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Hip/Shoulder Width Ratio Alters the Spread of Spinal Anesthesia: A Prospective Observational Study

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Introduction: Many factors have been tested to predict the spread of spinal anesthesia in clinical practice. In the study we aimed to investigate the correlation between hip/shoulder width ratio and spread of spinal anesthesia.

Method: Sixty patients were enrolled in this study to determine the correlation between hip/shoulder width ratio and the spread of spinal anesthesia. The L4-L5 interspace, navigated by ultrasonography, was introduced at lateral position with a 25G spinal needle. 3ml 0,5% hyperbaric bupivacaine was injected intrathecal in 15 seconds. Age, height, weight, body mass index, hip/shoulder width ratio and vertebral column length were recorded. Spinal anesthesia spread was assessed at 0, 5, 10, 20, and 30 minutes after spinal anesthesia. Patient was turned supine 5 minutes after intrathecal injection. Multiple linear regression analysis was used to analyze correlation between the spread of spinal anesthesia and age, height, weight, hip/shoulder width ratio, vertebral column length.

Results: The study was completed without dropout and sixty participants were included into analysis. There was a strong correlation between the spread of spinal anesthesia and hip/shoulder width ratio (r=0,766; p<0,0001) and a negative correlation with the height and vertebral column length (r= -0,572; -0,738 and p=0, 000; 0, 000 respectively).

Conclusion: Cephalad spread of spinal anesthesia with a fixed dose of hyperbaric bupivacaine is strongly correlated with hip/shoulder width ratio and inversely correlated with height and vertebral column length. We may observe more spread with 0, 5% hyperbaric bupivacaine in patients with a greater hip/shoulder ratio and a shorter height.

Keywords: Spinal anesthesia, hyperbaric bupivacaine, hip/shoulder ratio.

Introduction

Spinal anaesthesia is commonly preferred by anaesthesiologists for inguinal hernia repair and uncomplicated lower extremity surgeries. The spread of spinal anaesthesia with a given dose of plain bupivacaine is generally unpredictable whereas hyperbaric bupivacaine provides more predictable spread of spinal anaesthesia (1-4). Greene 4 has described 25 factors that affect the spread of spinal anaesthesia but in clinical practice it is hard to isolate one factor and quantify its effect on the spread of spinal anaesthesia from the others. There is a great interest on defining the determinants of spinal anaesthesia spread in recent studies (5-9). Measures that are practically obtainable and have a predictive value on spinal anaesthesia spread will help the clinicians to predict the spread of spinal anaesthesia for individual patients.

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In our former study, we confirmed the correlation between hip/shoulder width ratio (HSR) and the spread of anaesthesia with a given dose of hyperbaric bupivacaine in parturients (10). In the current study, we aimed to study the correlation of HSR and spread of spinal anaesthesia in non-pregnant patient population. We hypothesized that HSR>1 correlates with increased spread of spinal anaesthesia with a given dose of hyperbaric bupivacaine.

Materials and Method

After receiving approval from the Ethical Committee this prospective observational study was registered at Australian New Zealand Clinical Trials Registry. A written informed consent was obtained from all participants and was archieved by the authors. The study was carried out in accordance with Declaration of Helsinki between 15.10.2015-30.12.2015, data was collected at 0, 5, 10, 20, and 30 minutes after spinal anesthesia and follow up of the patients ended when the patients were discharged to ward.

Subjects

Sixty patients aged 20 to 65 years, with a weight from 49 to 103 kg and heights from 147 to 197 cm were enrolled into the study. Patients that have a contraindication for spinal anaesthesia (coagulopathy, infection at puncture site, anticoagulant medication or patient refusal to spinal anaesthesia), patients with vertebral column abnormalities or patients with a prior history of spinal or spinal canal surgery and pregnant patients were excluded from study.

Methodology

The primary outcome of the current study was the correlation of HSR with the spread of spinal anaesthesia with a given dose of hyperbaric bupivacaine. Secondary outcomes of the study were the presence of correlation between the spread of spinal anaesthesia with patient age, weight, height and vertebral co-lumn length (VCL).

A large bore (18G) intravenous line was secured on the dorsum of left hand and 500 ml Ringer's lactate solution was infused 30 minutes before the patients' transfer to operation room. After standard ASA monitorization (noninvasive blood pressure, electrocardiogram, pulse oximeter), patient sit on the horizontal operation table and hip width was measured between the two iliac crests, shoulder width was measured between the two acromion processes, VCL was measured from the C_7 spinous prominence to sacral hiatus (C_7 - SH).

