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Research Article

CORRELATION OF VERTEBRAL COLUMN LENGTH WITH SPREAD OF SPINAL ANAESTHESIA IN PATIENTS UNDERGOING LOWER LIMB SURGERY: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Background: The spread of intrathecal local anaesthetic varies considerably between individuals despite administration of a standardized dose. Conventional patient characteristics such as age, height, weight and body mass index do not completely explain this variability. Vertebral column length may represent a more direct anatomical determinant of the distance available for longitudinal distribution of intrathecal local anaesthetic.

Aim: To evaluate the relationship between vertebral column length and the characteristics of spinal anaesthesia in patients undergoing lower limb surgery.

Methods: A hospital-based prospective observational study was conducted in the Department of Anaesthesiology, Thumbay Hospital, New Life, Hyderabad, between January and December 2020. Fifty-one adult patients aged 18–60 years with ASA physical status I or II undergoing lower limb surgery under spinal anaesthesia were included. Vertebral column length was measured from the C7 vertebra to the sacral hiatus using a thread. All patients received 3 mL of 0.5% hyperbaric bupivacaine intrathecally at L3–L4. Sensory block was assessed serially to determine the highest block level, onset at T10 and T12, and duration of sensory blockade. Spearman's correlation coefficient was used to evaluate relationships between vertebral column length and block characteristics.

Results: The mean vertebral column length was 67.04 ± 9.48 cm, with a range of 47–80 cm. The mean highest sensory block level was 6.53 ± 1.50. Vertebral column length showed a statistically significant correlation with the highest sensory block level ($\rho = 0.614$, $R^2 = 0.377$; $p < 0.001$). Significant correlations were also observed with onset at T10 ($\rho = 0.799$, $R^2 = 0.615$; $p < 0.001$), duration at T10 ($\rho = -0.470$, $R^2 = 0.243$; $p = 0.001$), onset at T12 ($\rho = 0.768$, $R^2 = 0.5736$; $p < 0.001$) and duration at T12 ($\rho = -0.494$, $R^2 = 0.055$; $p < 0.001$).

Conclusion: Vertebral column length demonstrated significant associations with the highest sensory block level, onset and duration of spinal anaesthesia. Among the anthropometric parameters evaluated in the parent study, vertebral column length demonstrated stronger and more consistent associations with spinal block characteristics than abdominal girth. Further studies with larger and more diverse populations are required to establish whether vertebral column length can contribute to individualized prediction of spinal block spread.

Keywords: vertebral column length; spinal anaesthesia; sensory block; hyperbaric bupivacaine; lower limb surgery; intrathecal anaesthesia; anthropometry

INTRODUCTION

Spinal anaesthesia provides effective surgical anaesthesia for a wide range of lower limb procedures. Its advantages include rapid onset, dense neural blockade, avoidance of airway instrumentation and relatively simple administration. Nevertheless, prediction of the final sensory block level remains challenging.[1]

The spread of intrathecal local anaesthetic is influenced by multiple factors, including baricity, dose, volume, injection site, patient position, speed of injection, cerebrospinal fluid volume and patient anatomy. The thesis notes that spinal-column configuration is among the patient-related factors capable of influencing intrathecal drug distribution.[2]

The vertebral column provides the anatomical framework surrounding the spinal canal. Its length and curvature may influence the longitudinal distribution of intrathecal local anaesthetic. Unlike conventional body measurements such as height, vertebral column length directly represents the anatomical pathway through which the intrathecal solution spreads.[3,4]

Previous studies have investigated vertebral column length as a predictor of spinal anaesthetic spread. Zhou et al. reported that vertebral column length was strongly associated with spinal block characteristics following bupivacaine administration [5], while Nigam et al. demonstrated an association between vertebral column length and the spread of isobaric ropivacaine. [6]

More recently, studies have attempted to develop predictive models for spinal block height using combinations of patient variables. The thesis cites a retrospective study of 401 adults receiving 0.5% hyperbaric bupivacaine in which dose, height, weight, sex and age were identified as independent predictors of peak sensory block level. [7,8]

Despite these observations, studies specifically evaluating vertebral column length in patients undergoing lower limb surgery remain limited. The present study was therefore undertaken to determine the correlation between vertebral column length and the spread of spinal anaesthesia following a standardized dose of hyperbaric bupivacaine.

