ISSN: 2091-2331 (Print) 2091-234X (Online)

Journal of Nobel Medical College

Volume 13, Number 01, Issue 24, January-June 2024, 9-14

Original Article

Effect of Abdominal Girth and Vertebral Column Length in Spread of Spinal Anesthesia for Lower Limb Surgery: A Prospective Study

Rupak Bhattarai*, Parasmani Sah, Neelam Chetry, Rajeev Dev, Prabin Sharma, Anish Pokharel

Department of Anesthesiology, Critical Care and Pain Management, Nobel Medical College Teaching Hospital, Biratnagar, Nepal

Article Received: 18th February, 2024; Accepted: 20th April, 2024; Published: 30th June, 2024

DOI: https://doi.org/10.3126/jonmc.v13i1.68053

Abstract

Background

Subarachnoid spread of local anesthetics is quite erratic and is determined by several factors. There is a high predictive for the spread of spinal anaesthesia in terms of abdominal girth and vertebral column length. Our study is designed to determine the effect of abdominal girth and vertebral column length with cephalad spread of spinal anaesthesia for a given dose of 0.5% hyperbaric bupivacaine in Nepalese patients.

Materials and Methods

In this prospective observational study, a total 100 patients of ASA PS I-II, aged16-65 years and undergoing lower extremity surgery under spinal anesthesia were enrolled. 2.8 mL of 0.5% hyperbaric bupivacaine was injected intrathecally at L3-4 interspace in sitting position. Extent of sensory blockade was assessed for 60 min. Simple linear regression, multiple linear regression and Pearson's correlation coefficient analysis were performed to determine the correlation between patient variables viz abdominal girth, vertebral column length, height, weight, body mass index and age and maximum sensory block height.

Results

Abdominal girth and vertebral column length correlated significantly with the maximal sensory block height after intrathecal administration of a fixed dose of 0.5% hyperbaric bupivacaine by all the three statistical tools used.

Conclusion

Abdominal girth and vertebral column lengthcorrelate significantly with the maximal sensory block height in Nepalese patients receiving a fixed dose subarachnoid block with 0.5% hyperbaric bupivacaine

Keywords: *Bupivacaine, Lower extremity, Patients*

***Corresponding Author:**
Dr. Rupak Bhattarai
Associate Professor
Email: bhattarairupak@hotmail.com
ORCID: https://orcid.org/0000-0002-5521-081X

Citation
Bhattarai R, Shah P, Chetry N, Dev R,Sharma P, Pokharel A, Effect of Abdominal girth and vertebral column length in spread of spinal anesthesia for lower limb surgery: A Prospective study, JoNMC. 13:1 (2024) 9-14. DOI: https://doi.org/10.3126/jonmc.v13i1.68053.

Introduction

Spinal anaesthesia has wide range of clinical applications for obstetrics, orthopaedic and general surgery. Spinal anaesthesia has the definitive advantage that profound nerve block can be produced simply using direct injection of small amount of local anaesthetics (LA) into cerebrospinal fluid (CSF) [1,2].

The utmost challenge of this technique is to maintain the spread of local anaesthetics into the cerebrospinal fluid, thus providing acceptable block for the surgery. As there are several factors which determines the spread of local anaesthetics in cerebrospinal fluid and is unpredictable [3,4,5,6]. In order to determine the dose of bupivacaine for spinal anaesthesia patient's age, height, weight and body mass index (BMI) is being clinically evaluated [7]. But as per previous studies, these variables have lower predictive value for spread of local anaesthetics in spinal anaesthesia [8,-11]. Therefore, abdominal girth (AG) and vertebral column length (VCL), by some authors showed highly predictive in terms of spread of given dose of bupivacaine for spinal anaesthesia [7, 12].

People with different ethnic origin are likely to have different anthropometric characteristics. So far, we have not come across any report which has attempted to find out the degree of correlation between cephalad spread of LA into CSF and the VCL and/or AG.This study primarily aimed to identify the specific correlation between AG, VCLand maximum sensory block height after given dosage of 0.5% hyperbaric bupivacaine for spinal anaesthesia for lower limb surgery in Nepalese subject. Secondarily, the correlation of age, height, weight and BMI with spread of spinal anaesthesia was also studied.