After obtaining the anthropometric measurements, lumbar puncture was performed at lateral decubitus position with midline approach using a 25G spinal needle at the $L_4 – L_5$ interspace guided with ultrasound for precise navigation of intervention interspace. Opioids were not added to intrathecal local anaesthetics. After observing free flow of cerebrospinal fluid, 3ml (15mg) 0.5% hyper-baric bupivacaine in 7.3% glucose was injected in 15 seconds with the needle aperture directed cephalad without barbotage. After spinal injection, the patient was kept in lateral decubitus position for 5 min and then turned to supine on the horizontal positioned operating table. No changes in position of the operation table were made throughout the surgery.

A 22G needle was used to detect the cephalad spread of spinal anaesthesia by loss of sensation to pinprick at 5, 10, 20, and 30 minutes after spinal injection. We started to test the spread of spinal anaesthesia starting from caudal (starting from 5^{th} sacral dermatome) and continued to cephalad till the feeling changed from dullness to sharp pain at both midclavicular lines. The number of blocked segments were recorded from the maximum cephalad spread dermatomal level to S_5. General anaesthesia would be induced if the spread of spinal anaesthesia was inadequate for the surgery or failed.

Hypotension was accepted as 30% decrease from the baseline systolic blood pressure (SBP) or SBP<90mmHg and treated with infusion of Lactated Ringer's solution and 5 mg ephedrine boluses as needed. Bradycardia was defined as heart rate <50 beats/minute and treated with 0.5 mg atropine when needed.

Patient variables including age,weight,height and vertebral column length were recorded.

Statistical Analysis

The sample size of the study was calculated by G*Power 3.1.9.2, a flexible statistical power analysis package program, using the data gained from the preliminary results of the study. Five patient variables were included in the current study. Minimum required sample size (n) was calculated to be 58 to detect an anticipated effect size of 0.37 for a desired statistical power level of 0, 85 at a probability level of 0,05. The statistical analysis of all data was performed with IBM SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Frequencies, percentages, mean standard deviation, median, min-max parameters were used to analyze quantitative data. Qualitative data was analyzed by Fisher's chi-square test. Means±standard deviation were used to express data with normal distribution. A bivariate linear correlation analysis was used to test the correlation between the spread of spinal anaesthesia and participants' age, weight, height, VCL and HSR. A stepwise multiple linear regression analysis was used to detect the correlation between spread of spinal anaesthesia and participants' age, weight, height, VCL and HSR. R2 is the determination coefficient of the multiple regression equation. P value<0.05 was considered statistically significant.

Results

All patients included in the study reached a satisfactory spinal anaesthesia level for scheduled operation (either orthopaedic surgery with a thigh tourniquet or unilateral inguinal hernia repair) and included in statistical analysis.

Patient variables are summarized in Table-1. The maximum cephalad spread of spinal anaesthesia ranged from T10 to C8 and time to reach maximum sensory block was 13.4±2.1 minutes.

Table 1. Patient Variables

Patient Variables	Mean±SD
Gender (F/M)	20/40
Age (y)	47.3±12.5
Height (cm)	169.3±10.5
Weight (kg)	77.7±10.7
BMI (kg/m^2)	27.4±5.0
ASA physicalstatus (I/II)	46/14
Hip Width (cm)	46.9±4.3
Shoulder Width (cm)	47.5±4.9
HSR	0.996±0.129
VCL (cm)	62.5±4.5

Data are given as mean±standard deviation (SD) or numbers. HSR: hip/shoulder width ratio, VCL: vertebral column length measured between the spinous process of C_7 vertebra to sacral hiatus.

Table-2 summarizes Pearson bivariate correlations between patient variables and the cephalad spread of spinal anaesthesia. Multiple linear regression showed that there was a significant correlation (p<0,0001) between HSR and a negative correlation with VCL and cephalad spread of spinal anaesthesia (Table-3, Figure -2, Figure-3) whereas age and weight of the patients had small correlations with spread of spinal (p=0,688; 0,843 respectively).