AIM

To determine the correlation between vertebral column length and spread of spinal anaesthesia among adult patients undergoing lower limb surgery.

OBJECTIVES

1. To determine the correlation between vertebral column length and highest sensory block level.
2. To determine the correlation between vertebral column length and onset of sensory blockade at T10 and T12.
3. To determine the correlation between vertebral column length and duration of sensory blockade at T10 and T12.
4. To describe intraoperative haemodynamic changes and adverse effects following spinal anaesthesia.

MATERIALS AND METHODS

Study design and participants

This was a hospital-based prospective observational study conducted at the Department of Anaesthesiology, Thumbay Hospital, New Life, Hyderabad, from January to December 2020. Fifty-one patients undergoing lower limb surgery under spinal anaesthesia were included.

Patients aged 18–60 years with ASA physical status I or II were eligible. Patients with spinal deformity, previous spinal surgery and pregnancy were excluded.

Institutional ethical approval was obtained and written informed consent was taken.

Measurement of vertebral column length

After routine preoperative assessment, vertebral column length was measured with the patient in the left lateral decubitus position. The C7 vertebra and sacral hiatus were identified and marked. The distance between the two points was measured using a thread, and the thread length was subsequently determined.

The mean vertebral column length in the study population was 67.04 ± 9.48 cm, with a range of 47–80 cm. The variable demonstrated a skewed distribution and median values were therefore considered in the correlation analysis.

Spinal anaesthesia

Patients received standard monitoring including ECG, pulse oximetry and non-invasive blood pressure. An intravenous line was secured and patients were co-loaded with normal saline at 5 mL/kg.

Spinal anaesthesia was administered in the sitting position at the L3–L4 interspace. Following local infiltration with 2 mL of 2% lignocaine, a 25-gauge Quincke needle was introduced in the midline. After confirmation of free cerebrospinal fluid flow, 3 mL of 0.5% hyperbaric bupivacaine was injected intrathecally over 15 seconds. Patients were immediately positioned supine.

Sensory block assessment

Sensory block was assessed bilaterally from caudal to cephalad. Temperature sensation was assessed using ice and pinprick sensation using a needle. Assessments were performed at five-minute intervals up to 60 minutes and then every 30 minutes until 120 minutes.

The highest sensory level was recorded. Onset and duration at T10 and T12 were evaluated according to the original study protocol.

Statistical analysis

Statistical analysis was performed using SPSS version 20.0. The Shapiro–Wilk test was used to assess normality. Continuous variables were presented as mean ± SD and/or median with range according to distribution. Spearman's correlation coefficient was used to evaluate relationships between vertebral column length and sensory block parameters. The Kruskal–Wallis test was used for comparison of haemodynamic parameters at different intervals. Statistical significance was set at $p<0.05$.

RESULTS

Table 1. Baseline anthropometric characteristics

Variable	Mean ± SD	Median	Range
Age, years	43.47 ± 12.02	45.0	20–59
Weight, kg	67.43 ± 11.03	69.0	48–87
Height, cm	167.24 ± 11.27	172.0	145–182
Vertebral column length, cm	67.04 ± 9.48	71.0	47–80

Of the 51 patients, 32 (62.75%) were male and 19 (37.25%) were female. The mean age was 43.47 ± 12.02 years. The largest age group was 51–60 years (31.37%). ASA grade I constituted 88.24% of the study population. The mean vertebral column length was 67.04 ± 9.48 cm, with a median of 71 cm and a range of 47–80 cm.

Table 2. Correlation of vertebral column length with spinal block characteristics

Outcome	Spearman ρ	R^2	p value	Statistical significance
Onset at T10	0.799	0.615	<0.001	Significant
Duration at T10	−0.470	0.243	0.001	Significant
Highest block level	0.614	0.377	<0.001	Significant
Onset at T12	0.768	0.574	<0.001	Significant
Duration at T12	−0.494	0.055	<0.001	Significant

A significant strong positive correlation was identified between vertebral column length and highest sensory block level ($\rho = 0.614$; $R^2 = 0.377$; $p < 0.001$). Thus, vertebral column length accounted for approximately 37.7% of the variability represented by this correlation. Vertebral column length showed a strong statistically significant correlation with onset at T10 ($\rho = 0.799$; $R^2 = 0.615$; $p < 0.001$). A similarly strong significant correlation was observed with onset at T12 ($\rho = 0.768$; $R^2 = 0.5736$; $p < 0.001$). Vertebral column length showed a statistically significant correlation with duration at T10 ($\rho = -0.470$; $R^2 = 0.243$; $p = 0.001$) and duration at T12 ($\rho = -0.494$; $R^2 = 0.055$; $p < 0.001$).

