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Original Article

The spread of spinal anesthesia in term parturient: effect of hip/shoulder width ratio and vertebral column length

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Abstract: Objective: This study aims to determine the effect of age, height, weight, BMI, hip/shoulder width ratio, and vertebral column length on the spread of spinal anesthesia in term parturient. In pregnant patients with a larger hip width and a relative narrow shoulder width, more cephalad spread of spinal anesthesia is observed with a fixed dose of hyperbaric bupivacaine. We hypothesized that the increase in cephalad spread of spinal anesthesia may be correlated with the increased hip/shoulder width ratio. Methods: Age, weight, height, body mass index, hip width, shoulder width, hip/shoulder width ratio, and vertebral column length were recorded for 75 term parturient. The L4-L5 interspace was introduced and 2 ml 0.5% hyperbaric bupivacaine was injected subarachnoid in 10 seconds without barbotage. Pearson and Sperman's Rho Correlation Tests were used for the analysis of correlation between patient characteristics and the cephalad spread of spinal anesthesia. Results: Hip/shoulder width ratio had a positive correlation with the cephalad spread of spinal anesthesia (P=0.037). Other patient variables in the present study did not have correlation with the cephalad spread of spinal anesthesia (P>0.05). Vertebral column length had correlation with patient height (P=0.01). Conclusions: The cephalad spread of spinal anesthesia is correlated with hip/shoulder width ratio in term parturient patients. Vertebral column length has no correlation with the spinal anesthesia spread but correlates with the height of the parturient. The hip/shoulder width ratio may be more important than either patient height or vertebral column length in predicting the cephalad spread of spinal anesthesia for each parturient.

Keywords: Anesthesia, spinal, hip, obstetric, pregnancy

Introduction

Spinal anesthesia is widely used for cesarean section worldwide. Although spinal anesthesia has many advantages for the mother and the newborn (e.g. the parturient can hear the birth of the newborn and immediate contact between the mother and newborn can be established) compared to general anesthesia, it possesses some risks as hypotension which is the most common side effect of spinal anesthesia and directly related to spread of spinal anesthesia. To predict the spread of spinal anesthesia for every parturient, andto provide sufficient surgical anesthesia while preventing hypotension, several patient variables have been researched.

The spread of local anesthetics in the subarachnoid space for a given dose of a local anesthetic drug is affected by more than twenty factors [1]. Patient characteristics, technique of injection, baricity of the local anesthetic agent and the posture of the patient are the most studied variables to affect the spread of spinal anesthesia.

Patient position, sex, age, weight, height, body mass index, and vertebral column length were the patient variables studied to affect the spread of spinal anesthesia [2]. The hyperbaric local anesthetic solutions provide a more predictable anesthesia for cesarean section. Pregnancy itself is one of the factors influencing the distribution of local anesthetic solutions in cerebrospinal fluid since hormonal and anatomical changes occur during pregnancy [3]. Anatomical widening of the hips and laxation of symphysis pubis under control of gestational