Table-2. The relation of patient variables and the spread of spinal anesthesia

Correlation of Variables with Spread of Spinal Anesthesia	r	p
Age (y)	0.102	0.437
Height (cm)	-0.572	0.0001
Weight (kg)	0.190	0.146
HSR	0.766	0.0001
VCL (cm)	-0.738	0.0001

VCL: Vertebral column length measured between the spinous process of C_7 vertebra to sacral hiatus, HSR: hip/shoulder width ratio, r: correlation coefficient

Table-3. Multiple lineer regression of patient variables and the spread of spinal anesthesia

	Spread of Spinal Anesthesia			
			95% CI	
Variables	*b*	*p*	Lower bound	Upper bound
Age	-0,059	0,212	-	-
Height	-0,111	0,306	-	-
Weight	0,78	0,302	-	-
HSR	8,598	0,000	5,382	11,814
VCL	-0,201	0,000	-0,289	-0,113

HSR: hip/shoulder width ratio, VCL: vertebral column length measured between the spinous process of C_7 vertebra to sacral hiatus, *b*: regression coefficient, 95% CI: 95% confidence interval for the partial coefficients. Regression equation, y=17,036+8,598x1-0,201x2, y is predicted spread of spinal anesthesia, x1 is measured hip/shoulder width ratio, and x2 is measured vertebral column length in cm.

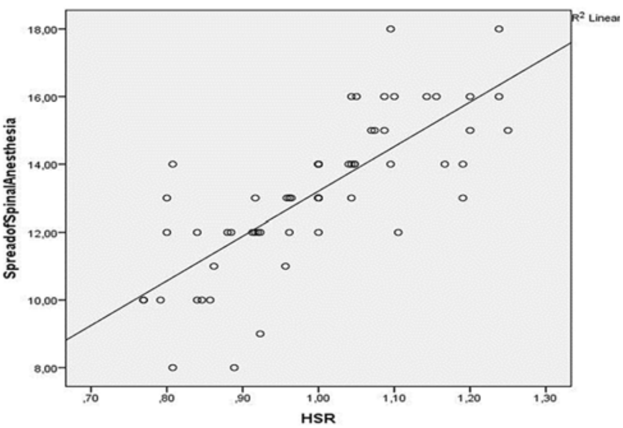

Figure-1. Linear Correlation Analysis of hip/shoulder width ratio and the spread of spinal anesthesia. HSR, hip/shoulder width ratio; Spread of spinal anesthesia is the number of dermatomes blocked starting from the fifth sacral dermatome; r=0,766; p<0,0001; r, linear correlation coefficient.

Adjusted R2 was 0,687for the regression equation of Y=17,036+8,598x1-0,201x2 where Y is predicted spread of spinal anaesthesia, x1 is measured hip/shoulder width ratio, and x2 is measured vertebral column length in cm.

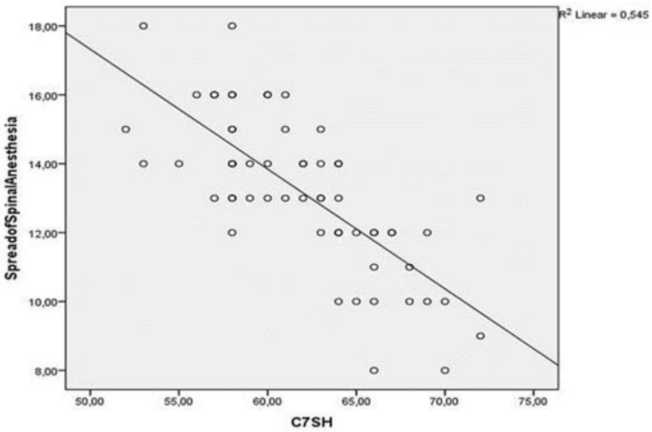

Figure-2. Linear Correlation Analysis of Vertebral Column Length and the spread of spinal anesthesia. C7SH, vertebral column length measured between spinous process of seventh cervical vertebra to sacral hiatus in cm; Spread of spinal anesthesia is the number of dermatomes blocked starting from fifth sacral dermatome; r=-0,738; p<0,0001; r, correlation coef.

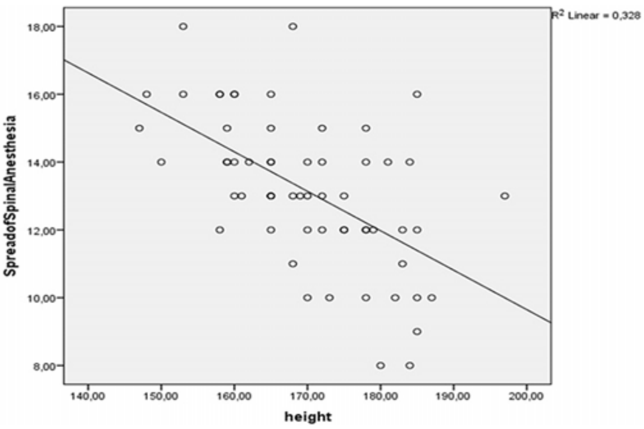

Figure-3. Linear Correlation Analysis of height and the spread of spinal anesthesia. height, patient height in cm; Spread of spinal anesthesia is the number of dermatomes blocked starting from the fifth sacral dermatome; r= -0,572; p= 0,000; r, linear correlation coefficient.