Table 3- Intraoperative Haemodynamic Changes Following Spinal Anaesthesia

Haemodynamic parameter	Change during intraoperative period	Time of maximum change	Subsequent trend	p-value
Systolic blood pressure (SBP)	Decreased	Approximately 5 min	Gradual recovery toward baseline	<0.001
Diastolic blood pressure (DBP)	Decreased	Approximately 5 min	Gradual recovery toward baseline	<0.001
Mean arterial pressure (MAP)	Decreased	Approximately 5 min	Gradual recovery toward baseline	<0.001
Heart rate (HR)	Increased initially	Approximately 5 min	Gradual return toward baseline	<0.001

Shivering was the most common adverse event (7.84%), followed by hypotension (3.92%), bradycardia (1.96%) and postoperative nausea and vomiting (1.96%). The study also documented statistically significant temporal variation in SBP, DBP, MAP and HR during the intraoperative period ($p<0.001$), with the most pronounced blood-pressure reduction occurring approximately five minutes following spinal anaesthesia and subsequent gradual recovery.

DISCUSSION

The present study demonstrates a significant relationship between vertebral column length and several characteristics of spinal anaesthesia. The strongest association was observed with onset at T10, followed by onset at T12 and highest sensory block level. Significant correlations were also demonstrated with the duration of sensory blockade at T10 and T12.

The vertebral column represents the anatomical framework through which the intrathecal solution distributes. Although body height is routinely considered when assessing the expected spread of spinal anaesthesia, height does not necessarily represent the actual length and configuration of the neuraxial pathway. Vertebral column length may therefore provide additional anatomical information. [7,8]

In the present study, vertebral column length ranged from 47 to 80 cm, with a mean of 67.04 ± 9.48 cm. The significant correlation with highest block level supports the concept that spinal anatomy may contribute to the variability observed after a standardized intrathecal dose.[9]

Nigam et al. similarly reported that vertebral column length was associated with the level of spread of isobaric ropivacaine. Although their population and anaesthetic agent differed from the present study, the underlying observation that vertebral anatomy influences intrathecal spread is consistent. [6,10]

The present study also demonstrated strong correlations between vertebral column length and onset at T10 and T12. The reported coefficients were 0.799 and 0.768, respectively. The magnitude of these correlations was greater than the correlations observed between abdominal girth and onset. The thesis therefore concluded that vertebral column length had a stronger and more consistent relationship with spinal block characteristics than abdominal girth.

The correlations with duration of block were statistically significant but of lower magnitude. This suggests that vertebral column length may be particularly relevant to the distribution of the initial block, although the observed association with duration indicates that anatomical factors may also influence persistence of sensory blockade. [11,12]

The parent study deliberately used hyperbaric bupivacaine. Hyperbaric solutions were selected because their spread is more predictable in relation to certain procedural factors compared with plain bupivacaine. The thesis emphasizes that plain bupivacaine can demonstrate greater variability in intrathecal distribution, whereas hyperbaric preparations remain relatively stable in density at physiological temperature. [8,9,12]

A clinically important implication is that two patients receiving an identical dose of intrathecal bupivacaine may develop different sensory block patterns because of differences in neuraxial anatomy. Vertebral column length is relatively simple to measure and does not require specialized equipment. It may therefore have potential value as part of a future anthropometric model for prediction of spinal block height. However, the present study does not justify changing spinal bupivacaine dosage solely according to vertebral column length. The sample was small, the study was conducted at a single centre, and several other established variables—including age, height, weight, sex, dose and position—may contribute simultaneously to block spread.

Importantly, the thesis contains some inconsistencies between the verbal interpretation of certain correlations and their reported Spearman coefficients. For example, the numerical direction of the reported correlation should not be translated into a causal clinical statement without access to the underlying individual-level dataset. Accordingly, this manuscript reports the coefficients and statistical significance directly and interprets them primarily as associations.