Materials and Methods

This is a prospective observational study conducted for a period of one year from May 2023 to April 2024 in Nobel Medical College Teaching Hospital. Approval for the study was obtained from the Institutional Review Committee (IRC). Patients belonging to age group 16-65 years with American Society of Anesthesiologists Physical Status (ASA PS) I & II undergoing lower limb surgeries under spinal anaesthesiawere included. The exclusion criteria were patient refusal for consent, any contraindications for spinal anaesthesia, ASA PS III or more, and history of spine surgery, diabetes spinal deformity and pregnancy.

Sample size was estimated based on the finding of a previous study by Zhou et.al. [7] expecting similar correlation coefficient r=0.383, and accepting α error of 5% and β error of 5%. Adding 20% for the non-respondance, a sample of 100 patients undergoing lower limb surgery under spinal anaesthesia was taken.

All the patients were explained about the nature of the study during the preoperative visit and informed consent was obtained. All the patients were kept fasting for 8–10 h before surgery. All the patients were pre-medicated with diazepam 5-7.5 mgin the night before and two hours prior to surgery. After thepatients entered the operating room,height (defined as length from vertex to heel) was measured. Weight of the patient was either measured whenever possible or estimated based on the patient's previously measured weight. And the BMI was calculated. The patient was placed in supine position, and at the level of the umbilicus, the AG (in cm) was measured at the end of expiration using measuring tape. VCL (in cm) was measured from C7 vertebra (spinous process) to sacral hiatus in lateral position. Intravenous accesswasestablished, and Ringer's lactate 10 mL/kg was preloaded before anaesthesia in all the patients. Baseline heart rate (HR) and blood pressure (BP) were recorded. Noninvasive BPwasrecorded every 5 min; electrocardiography (ECG) and pulse oximetry (SpO_2)were continuously monitored in all the patients.

In the operation theatre, the patient was explained about the technique of anaesthesia and the cooperation required. The patient was placed in sitting position with spinal column flexion. The L3-4interspace was confirmed by accepting that a line joining iliac crests approximated to L3-L4 interspace. A 25-gauge Quincke spinal needle was insertedadopting standard-midline approach, with the orifice pointing cephalad. A fixed volume (2.8 mL) of 0.5%hyperbaric bupivacaine solutionwasinjected intrathecally at room temperature at aspeed of approximately 2 mL in 10 s after confirming free flow of CSF. After the administration of bupivacaine, the patient was placed in supine positionimmediately. The spinalanaesthesia spread was assessed by loss of pin prick sensation using a 23G hypodermic needle at 5, 10, 20, 30, 45 and 60 min after intrathecal injection in both mid-clavicular lines. Temperature sensation was also assessed by cold using an alcohol swab at the same time. Patient's demographic data, diagnosis and surgery to be performed were recorded. Intraoperative adverse events if any were noted.

The data collected was entered into Microsoft excel sheet and exported to SPSS 11.5 version.

Frequency, percentage, mean, standard deviation, range were calculated to describe variables. Karl-Pearson correlation coefficient was calculated to find association of the continuous variables. F-test was used to test the significance of correlation. Simple linear regression and multiple linear regression analysis were performed to demonstrate the relationship between patient variables and maximum level of sensory block. Probability of significance was set at 5% level.

Results

The demographic parameters of the patients and the maximal sensory block height achieved are presented in table 1.

Table 1: Patient variables and maximal sensory block height

Parameter	Mean (SD)	Median (IQR)	Range	Number (%)
*Age (years)	38.75 (13.35)	39 (27.5-48)	19-65	_
**Sex (male/ female)	_	_	_	74/26
*AG (cm)	72.37 (12.91)	71.5 (64-86)	48-110	_
*VCL (cm)	55.94 (7.5)	55 (50-62)	42-72	_
*Height (m)	1.62 (0.07)	1.63 (1.56-1.66)	1.42-1.8	_
*Weight (kg)	60.70 (8.53)	60 (55-65)	38-85	_
*BMI (kg/m^2)	23.11 (3.19)	22.49 (21.1-25.39)	16.44-33.20	_
*Maximal sensory block height (thoracic segment)	_	T5 (T6 - T4)	T2-T8	_

*Values are in mean (SD), median and range.
**Value is in number/percentage.

