and vertical angulation. The main limitation is its pilot design. The sample was restricted to non obese adults with clinically normal spines. The study was not powered to detect rare complications or small differences in success rate. Operator experience may also influence the number of attempts and redirections.

VI. Conclusion

A paraspinous entry point 0.5 cm lateral and 0.5 cm caudal to the inferior tip of the L3 spinous process achieved successful L3-L4 subarachnoid block with the smallest horizontal and vertical angles and fewer needle manipulations. More lateral and caudal entry required greater angulation and more redirections without changing skin to subarachnoid distance. The findings support the 0.5x0.5 coordinate as a practical starting point for landmark based paraspinous spinal anesthesia in non obese adults with normal spinal anatomy.

Declarations

Ethics approval: The study was approved by the institutional ethics committee of SMS&R, Sharda University. Written informed consent was obtained from all participants.

Funding: No external funding was reported in the thesis source document.

Conflicts of interest: None declared.

Data availability: The deidentified case record data are summarized in the tables and figures of this manuscript.

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