Discussion

In this study, we demonstrated that HSR>1 has a correlation with higher cephalad spread of 0.5% hyperbaric bupivacaine spinal anaesthesia. Barker et al. (11) showed that hyperbaric solutions pool in the dependent sections of the spinal canal. Kitahara et al. (12) demonstrated that hyperbaric local anaesthe-tics move to dependent side of the spine under the gravitational force. In the lateral position on a horizontal table, patients with greater hip width and a narrow shoulder width, resulting in HSR>1, assumes a relative Trendelenburg position and this aids hyperbaric 0.5% hyperbaric bupivacaine to move more cephalad under the effect of gravity. In the current study, a higher correlation between HSR and spread of spinal anaesthesia was achieved compared to our former study carried out with pregnant patient population (10). The difference between the two studies may be result of physiological changes at receptor level and physical changes in the lumbar anatomy during pregnancy.

In the current study, the patients reached a minimum sensory block level of T10 and a maximum sensory block level of C8. Patients who reached a sensory block level above T4 (n=15) had a HSR>1. These results were in accordance with our hypothesis since a HSR value greater than one resulted in a higher spread of spinal anaesthesia. We did not observe any respiratory disturbances in patients that had a sensory block above T4 dermatome level. In our study, we found a strong negative correlation with spread of spinal anaesthesia and VCL. Our results are in accordance with previous studies6, 13. As the VCL increases the spread of hyperbaric bupivacaine is limited to lower dermatome levels. Although these two previous studies were conducted with parturient patient population, in the current study we found similar correlation results in non pregnant patient population between VCL and the spread of spinal anaesthesia which is in accordance with the results of Zhou et al (9).

Stepwise multiple linear regression analysis of our data showed that both HSR and VCL are strong predictors of spread of spinal anaesthesia. These two patient variables are practically measurable during daily practice and can provide clinicians a provision of estimated spread of spinal anaesthesia with a given dose of hyperbaric bupivacaine when used in combination.

We found a reverse correlation between the height and the spread of spinal anaesthesia. Pitkanen et al. (14) also found a significant relation between level of analgesia and height of the patients. Norris et al. (15) reported that there was no significant correlation between the height of the patients and the spinal anaesthesia spread. The difference between the current study and that of Norris et al. (15) may be due to the difference between the sample population studied and the technique of spinal anaesthesia and the dose of bupivacaine administered intrathecal. Another reason for difference in the results of current study and that of Norris et al. (15) may be due to the method used for localization of intervertebral space. We used ultrasonography to detect the intervention interspace whereas palpation was the method used in the Norris's study.

Age, weight, and body mass index of the patients had no correlation with the spread of spinal anaesthesia. This result is in accordance with the previous studies that investigated the effect of these three parameters on the spread of spinal anaesthesia (2, 14, 15).

Limitations related to the current study includes the results obtained from the current study may guide anaesthesiologists to expect higher levels of spinal spread in patients with shorter height and HSR>1 however more than twenty factors effecting the level of spinal anaesthesia spread were defined and we could study only a part of these variables with trying to keep the rest of the variables constant. Combining more factors to predict the probable level of spinal anaesthesia on patient base during clinical practice will be logical. New studies with a greater sample size including more variables can help to obtain more reliable results with a greater predictive value.

Conclusion

HSR, VCL and patient height has a significant correlation with spread of spinal anaesthesia with a given dose of 0.5% hyperbaric bupivacaine. Measurements obtained from patient hip, shoulder, VCL and height will help the anaesthesiologists to predict the spread of spinal anaesthesia and to titrate the dose of intrathecal 0.5% hyperbaric bupivacaine for individual patient. We should expect to obtain higher spinal anaesthesia levels when the patient has a HSR>1 and the height and VCL of the patient is short.

Acknowledgments

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Conflict of Interests

The authors have no conflict of interest.

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