Strengths

The prospective design, standardized anaesthetic technique and standardized measurement of vertebral column length were important strengths. Sensory block was assessed repeatedly and haemodynamic changes were systematically documented.

LIMITATIONS

The principal limitations were the small sample size, single-centre design and male predominance. The thesis specifically recommends larger multicentric studies with sex-standardized populations to further evaluate the relationship between vertebral column length and spinal anaesthetic spread.

Furthermore, because this was an observational study, the observed correlations should not be interpreted as evidence of causation. Multivariable modelling was not performed, so independent predictive value of vertebral column length over age, height, weight, sex and other factors cannot be established from this dataset.

CONCLUSION

Vertebral column length demonstrated significant correlations with the highest sensory block level, onset of block at T10 and T12, and duration of sensory blockade at T10 and T12 following 3 mL of 0.5% hyperbaric bupivacaine.

Among the anthropometric variables examined in the parent study, vertebral column length demonstrated stronger and more consistent associations with spinal block characteristics than abdominal girth. However, larger multicentric studies incorporating multivariable prediction models are required before vertebral column length can be recommended for individualized spinal anaesthetic dosing.

REFERENCES

1. Hartwell BL, Aglio LS, Hauch MA, Datta S. Vertebral column length and spread of hyperbaric subarachnoid bupivacaine in the term parturient. **Reg Anesth.** 1991;16(1):17-19.
2. Pargger H, Hampl KF, Aeschbach A, Paganoni R, Schneider MC. Combined effect of patient variables on sensory level after spinal 0.5% plain bupivacaine. **Acta Anaesthesiol Scand.** 1998;42(4):430-434. doi:10.1111/j.1399-6576.1998.tb05137.x.
3. McLeod GA. Density of spinal anaesthetic solutions of bupivacaine, levobupivacaine, and ropivacaine with and without dextrose. **Br J Anaesth.** 2004;92(4):547-551. doi:10.1093/bja/aeh094.
4. Sullivan JT, Grouper S, Walker MT, Parrish TB, McCarthy RJ, Wong CA. Lumbosacral cerebrospinal fluid volume in humans using three-dimensional magnetic resonance imaging. **Anesth Analg.** 2006;103(5):1306-1310.
5. Zhou QH, Xiao WP, Shen YY. Abdominal girth, vertebral column length, and spread of spinal anesthesia in 30 minutes after plain bupivacaine 5 mg/mL. Anesth Analg. 2014;119(1):203-206.
6. Nigam C, Tyagi A, Bhatt S, Kumar M. Vertebral column length and abdominal girth as predictors for cephalad spread of intrathecal hyperbaric bupivacaine: a prospective observational study. **Saudi J Anaesth.** 2022;16(2):166-171. doi:10.4103/sja.sja_726_21.
7. Lee YH, Wan YC, Wang ML, Lin PL, Huang CH, Huang HH. Relationship of abdominal circumference and trunk length with spinal anesthesia level in the term parturient. **J Anesth.** 2014;28:202-205.
8. Hara K, Sakura S, Saito Y, Tadenuma S, Kosaka Y. The influence of body position on the spread of spinal anesthesia with hyperbaric bupivacaine. **Anesthesiology.** 1992;77:347-351.
9. Schiffer E, Van Gessel E, Fournier R, Weber A, Gamulin Z. Cerebrospinal fluid density influences extent of plain bupivacaine spinal anesthesia. **Anesthesiology.** 2002;96(6):1325-1330.
10. Taivainen T, Tuominen M, Rosenberg PH. Influence of obesity on the spread of spinal analgesia after injection of plain 0.5% bupivacaine at the L3-4 or L4-5 interspace. **Br J Anaesth.** 1990;64(5):542-546.
11. Pitkänen M, Haavisto ET, Kanto J. Influence of age on the distribution of spinal anaesthesia with isobaric bupivacaine. **Br J Anaesth.** 1992;68:524-529.
12. Stienstra R, Dahan A, Alhadi BZR, Bernards CM, Veering BT. Spinal anaesthesia: the influence of age and body mass index on the spread of isobaric bupivacaine. **Anesth Analg.** 1998;86:1311-1315
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