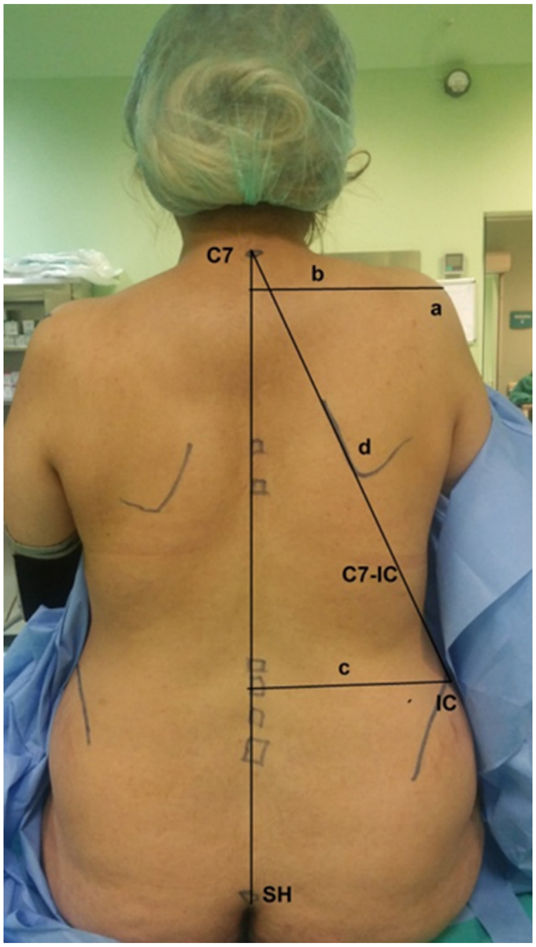

Figure 1. The anatomical measurement landmarks. Demonstrating the landmarks for the anthropometric measures. a: acromion process, b: distance from acromion process to midline, c: distance from iliac crest to midline, d: wing of scapula, C7: Spinous process of C7 vertebra, IC: iliac crest, SH: sacral hiatus, C7-IC: distance from C7 vertebra prominence to iliac crest.

hormones to prepare the birth canal for birth is in the nature of pregnancy at term.

Based on this fact we hypothesized that the increased hip/shoulder width ratio (HSR) may play a role in the cephalad spread of spinal anesthesia which is a practically measurable patient variable to predict the spread of spinal anesthesia. Data was also recorded for patient age, height, weight, body mass index (BMI), and vertebral column length (VCL) to determine their effect on the cephalad spread of spinal anesthesia.

Materials and methods

After receiving approval from the Turgut Özal University Ethical Committee (08.10.2015, 99-950669/216), and the written informed consent by all the participants (75 term parturient; 18-40 years; weight 52-106 kg; height 148-175 cm) were enrolled in the study from October 2015 to December 2015. Term ASA physical status I-II parturient that consented to spinal anesthesia for elective cesarean delivery was included in the study. The pregnant patients that rejected the study or spinal anesthesia, any contraindication for spinal anesthesia, present severe cardiovascular disease, prior spine or spinal canal surgery, ASA physical status greater than II, emergent cesarean sections or laboring parturient, patients shorter than 145 cm and taller than 180 cm were excluded.

The pregnant patients fasted for 8 hours and 500 ml of Lactated Ringer's solution was infused via an 18-gauge intravenous cannula 30 minutes before the cesarean section. Anthropometric measures were recorded at sitting position on a horizontal operation table (**Figure 1**). Hip size was measured between the two iliac crests and shoulder size between the two acromion processes. Vertebral column length was measured from the C7 prominence to sacral hiatus (C7-SH) and to iliac crest (C7-IC). Patients were monitored with standard American Society of Anesthesiologists monitors. During spinal anesthesia procedure, all patients were placed on the left lateral decubitus position with their legs, back and neck flexed and the head supported by a pillow. A 25 G spinal needle was introduced at L3-L4 interspace using a midline approach with the opening of the spinal needle turned cephalad and 2 ml (10 mg) hyperbaric bupivacaine (bupivacaine 5 mg/ml in 80 mg/ml dextrose) was injected in 10 seconds without barbotage after observing the free flow of the cerebrospinal fluid. After the subarachnoid injection of hyperbaric bupivacaine, the parturient was placed supine on a horizontal operation table with left uterine displacement and the operation table was kept horizontal until the end of the surgery.

A 22 G needle was used to detect the cephalad spread of spinal anesthesia at both midclavicular lines by loss of sensation to pinprick test at 5, 10, 20 and 30 minutes after spinal injection. Pinprick test started from the anesthetized area and continued to cephalad till the feeling changed from dullness to sharp pain at both midclavicular lines. The number

Table 1. Patient characteristics

Patient characteristics	*Mean* ± SD*
Age (y)	27.8±4.9
Height (cm)	161.1±5.9
Weight (kg)	80.3±11.4
BMI (kg/m²)	31.0±4.6
ASA physical status (I/II)	66/9
Hip width (cm)	45.5±3.8
Shoulder width (cm)	51.0±4.8
Hip/Shoulder width ratio	1.124±0.096
Vertebral column length (C7-SH) (cm)	58.1±3.3
Vertebral column length (C7-IC) (cm)	50.2±3.4

*: standard deviation.