Simple linear regression analysis showed significant positive correlation of AG (β=0.049, p<0.001) and negative correlation VCL (β=-0.035, p=0.027) of the patient with maximal sensory block height(table 2).

Table 2: Simple linear regression of patient's variables with maximal sensory block height

Description	â coefficient (SE)	95% CI	p-value
Abdominal girth (cm)	0.049 (0.0079)	0.033 to 0.065	<0.001
Vertebral column length (cm)	-0.035 (0.0158)	-0.067 to 0.004	0.027
BMI (kg/m^2)	0.146 (0.0358)	0.075 to 0.217	<0.001
Weight (kg)	0.035 (0.0138)	0.007 to 0.062	0.013
Height (m)	-3.03 (1.673)	-6.35 to 0.28	0.73
Age (years)	0.009 (0.009)	-0.008 to 0.027	0.27

The scatter plot of maximal sensory block height against the vertebral column length and abdominal girth is shown in figure 1 and figure 2 respectively.

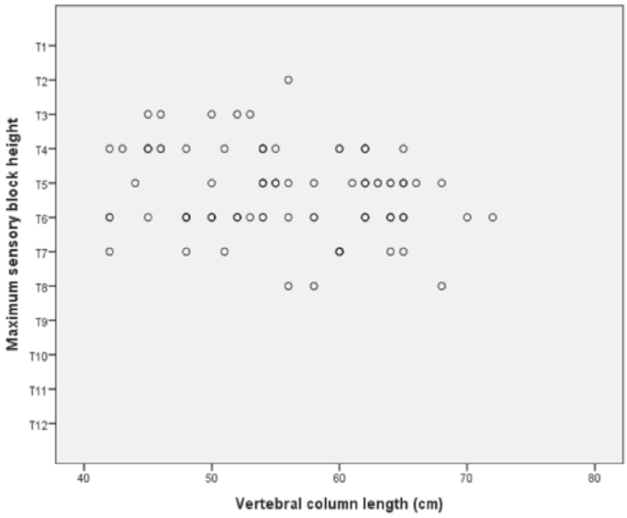

Figure 1: Relationship between vertebral column length and maximum sensory block height

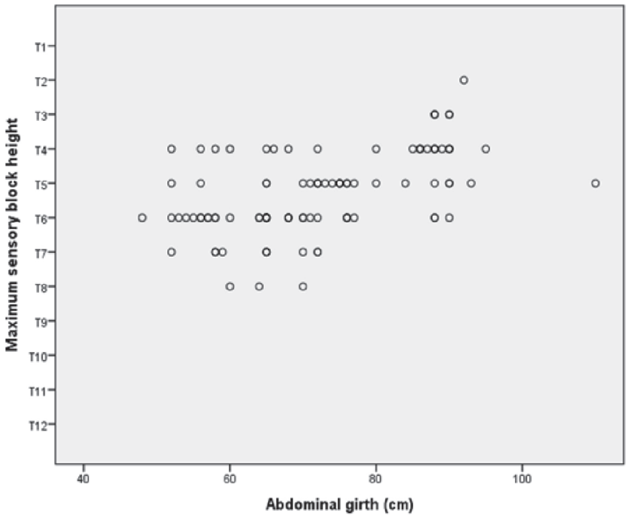

Figure 2: Relationship between abdominal girth and maximum sensory block height

Multiple linear regression analysis demonstrated significant correlation of the maximal sensory block height achieved with abdominal girth and vertebral column length. Correlation coefficient, 95% CI and p value calculated by multiple regression analysis are shown in table 3.

