Section: Anaesthesiology

Original Research Article

EFFECT OF ABDOMINAL GIRTH, VERTEBRAL COLUMN LENGTH, AND BODY MASS INDEX ON THE SPREAD OF SPINAL ANESTHESIA IN TERM PARTURIENTS UNDERGOING ELECTIVE CAESAREAN SECTION

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Corresponding Author:
Dr. Hariom Khandelwal,
Email: drhkhandelwal00@rediffmail.com

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Manaswita Bisht[1], Tenzin Kyizom[2], Nigar Bari[3], Hariom Khandelwal[4], Kanika Sachdeva[5]

[1]Manaswita Bisht, Junior Resident, Department of Anaesthesiology, Shri Guru Ram Rai Institute of Medical and Health Sciences, India.
[2]Tenzin Kyizom, Associate Professor, Department of Anaesthesiology, Shri Guru Ram Rai Institute of Medical and Health Sciences, India.
[3]Nigar Bari, Associate Professor, Department of Anaesthesiology, Shri Guru Ram Rai Institute of Medical and Health Sciences, India.
[4]Hariom Khandelwal, Professor, Department of Anaesthesiology, Shri Guru Ram Rai Institute of Medical and Health Sciences, India.
[5]Kanika Sachdeva, Associate Professor, Department of Anaesthesiology, Shri Guru Ram Rai Institute of Medical and Health Sciences, India.

ABSTRACT

Background: Spinal anaesthesia is widely preferred for elective caesarean sections due to its efficacy and safety. However, variability in block spread remains a concern, influenced by multiple maternal anthropometric parameters. **Objectives:** To evaluate the relationship between abdominal circumference (AC), vertebral column length (VCL), VCL/AC² ratio, and body mass index (BMI) with the cephalad spread of spinal anaesthesia in term parturients undergoing elective caesarean section. **Materials and Methods:** This prospective observational study included 196 term parturients. Measurements of AC, VCL, BMI, and VCL/AC² were recorded. A standardized spinal anaesthetic technique was followed. Sensory and motor block characteristics, hemodynamic changes, and complications were analysed using non-parametric statistical tools. **Result:** Greater AC and BMI were associated with faster sensory onset and higher block height. VCL and VCL/AC² correlated significantly with anaesthetic spread parameters. Age showed no significant association. Most participants tolerated anaesthesia well, with minimal complications. **Conclusion:** Abdominal circumference, BMI, and vertebral column length significantly affect the spread of spinal anaesthesia in term parturients. These variables may aid in predicting anaesthetic spread and tailoring dosage.

INTRODUCTION

The term "Spinal Anaesthesia" was introduced by Leonard Corning in 1885,[1] and remains the preferred technique for caesarean sections due to advantages such as minimal drug use, reduced airway manipulation, early mobilization, and shorter hospital stay.[2] The optimal sensory level for caesarean delivery is a bilateral block between T4 and T6, assessed by pinprick2. However, the spread of spinal anaesthesia varies widely, potentially leading to inadequate block or hemodynamic instability.[3,4] Patient-specific factors such as age, height, weight, abdominal girth, BMI, and vertebral column length (VCL) have been studied for their influence on anaesthetic spread, but findings remain inconclusive.[5-8] Pregnancy-related anatomical and hormonal changes can alter cerebrospinal fluid dynamics, affecting drug distribution.[9,10] Abdominal circumference, in particular, reflects uterine size and intra-abdominal pressure, which may displace CSF and enhance cephalad spread.[11-13] Among proposed indices, the VCL/AC² ratio has emerged as a reliable predictor, as highlighted by Lee et al.[14] Additionally, gestational factors like pubic laxity and widened hip-to-shoulder ratio may further influence anaesthetic spread15. Based on these observations, we conducted a prospective observational study to evaluate the correlation of abdominal circumference, vertebral column length, and BMI with spinal anaesthesia spread in term parturients. Secondary outcomes included block characteristics, incidence of hypotension, vasopressor requirement, and associated side effects.