Table 2. The patient characteristics and their correlation with the cephalad spread of spinal anesthesia

Patient characteristics	*Loss of pinprick discrimination*	
	r	*P**
Age (y)	-0.10	0.373
Height (cm)	0.13	0.248
Weight (kg)	-0.10	0.401
BMI (kg/m²)	-0.16	0.181
Vertebral column length (cm, C7-SH)	0.18	0.124
Vertebral column length (cm, C7-IC)	0.17	0.135
Hip width (cm)	0.24	0.037
Shoulder width (cm)	-0.04	0.760
Hip/Shoulder width ratio	0.30	0.009

*: P<0.05 is accepted as statistically significant.

of blocked segments was recorded starting from fifth sacral vertebra up to the maximum cephalad spread. Surgery started when spinal anesthesia reached to 6th thoracic dermatome level. General anesthesia would be induced if the spinal anesthesia spread was inadequate for the surgery or failed.

Hypotension was accepted as 20% decrease from the baseline systolic blood pressure (SBP) or SBP<90 mmHg and treated with 5 mg intravenous ephedrine boluses and hydration with Lactated Ringer's solution as needed. Bradycardia was defined as a heart rate (HR)<50 beats/minute and was treated with intravenous atropine.

Statistical analysis

The power analysis of the study was calculated by G*Power 3.1.9.2 statistical package program. Minimum sample size (n) was calculated to be 72 at a probability level (α)=0.05 and effect size (ρ)=0.37 for a statistical power level (1-β)=0.91. The statistical analysis of all data was performed with IBM SPSS 21.0 (SPSS Inc., Chicago, IL) package program. Normal distribution of the data was analyzed with Kolmogorov-Smirnow and Shapiro-Wilk tests; repeated measures ANOVA was used for quantitative data measured at different sampling intervals, data that did not have normal distribution was analyzed with Friedman test. If a statistical significance was detected, Tukey HSD test was used to determine which parameter was responsible for the difference. The correlation between the cephalad spread of spinal anesthesia and age, height, weight, BMI, HSR, and VCL (C7-SH and C7-IC) were analyzed with Pearson and Sperman's Rho Correlation Tests. A *p* value <0.05 was considered statistically significant.

Results

All parturients included in the study reached a satisfactory spinal anesthesia dermatome level for cesarean delivery and their characteristics are summarized in **Table 1**. Time to reach maximum sensory block was between 12-minutes (15.3±1.6 minutes) and the maximum cephalad spread of spinal anesthesia ranged from T4 to C6. **Table 2** summarizes the relationship between patient characteristics and the cephalad spread of spinal anesthesia. Atropin was necessary for six (5%) and ephedrine for 35 (46.7%) of the parturients. There was no correlation between patient age (P=0.37), height (P=0.24), weight (P=0.40), BMI (P=0.18) and the anesthesia spread. There was a significant correlation between HSR and cephalad spread of spinal anesthesia (P=0.009; **Figure 2**). VCL (C7-SH and C7-IC) did not have a correlation with the cephalad spread of spinal anesthesia (P=0.124; P=0.135) but had a statistically significant correlation with the height of the patient (P=0.032; P=0.019) (**Figures 3** and **4**).

Discussion

Although cephalad spread of spinal anesthesia is multifactorial and is hard to predict the level of spinal anesthesia, the parameters that are easily measurable may aid to predict the anesthesia spread at the daily practice. Patient position and the baricity of the local anesthetic drugs are the two factors influencing caudal or