Table 3: Multiple linear regression of patient variables with maximal sensory block height

Variables	â coefficient (S.E.)	95% CI	p-value
AG (cm)	0.050 (0.0085)	0.033 to 0.067	< 0.001
VCL (cm)	-0.055 (0.018)	-0.91 to -0.019	0.003
Age (years)	0.005 (0.0075)	-0.0089 to 0.020	0.428
Height (m)	15.02 (10.238)	-5.309 to 35.359	0.146
Weight (kg)	-0.163 (0.133)	-0.428 to 0.102	0.225
BMI (kg/m^2)	0.489 (0.349)	-0.205 to 1.183	0.165

Pearson's correlation coefficients were calculated to show the interrelationship between patient's variables and maximal sensory block height (table 4).

Table 4: Pearson's correlation of patients' variables with maximal sensory block height

Patients' variable	Pearson's correlation coefficient (c)	p-value
Age (years)	0.109	0.27
AG (cm)	0.532	< 0.001
VCL (cm)	-0.221	0.02
Height (m)	-0.180	0.07
Weight (kg)	0.247	0.013
BMI (kg/m^2)	0.382	0.0001

Discussion

In this study we found significant correlation of patient's AG and VCL with the maximal sensory block height after spinal anaesthesia. Simple linear regression analysis showed significant correlation of weight and BMI of the patient with cephalad spread of spinal anaesthesia (p<0.05). Pearson's correlation analysis demonstrated significant correlation of the patient's AG, VCL, weight and BMI with the cephalad spread of spinal anaesthesia.

Increase in intra-abdominal pressure has been found to result in decreased lumbosacral CSF volume and is likely to produce more extensive neuraxial blockade through diminished dilution of local anaesthetic [13].Greater AG has been shown to be associated with a more notable increase in the intra-abdominal pressure which causes distension of the epidural veins thereby reduce the CSF volume by compressing the CSF space [14, 15].

Hartwell et al. in their study demonstrated significant correlation between VCL measured from C7 to the level of the iliac crest (r = 0.32, p = 0.025) and to the sacral hiatus (r = 0.38, p = 0.006) and the level of sensory block height after the subarachnoid administration of 12 mg hyperbaric bupivacaine in term pregnant patients [16].Our study also showed similar finding i.e., significant correlation between the VCL and maximal sensory block height. Simple linear regression and multiple linear regression analyses showed significant negative relationship between VCL and maximal sensory block height with respective regression coefficient (β = -0.035, 95% CI -0.067 to -0.004, p = 0.02 and β=-0.055, 95% CI -0.91 to -0.019, p=0.003). A significant negative relationship between VCL and maximal sensory block height was also observed in Pearson's correlation analysis (c=-0.221, p=0.02). Zhou et al. have also reported similar findings of linear regression analysis showing strong correlation between AG and 0.5% plain bupivacaine dose (r = -0.827 for T12, r = -0.806 for T10; both p < 0.0001) [7].Although not included in our primary objectives we also assessed the correlation of maximal sensory block height with patient's age using simple linear regression analysis and multiple linear regression analysis. We did not find any significant correlation between age of the patient and the maximal sensory block height after spinal anaesthesia (p >0.05). This finding in our study differs from the findings of the study by Cameron et al. which demonstrated a positive correlation (r=0.5) between age and level of sensory block after giving 4 mL of 0.5% plain bupivacaine in 33 patients [17]. Pitkanen et al. also demonstrated a correlation (r=0.227) between age and level of sensory block in their study of 124 patients [9]. The difference in our and their findings may have resulted from the difference in several factors such as the age group studied, the preparation and volume of drug used, demographic and anthropometric differences of subjects etc.

Greene has suggested an association between patient's height and the maximum level of sensory blockade after spinal anaesthesia but our study failed to show significant correlation between these two factors (β=-3.03, p= 0.073) [4]. In contrast to our study, Pitkanen demonstrated higher cephalad spread of spinal anaesthesia in shorter than normal individual after giving 3 mL of 0.5% isobaric bupivacaine in 90 patients [18]. Though minimum effective doses of bupivacaine based on the height (0.06 mg/cm height) has been suggested for caesarean section, no correlation between height and level of sensory blockade was shown in term parturient [19,20,21].The explanation given for the results is that the difference in height between adult is more due to length of the lower limb long bones, than the spine. The role of patient height in determining sensory level of anaesthesia may be clinically more important when spinal anaesthesia is used in children.