MATERIALS AND METHODS

This prospective observational study was conducted at Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, following approval from the Institutional Ethics Committee. Term parturients aged between 18 and 40 years, with a gestational age of 37 weeks or more, scheduled for elective caesarean section under spinal anaesthesia, were enrolled. The minimum required sample size was calculated to be 196, considering an anticipated effect size of 0.15, a 95% confidence level, and 80% power, with the study spanning 18 months.

Patients with obstetric complications such as preeclampsia, known allergies to anaesthetic agents, coagulation abnormalities, systemic disorders including cardiovascular, renal or hepatic diseases, spinal deformities, or local infection at the lumbar puncture site were excluded. After obtaining written informed consent, all participants underwent pre-anaesthetic evaluation and routine investigations, including CBC, renal profile, coagulation parameters, ECG, and relevant serological markers.

On the day of surgery, participants were kept fasting and an intravenous cannula was secured with preloading of Ringer Lactate at 10 mL/kg over 30 minutes. Anthropometric measurements were recorded by a separate anaesthesiologist not involved in the administration of anaesthesia. Weight was recorded in kilograms and height in meters to calculate BMI. Abdominal circumference was measured at the umbilical level in the supine position at end-expiration, while vertebral column length was recorded from C7 to the sacral hiatus in the sitting position. The VCL/AC² ratio was calculated accordingly.

Spinal anaesthesia was administered in the operating room under strict asepsis using a 25G Quincke's needle at the L3–L4 interspace, and 2.4 mL of intrathecal drug was injected following confirmation of free CSF flow. Sensory block was assessed along the mid-axillary line at one-minute intervals until T10 was reached, with the highest level recorded at 20 minutes. Duration was defined from onset at T10 to regression to S2. Motor block was evaluated based on time to complete paralysis and full recovery.

Data were entered into Microsoft Excel and analysed using SPSS version 21.0. Shapiro-Wilk test revealed non-normal distribution of the data, leading to the application of non-parametric tests. Chi-square test was used for categorical variables, while Kruskal-Wallis and Friedman tests were applied for inter- and intra-group comparisons respectively. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The present study assessed the effect of abdominal girth, vertebral column length (VCL), and body mass index (BMI) on the spread of spinal anaesthesia in term parturients undergoing elective caesarean section. Most participants were aged 25–30 years, with a mean age of 28.43 years. Controlled gestational diabetes was present in 28.57% of cases. The majority had normal (32.1%) or overweight (28.1%) BMI, with a mean of 25.96 ± 2.54 (Table 1). Mean gestational age was 38.47 weeks. Average VCL and AC were 55.44 cm and 102.12 cm, respectively. Sensory block onset occurred at 1.46 minutes and motor block at 2.00 minutes. Mean duration of motor block was 150.63 minutes and sensory block was 100.03 minutes (Table 2). Hemodynamic parameters declined initially post spinal anaesthesia but returned to baseline within 60–90 minutes. Oxygen saturation remained stable, indicating good anaesthetic tolerance (Table 3).

Table 1: Demographic, Comorbidity, and BMI Profile of Study Participants

Category	Subgroup	Frequency (n)	Percentage (%)	Mean ± SD
Age Group	18–25 years	37	18.9	**28.43 ± 4.72**
	25–30 years	74	37.8	
	30–35 years	40	20.4	
	35–40 years	45	23.0	
Comorbidities	Controlled GDM	56	28.57	-
	No Comorbidities	140	71.43	
BMI Category	Underweight	36	18.4	**25.96 ± 2.54**
	Normal	63	32.1	
	Overweight	55	28.1	
	Obese	42	21.4	