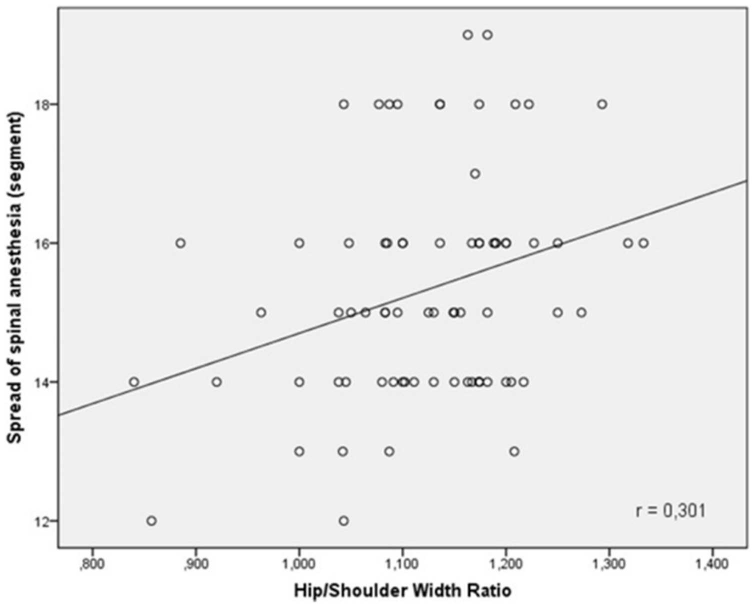

Figure 2. The correlation between hip/shoulder width ratio and the spread of spinal anesthesia. Demonstrates the significant correlation between the spread of spinal anesthesia and hip/shoulder width ratio (P=0.009).

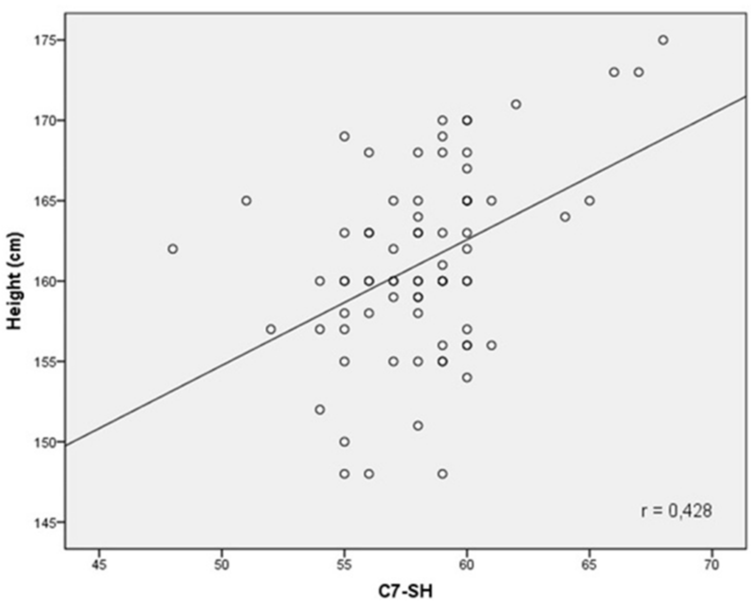

Figure 3. The correlation between vertebral column length (C7-SH) and patient height. Demonstrates the correlation between the height of the patient and vertebral column length (in the figure C7-SH represents the distance between the process of C7 vertebra to the sacral hiatus) (P=0.124).

cephalad spread of spinal anesthesia under the effect of gravitational forces [1, 2, 4, 5].

We found a positive correlation between HSR and the cephalad spread of spinal anesthesia with a given dose of hyperbaric bupivacaine in term parturient. Physiological factors and hormones during pregnancy effect on the bonny structure of the pelvis to provide a birth canal for the fetus resulting in an increased hip size [6]. Since the trunk gains a relative Trendelenburg position on the horizontal operating table due to a wider hip, the increased HSR may result in spilling of the hyperbaric local anesthetic solution more cephalad leading to an increased spread of spinal anesthesia. To our knowledge, there was no prospectively designed study documenting the effect of HSR on the spread of spinal anesthesia in the literature. The increased HSR may be one of the important patient variables altering the cephalad spread of spinal anesthesia in pregnant patients undergoing cesarean section observed in the current study.