Though multiple linear correlation analysis in our study failed to show significant correlation (p>0.05), simple linear regression analysis showed significant positive relation of level of sensory block height with BMI (β =0.146, 95%CI 0.075 to 0.217, p<0.001) and weight (β =0.035, 95%CI 0.007 to 0.062 p=0.013) of patients. Wefound a significant positive correlation of maximal sensory block height with BMI (c=0.382, p<0.001) and weight (c=0.247, p=0.013)in Pearson's correlation analysis also. This finding is supported by the finding of the previous study conducted by McCulloch and Littlewood in which there were strong correlation between weight and BMI of patient and level of sensory blockade after giving 4 mL of 0.5% plain bupivacaine in 50 patients undergoing cystoscopic procedure under spinal anaesthesia [10]. Pargger et al. also demonstrated significant correlation between BMI and level of sensory blockade (r=0.25, P<0.05) following subarachnoid injection of 18 mg of 0.5% plain bupivacaine in 100 patients [11]. Tuominenet al. also reported more extensive cephalad spread of sensory block in patients with increased BMI compared with normal BMI after intra-thecal administration of 3 mL of 0.5% plain bupivacaine [8].

Positive relationship between obesity and the level of sensory blockade after spinal anaesthesia has been demonstrated in different studies [5, 7, 10, 22].The precise mechanism by which BMI affects the spread of spinal block is unclear. However, CSF volume appears to be one of the important factors. The reduced CSF volume in obese patients is believed to be the result of increased intra-abdominal pressure or increased epidural fat or inferior venacava occlusion leading to distension of epidural vein [23].

Our findings are well supported by the findings of the study conducted by Zhou et al. in which, linear regression analysis showed significant univariate correlation among weight, height, BMI, abdominal girth, vertebral column length and the spread of spinal anesthesia (all P<0.039) [12].Like in our study, multiple regression analysis in their study also showed AG and the VCL to be the key determinants for spinal anesthesia spread (both P < 0.0001).

Conclusion

In conclusion, our study showed the significant correlation of AG and VCL with maximal sensory block height in Nepalese subject studied. Significant positive correlation exists between BMI and maximal sensory block height. So based on this study it is suggested that lesser dose of 0.5% hyperbaric bupivacaine is needed in patient with higher AG and BMI and lowerVCL.

Limitation

This study has some limitations. We included only patients between 16 to 65 years of age of ASA PS I and II. So, the correlation of patients' variables with level of sensory block in extreme of age is yet to be studied. As all the patients were posted for lower limb surgery, it was difficult to take the exact weight of some patients. This may be source of bias in the result.

Acknowledgement: None

Conflict of interest: None

References

[1] Greene NM, Uptake and elimination of local anesthetics during spinal anesthesia, Anesth Analg. 62:11(1983)1013-24. PMID: 6354003.

[2] Pittoni G, Toffoletto F, Calcarella G, Zanette G, Giron GP, Spinal anesthesia in outpatient knee surgery: 22-Gauge versus 25-gauge sprotte needle, Anesth Analg. 81:1 (1995)73-9. DOI: 10.1097/00000539-199507000-00015. PMID: 7598286.

[3] Logan MR, McClure JH, Wildsmith JAW, Plain bupivacaine: an unpredictable spinal anaesthetic agent, BrJ Anaesth. 58:3(1986)292-6. DOI: 10.1093/bja/58.3.292. PMID:3947490.

[4] Greene NM, Distribution of local anesthetic solutions within the subarachnoid space, Anesth Analg. 64:7(1985)715-30. PMID:3893222.

[5] Liu SS, McDonald SB, Current issues in spinal anesthesia, Anesthesiology. 94:5(2001):888-906.DOI:10.1097/00000542-200105000-00030. PMID:11388543.

[6] Stienstra R, Greene NM, Factors affecting the subarachnoid spread of local anesthetic solutions, Reg Anesth. 16:1(1991)1-6. PMID: 2007097.