Table 2: Gestational, Anatomical, and Anaesthetic Block Characteristics

Parameter	Mean ± SD
Gestational Age (weeks)	38.47 ± 1.95
Vertebral Column Length (VCL, in cm)	55.44 ± 1.66
Abdominal Circumference (AC, in cm)	102.12 ± 6.71
VCL/AC² Ratio	0.0052 ± 0.001
Onset of Sensory Block (T10, in min)	1.46 ± 0.62
Onset of Motor Block (in min)	2.00 ± 0.87
Maximum Height of Sensory Block	3.00 ± 0.38
Time to Reach Max Sensory Block (min)	5.81 ± 0.68
Time to Reach T4 Level (min)	5.53 ± 1.31

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Duration of Motor Block (min)	150.63 ± 11.91
Duration of Sensory Block (min)	100.03 ± 9.99

Table 3: Distribution of Study Participants as per Hemodynamic Parameters Over Time

Time (min)	HR (Mean ± SD)	SBP (Mean ± SD)	DBP (Mean ± SD)	MAP (Mean ± SD)	SpO_2 (Mean ± SD)
0	87.7 ± 9.3	132.3 ± 13.4	76.8 ± 8.7	95.3 ± 10.2	98.0 ± 1.5
2.5	82.8 ± 8.7	123.1 ± 12.9	75.2 ± 8.4	91.2 ± 9.9	97.8 ± 1.5
5	78.3 ± 8.9	109.0 ± 12.5	74.0 ± 8.0	85.7 ± 9.5	97.5 ± 1.5
7.5	73.2 ± 8.2	102.8 ± 12.1	68.0 ± 7.8	79.6 ± 9.2	96.9 ± 1.5
10	73.2 ± 9.1	97.5 ± 11.8	61.5 ± 7.6	73.5 ± 8.8	96.3 ± 1.5
20	75.1 ± 8.7	99.0 ± 12.6	62.5 ± 7.7	74.7 ± 9.0	95.8 ± 1.5
30	76.3 ± 9.2	104.5 ± 12.3	64.8 ± 8.0	78.0 ± 9.3	95.5 ± 1.5
40	78.6 ± 8.8	109.8 ± 12.7	65.0 ± 8.3	79.9 ± 9.6	96.0 ± 1.5
50	80.5 ± 8.6	113.0 ± 13.0	67.0 ± 8.5	82.3 ± 9.8	96.5 ± 1.5
60	82.6 ± 9.5	116.5 ± 13.2	70.5 ± 8.6	85.8 ± 10.0	97.0 ± 1.5
70	84.8 ± 8.7	118.7 ± 13.3	70.8 ± 8.7	86.8 ± 10.2	97.3 ± 1.5
80	85.9 ± 9.1	121.5 ± 13.5	71.0 ± 8.8	87.8 ± 10.3	97.7 ± 1.5
90	86.4 ± 9.4	123.4 ± 13.6	72.2 ± 8.9	89.3 ± 10.4	98.0 ± 1.5

Table 4: Correlation between Characteristics of Sensory and Motor Block and Demographic Variables

Parameter	Age	Height	Weight	BMI
Onset of sensory block (T10)	-0.45 (p=0.001)	-0.38 (p=0.003)	-0.30 (p=0.005)	-0.28 (p=0.006)
Maximum height of sensory block	0.40 (p=0.002)	0.45 (p=0.002)	-0.32 (p=0.003)	0.38 (p=0.002)
Time to reach max sensory block	0.35 (p=0.005)	-0.40 (p=0.004)	0.50 (p=0.001)	-0.44 (p=0.003)
Time to reach T4 level	-0.38 (p=0.003)	0.42 (p=0.002)	0.48 (p=0.002)	-0.41 (p=0.004)
Onset of motor block	-0.42 (p=0.001)	-0.39 (p=0.003)	-0.35 (p=0.004)	0.36 (p=0.002)
Duration of motor blockage	-0.50 (p=0.002)	-0.41 (p=0.004)	0.40 (p=0.002)	0.42 (p=0.001)

Abdominal circumference (AC) showed strong correlation with rapid and higher cephalad spread of anaesthesia. Greater AC was linked to faster onset, higher block height, and quicker reach to T4 level. VCL had a significant negative correlation with time to T4 level, suggesting faster spread in longer spines. VCL/AC² also showed significant associations, confirming its value as a predictive ratio for anaesthetic spread (Table 5).