In our study, we did not find a correlation between the VCL and the spread of spinal anesthesia hovewer Zhou Q. reported a significant correlation between VCL and the spread of spinal anesthesia [7]. They studied 114 non pregnant patients and found a significant correlation between VCL and spread of spinal anesthesia (P=0.009). The difference between this study and the current study may be due to the difference in baricityof the local anesthetics used (plain vs hyperbaric bupivacaine) and the patients in our study population were parturients. Unlike presented in our study, Hartwell BL. reported a correlation between the spread of spinal anesthesia and VCL in term parturient with a given dose of hyperbaric bu-

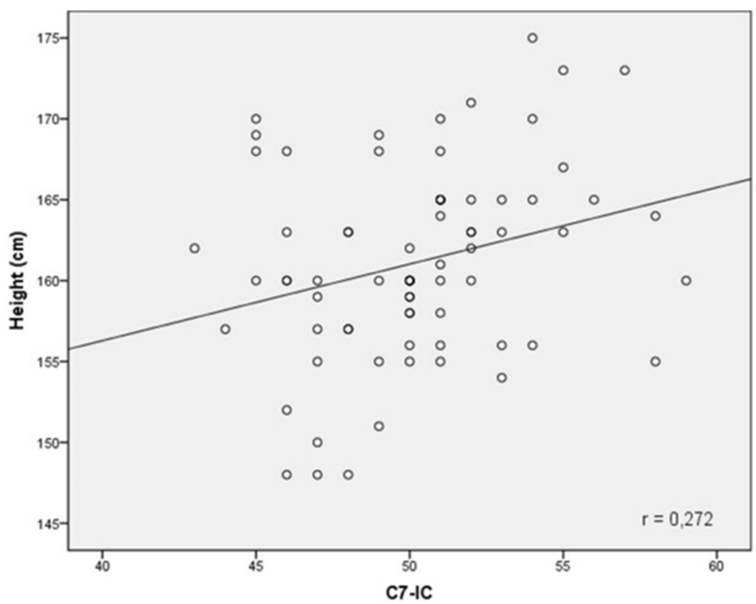

Figure 4. The correlation between vertebral column length (C7-IC) and patient height. Demonstrates the correlation between the height of the patient and vertebral column length (in the figure C7-IC represents the distance between the process of C7 vertebra to iliac crest) (P=0.135).

pivacaine [8]. Our results and those of Hartwell BL are different which may be due to the technical differences in administration of spinal anesthesia since we did not use barbotage; the level of spinal needle introduction segments and the volume injected subarachnoid are different in the studies. Hartwell also stated that there was a weak correlation between height and VCL; however in the current study we found a statistically significant correlation between height and VCL. Racial differences in our study population and the latter study may be the reason causing the differences in anthropometric measures and may explain the differences in correlation between VCL and the height of the patient. In a study carried out on non-pregnant patients by Perez-Tamayo [9], there was no correlation with the VCL and the spread of spinal anesthesia. Pargger also reported that there was no correlation between VCL and the cephalad spread of spinal anesthesia [2]. As supported by our results, Norris also have studied the effect of VCL on spinal anesthesia spread on parturient patient population with hyperbaric bupivacaine and reported no correlation [10].

Our finding of no correlation between the cephalad spread of spinal anesthesia and age, weight, height and BMI in pregnant patients supports that of other investigators [8, 10].

In a recent study by Xu F. [11], the effect of postural change from lateral to supine on the cephalad spread of spinal anesthesia after injection of 0.5% plain bupivacaine for cesarean section was studied and they concluded that it was an important mechanism for the cephalad spread. The authors explained the condition with venous engorgement of the epidural veins and an increased intraabdominal pressure when the patient turned to supine. Besides these mechanisms we speculate that, although HSR was not measured in this study, parturient population not always but generally have an increased HSR resulting in a relative Trendelenburg position and this might have contributed to the cephalad spread of spinal anesthesia. Since the local anesthetic agent used was plain bupivacaine, it acts hypobaric in cerebrospinal fluid at body temperature [12] and the longer the patient stays on lateral position before turning to supine (at a relative trendelenburg position on a horizontal operation table) the caudal pooling of a hypobaric agent may result in a less cephalad spread of spinal anesthesia in term parturient.

In conclusion, of the patient characteristics studied; age, weight, height, BMI, and VCL have no correlation with the cephalad spread of spinal anesthesia with a fixed dose of hyperbaric bupivacaine in term parturient. HSR has a significant correlation with the spread of spinal anesthesia. In pregnant patient population, more cephalad spread of anesthesia may be expected with increasing HSR which may be more valuable than VCL for predicting cephalad spread of spinal anesthesia.

Disclosure of conflict of interest

None.

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