[7] Zhou Q, Zhu B, Wei C, Yan M, Abdominal girth and vertebral column length can adjust spinal anesthesia for lower limb surgery, a prospective, observational study, BMCAnesthesiol.16:1(2015)22.DOI:10.1186/s12871-016-0184.PMID:27009023.

[8] Taivainen T, Tuominen M, Rosenber 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. 64:5 (1990) 542-6. DOI:10.1093/bja/64.5.542. PMID:2354091.

[9] Pitkänen M, Haapaniemi L, Tuominen M, Rosenberg PH, Influence of age on spinal anaesthesia with isobaric 0.5% bupivacaine, Br J Anaesth. 56:3 (1984) 279-84. DOI:10.1093/bja/56.3.279. PMID:6704278.

[10] McCulloch WJ, Littlewood DG, Influence of obesity on spinal analgesia with isobaric 0.5% bupivacaine, Br J Anaesth. 58:6 (1986) 610-4. DOI:10.1093/bja/58.6.610. PMID:3707798.

[11] 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. 42:4 (1998) 430-4. DOI: 10.1111/j.1399-6576.1998.tb05137.x. PMID: 9563862.

[12] 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. 119:1 (2014) 203-6. DOI: 10.1213/ANE.0000000000000199. PMID:24806139.

[13] Hogan QH, Prost R, Kulier A, Taylor ML, Liu S, Mark L, Magnetic resonance imaging of cerebrospinal fluid volume and the influence of body habitus and abdominal pressure, Anesthesiology. 84:6 (1996)1341-9. DOI:10.1097/00000542-199606000-00010. PMID:8669675.

[14] Sugerman H, Windsor A, Bessos M, Wolfe L, Intra-

abdominal pressure, sagittal abdominal diameter and obesity comorbidity, J Intern Med. 241:1(1997)71-9.DOI:10.1046/j.1365-2796.1997.89104000.x. PMID:9042096.
[15] Robinson LS, The collateral circulation following ligation of the inferior vena cava; injection studies in stillborn infants, Surgery. 25:3 (1949) 329-47. PMID: 18113324.
[16] Hartwell BL, Aglio LS, Hauch MA, Datta S, Vertebral column length and spread of hyperbaric subarachnoid bupivacaine in the term parturient, Reg Anesth. 16:1 (1991) 17-9. PMID: 2007099.
[17] Cameron AE, Arnold RW, Ghorisa MW, Jamieson V, Spinal analgesia using bupivacaine 0.5% plain variation in the extent of the block with patient age, Anaesthesia. 36:3 (1981) 318-22. DOI:10.1111/j.1365-2044.1981.tb10211.x PMID: 7224128.
[18] Pitkänen MT, Body mass and spread of spinal anesthesia with bupivacaine, Anesth Analg. 66:2 (1987) 127-31. PMID:3813056.
[19] Danelli G, Zangrillo A, Nucera D, Giorgi E, Fanelli G, Senatore R, Caseti A, The minimum effective dose of 0.5% hyperbaric spinal bupivacaine for cesarean section, Minerva Anestesiol. 67:7 (2001) 573-7. PMID:11602876.
[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. 41:7(1997) 884-7. DOI:10.1111/j.1399-6576.1997.tb04804.x. PMID:9265932.
[21] Norris MC, Patient variables and the subarachnoid spread of hyperbaric bupivacaine in the term parturient, Anesthesiology. 72:3 (1990) 478-82. DOI:10.1097/00000542-199003000-00015. PMID:2310028.
[22] Leino KA, Kuusniemi KS, Pälve HK, Tiusanen HT, Tuppurainen TT, The effect of body mass index on the spread of spinal block in patients with rheumatoid arthritis, J Anesth. 25:2 (2018) 213-8. DOI:10.1007/s00540-010-1082-3. PMID:21193999.
[23] Barclay DL, Renegar OJ, Nelson EW, The influence of inferior vena cava compression on the level of spinal anesthesia, Am J Obstet Gynecol. 101:6 (1968) 792-800. DOI:10.1016/0002-9378(68)90035-5. PMID:5660978.