Table 5: Correlation of AC, VCL, VCL/AC2, and Cephalad Spread of Spinal Anaesthesia

Correction values		Onset of sensory block	Maximum sensory block height	Time to reach max sensory block	Time to reach T4 level
AC and Cephalad Spread	**r-value**	-0.797	0.961	-0.648	0.83
	p-value	0.028	0.033	0.003	0.025
VCL and Cephalad Spread		C7–SH	C7–SH	C7–SH	C7–SH
	r-value	-0.359	0.629	0.166	-0.975
	p-value	0.043	0.014	0.037	0.004
VCL/AC² and Cephalad Spread	**r-value**	0.182	0.409	0.463	-0.681
	p-value	0.02	0.026	0.018	0.042

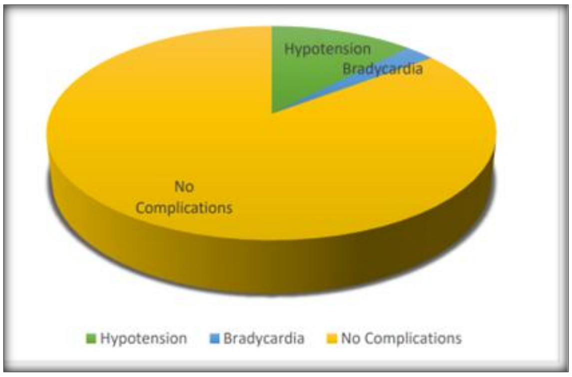

Figure 1: Shows that complications were minimal: 12.2% experienced hypotension and 2.6% bradycardia; 85.2% had no adverse events, showing high safety of spinal anaesthesia.

DISCUSSION

In our study, the mean age of participants was 28.43 years, with the majority in the 25–30 age group. Most had no comorbidities (71.43%), and 28.57% had controlled gestational diabetes. The mean BMI was 25.96 ± 2.54, indicating a predominantly overweight population. The mean VCL was 55.44 ± 1.66 cm, and AC was 102.12 ± 6.71 cm. The calculated VCL/AC² ratio was 0.0052. The mean onset of sensory and motor blocks were 1.46 and 2.00 minutes respectively. Hemodynamic variables showed an initial dip post spinal injection but stabilized within an hour. Only 12.2% developed hypotension and 2.6% bradycardia, indicating minimal complications. A significant correlation was found between the

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spread of spinal anaesthesia and BMI, height, weight, VCL, AC, and VCL/AC². Age had no significant effect. Bayal PK et al. similarly found weight, height, and BMI to be significant predictors of block spread but not age.[16] Ni TT et al. and Wei CN et al. supported the association with height and weight, although Wei found correlation only with height.[17,18] Seyhan TO et al. observed a significant correlation with weight alone.[19] In contrast, Ekeløf NP et al. and Norris MC found no significant relationship between block spread and anthropometric variables, including BMI, height, and weight.[20,21] AC showed strong correlation with faster onset, higher sensory level, and quicker reach to T4 level. Similar findings were reported by Bayal PK et al., who found a strong negative correlation between AC and time to T4.[16] Wei CN et al. and Lee YH et al. reported variable outcomes, with Wei showing greater correlation with VCL than AC in pregnant women, while Lee found no significant association with AC.[18,22] Ahad B et al. observed a trend toward higher sensory block with increased AC, but it was not statistically significant.[23] VCL showed a negative correlation with time to T4 level, indicating faster cephalad spread in individuals with longer vertebral columns. This supports findings from Ni TT, Wei CN, and Ahad B et al.[17,18,23] However, Wan Rubiza WM and Canturk M did not find a significant correlation.[24,25] Lastly, the VCL/AC² ratio demonstrated high statistical significance with block height and time to reach the maximum level, as also observed by Lee YH et al. and Hartwell BL et al.[22,26] These results underscore the importance of considering body geometry in predicting anaesthetic spread.

Limitations of the study

The limitations of the study include a single-center design, lack of control for drug baricity variations, and exclusion of patients with comorbidities that may affect block characteristics.

Strengths of the study

The strengths of the study include a robust sample size, standardized spinal anaesthesia technique, objective measurement of anthropometric parameters, and comprehensive statistical correlation.

CONCLUSION

We concluded that abdominal circumference, vertebral column length, and BMI significantly influence the cephalad spread of spinal anaesthesia in term parturients, while age showed no significant correlation.

REFERENCES

1. David LB. Spinal, epidural and caudal anesthesia, In: Milter RD, ed. Millers Anesthesia, 9th edn, Vol. 63. New York: Elsevier Churchill Livingstone, 2004 1653-1684.
2. ED (50) and (ED) 95 of intrathecal bupivacaine in morbidly obese patients undergoing cesarean delivery. Anaesthesiology 2011;114:529-35.
3. Oraon P, Hembrom B, Kumar M, Ram B, Lakra L. Comparative Study between Intrathecal 0.5% Isobaric Levobupivacaine, 0.5% Isobaric Ropivacaine, and 0.5% Hyperbaric Bupivacaine in Elective Lower Segment Cesarean Section: A Randomized Clinical Study. Anesth Essays Res. 2022 Apr-Jun;16(2):238-243. Epub 2022 Oct 7. PMID: 36447919; PMCID: PMC9701329.
4. Yentis SM. Height of confusion: Assessing regional blocks before cesarean section. Int J ObstetAnesth 2006;15:2-6.
5. Huang Q, Wen G, Hai C, Zheng Z, Li Y, Huang Z, Huang B. A Height-Based Dosing Algorithm of Bupivacaine in Spinal Anesthesia for Decreasing Maternal Hypotension in Cesarean Section Without Prophylactic Fluid Preloading and Vasopressors: A Randomized-Controlled Non-Inferiority Trial. Front Med (Lausanne). 2022 Jun 10;9:858115. PMID: 35755061; PMCID: PMC9226673.
6. She YJ, Liu WX, Wang LY, Ou XX, Liang HH, Lei DX. The impact of height on the spread of spinal anesthesia and stress response in parturients undergoing caesarean section: a prospective observational study. BMC Anesthesiol. 2021 Nov 30;21(1):298. PMID: 34847868; PMCID: PMC8630888.
7. Harten JM, Boyne I, Hannah P, Varveris D, Brown A. Effects of a height and weight adjusted dose of local anesthetic for spinal anesthesia for elective cesarean section. Anesthesia 2005;60:348-53.
8. Parthasarathy P, Aithal RR, Raghavendra Rao RS, Raghuram S, Ramesh R, Nazneen A. Correlation of Symphysiofundal Height and Abdominal Girth with the Incidence of Hypotension in Cesarean Section Under Spinal Anesthesia using Bupivacaine with Fentanyl as Adjuvant: A Clinical Study. Anesth Essays Res. 2019 Apr-Jun;13(2):214-218. doi: 10.4103/aer.AER_36_19. PMID: 31198233; PMCID: PMC6545932.
9. Kim JT, Shim JK, Kim SH, Jung CW, Bahk JH. Trendelenburg position with hip flexion as a rescue strategy to increase spinal anesthetic level after spinal block. Br J Anaesth 2007;98:396-400.
10. Higuchi H, Takagi S, Zhang K, Furui I, Ozaki M. Effect of lateral tilt angle on the volume of the abdominal aorta and inferior vena cava in pregnant and nonpregnant women determined by magnetic resonance imaging. Anesthesiology 2015;122:286-93.
11. Takiguchi T, Yamaguchi S, Tezuka M, Furukawa N, Kitajima T. Compression of the subarachnoid space by the engorged epidural venous plexus in pregnant women. Anesthesiology 2006;105:848-51.
12. Chun R, Baghirzada L, Tiruta C, Kirkpatrick AW. Measurement of intra-abdominal pressure in term pregnancy: A pilot study. Int J Obstet Anesth 2012;21:135-9.
13. Cantürk M, Cantürk FK, Dağlı R, Dağlı SS. The spread of spinal anesthesia in term parturient: Effect of hip/shoulder width ratio and vertebral column length. Int J Clin Exp Med 2016;9:21562-7.
14. Lee YH, Wang YC, Wang ML, Lin PL, Huang CH, Huang HH. Relationship of abdominal circumference and trunk length with spinal anesthesia level in the term parturient. JAnesth 2014;28:202-5
15. Yoo SW, Ki MJ, Kim D, Oh YJ, Lee J. The effect of an eye mask on midazolam requirement for sedation during spinal anesthesia: a randomized controlled trial. BMC Anesthesiol. 2021 Sep 25;21(1):232. PMID: 34563112; PMCID: PMC8464090.
16. Bayal PK, Golboyu BE, Ekinci M, Guden M, Ahiskalioglu A, Celik EC. Effects of anthropometric measurements on spinal anaesthesia block characteristics and hemodynamics. Medeniyet Med J. 2016;31(1):23–31.
17. Ni TT, Zhou Y, Yong AC, Wang L, Zhou QH. Intra-abdominal pressure, vertebral column length, and spread of spinal anaesthesia in parturients undergoing cesarean section: An observational study. PLoS ONE. 2018; 13(4):e0195489.

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18. Wei CN, Zhang YF, Xia F, Wang LZ, Zhou QH. Abdominal girth, vertebral column length and spread of intrathecal hyperbaric bupivacaine in the term parturient. Int J Obstet Anesth. 2017;31:63–7.
19. Seyhan TO, Sungur MO, Basaran B, Karadeniz MS, Demirel F, Xu Z, et al. The effect of intra-abdominal pressure on sensory block level of single-shot spinal anaesthesia for caesarean section: an observational study. Int J Obstet Anesth. 2015;24(1):35–40.
20. Ekeløf NP, Jensen E, Poulsen J, Reinstrup P. Weight gain during pregnancy does not influence the spread of spinal analgesia in the term parturient. Acta Anaesthesiol Scand. 1997 Aug;41(7):884-7.
21. Norris MC. Patient variables and the subarachnoid spread of hyperbaric bupivacaine in the term parturient. Anesthesiology. 1990 Mar;72(3):478- 82.
22. Lee YH, Wang YC, Wang ML, Lin PL, Huang CH, Huang HH. Relationship of abdominal circumference and trunk length with spinal anaesthesia level in the term parturient. J Anesth. 2014;28(2):202–5.
23. Ahad B, Moosaraza S, Sofi K, Rather AA. Correlation between vertebral column length and spread of isobaric subarachnoid ropivacaine in the term parturient. Int J Gen Med Pharmacol. 2016;6(2):11–20.
24. Wan Rahiza WM, Raha AR, Muhd Helmi A, Nadia MN, Muhammad M, Azmil Farid Z, et al. Correlation between spinal column length and the spread of subarachnoid hyperbaric bupivacaine in the term parturient. South Afr J Anaesth Analg. 2010;16(3):30–3
25. Cantürk M, Cantürk FK, Dağ H, Dağ SS. The spread of spinal anaesthesia in term parturient: effect of hip/shoulder width ratio and vertebral column length. Int J Clin Exp Med. 2016;9(11):21562–7.
26. Hartwell BL, Datta S, Aglio LS, Hauch MA. Vertebral column length and spread of hyperbaric subarachnoid bupivacaine in the term parturient. Reg Anesth. 1991;16(1):17–9.