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ORIGINAL ARTICLE

Relationship of abdominal circumference and trunk length with spinal anesthesia level in the term parturient

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Abstract
Background We hypothesized that body shape metrics influence the anatomy of spinal canal and intraabdominal pressure in three dimensions. We explored the effects of abdominal circumference, trunk length, and their combination on the level of spinal anesthesia in the term parturient in this study.
Methods Thirty term parturients, ASA class I–II, from 20 to 41 years of age, scheduled for cesarean section were enrolled in this observational study. Abdominal circumference (AC) and trunk length (TL) were recorded preoperatively. Spinal anesthesia was performed with 10 mg 0.5 % hyperbaric bupivacaine at the L4–L5 intervertebral space in all parturients. Correlation between maximal sensory spinal anesthesia level and physical parameters was analyzed with Spearman rank correlation coefficients. The calculated r value was compared with $r = 0$ with $p < 0.05$ as the significant level. The prediction power of these physical parameters for spinal level was evaluated by prediction probability.
Results The parameter TL/AC^2 was statistically correlated with maximal sensory level (Spearman correlation coefficient, −0.45 with $p < 0.02$). The prediction probability of TL/AC^2 for the dermatomal level was $P_K = 0.685$. If the dermatomal levels were lumped as higher (above T2) and lower (below T3) levels, the prediction probability of TL/AC^2 was as high as $P_K = 0.856$.
Conclusions TL/AC^2, which simulated the ratio of the long axis and transection area of the abdomen, was correlated with maximal spinal level, and parturients with low TL/AC^2 values tended to have higher dermatomal levels during spinal anesthesia.

Keywords Cesarean delivery · Spinal anesthesia · Abdominal circumference · Trunk length

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Introduction

Spinal anesthesia is commonly used for cesarean delivery. Excessive block increases hemodynamic instability and patient risk where as inadequate spread of local anesthetics cannot provide a satisfactory surgical condition. Therefore, to predict and control local anesthetics spreading in the cerebrospinal fluid is important. Factors affecting the extent of spinal anesthesia in obstetric patients has been investigated in many studies [1, 2]. Characteristics of the solution injected, the clinical technique used, and the patient's general features all have been found to make some contribution. Among these categories, the patient's general features are especially important for the determination of the spread of intrathecal local anesthetics. Increased cephalad spread of local anesthetics has been demonstrated with increased intraabdominal pressure, changes in anteroposterior spinal curves, and lumbar lordosis [3–6]. However, measuring these physiological parameters is not easy or suitable for daily practice. We assumed that body shape metrics might contribute to the foregoing factors and might have an influence on the spinal level. However, studies for patient characteristics such as body weight and height show controversial results for spinal level [7–10]. Hartwell et al. found that trunk length (i.e., distance from C7 to the sacral hiatus) had a much better correlation than body height [7], while other researchers showed different results [8]. Because body metrics is a three-dimensional concept, we postulated that considering simultaneously the long axis (trunk length) and short axis (abdominal circumference) might improve the correlation and prediction of the extent of spinal anesthesia. In this study, we examined this hypothesis in obstetric patients undergoing cesarean section.

Methods

For a Spearman correlation coefficient of at least 0.4 (which was the minimal value we thought to have some clinical interest) and the probability of type I error (alpha error) less than 0.05, the sample size must be at least 25. A few more samples than this minimal requirement were recruited so the actual sample size was determined as 30.

After institutional ethics committee approval and written informed consent from the patients were obtained, 30 parturients with term pregnancy, ASA class I–II, aged from 20 to 45 years, and who were scheduled for cesarean section were enrolled in this observational study. Parturients with preeclampsia or eclampsia, gestational diabetes mellitus, or other systemic diseases such as heart disease, renal dysfunction, or hepatic dysfunction were excluded. Parturients whose fetuses had systemic abnormalities as found during prenatal examination were also excluded.

Abdominal circumference (AC) was measured with the patient lying flat (supine), and the circumference at the level of the umbilicus was taken. Trunk length (TL) was measured as the distance from C7 spinous process to sacral hiatus. It was measured by a cloth yard with the patient lying left decubitus. The AC and TL were measured preoperatively before spinal anesthesia. The spinal anesthesia for all cases was performed with our standard practice. Parturients were monitored with electrocardiography, pulse oximetry, and noninvasive blood pressure monitoring. After giving 1,000 ml Ringer's solution for prehydration, 0.5 % hyperbaric bupivacaine 2 ml was injected intrathecally with a Quincke type, 27-gauge spinal needle at the L4–L5 intervertebral space in all parturients in left lateral decubitus position. The parturients were returned to the supine position with left lateral tilt for left uterine displacement immediately after injection of local anesthetics. The level of sensory blockade was checked by examining cold sensation with an alcohol pad every minute in the first 5 min after injection and then every 5 min until achievement of the maximal level of sensory blockade. If hemodynamic changes occurred consequent to the high spinal level, ephedrine was administered intravenously to maintain blood pressure within 20 % of the baseline value.

Statistical analysis

All variables except the sensory block level were summarized as mean and standard deviation (SD) in conventional units.

The relationship of the maximal sensory block level of spinal anesthesia with AC, TL, TL/AC, and TL/AC^2 was analyzed with the Spearman rank correlation coefficient The calculated r value was compared with $r = 0$. $p < 0.05$ was considered as statistically significant.

The prediction power of TL/AC^2 for maximal sensory level was analyzed by the prediction probability (P_K) [11]. The P_K value revealed the overlapping of the parameter values among different outcomes. A P_K value of 0.0 or 1.0 means perfect prediction and no overlapping at all of values among different outcomes, and the worst P_K value of 0.5 means a prediction no better than a random guess.

Results

We recruited 32 parturients in the study. The demographic data of the parturients is shown in Table 1. Two of the cases, with maximal spinal anesthetic level of T8 and T10, respectively, who required supplemental intravenous anesthetics, were excluded from the study because technical problems could not be ruled out as the reason for the low sensory levels. The statistical results of the other 30 cases are shown in Table 2, and the relationship between

Table 1 Clinical characteristics of the study subjects

Number	30
Age, years	33.1 (4.9)
Fetal gestational age, weeks	38.3 (1.1)
Body weight, kg	69.9 (9.2)
Body height, cm	158 (4.5)
Abdominal circumference, cm	99.9 (7.2)
Trunk length, cm	61.7 (4.2)

Means (SD) are shown

Table 2 Spearman rank correlation coefficient between measurements and spinal level

	Correlation coefficient
Abdominal circumference (AC, cm)	0.36
Trunk length (TL, cm)	−0.21
TL/AC	−0.36
TL/AC^2	−0.45 ($p < 0.02$)

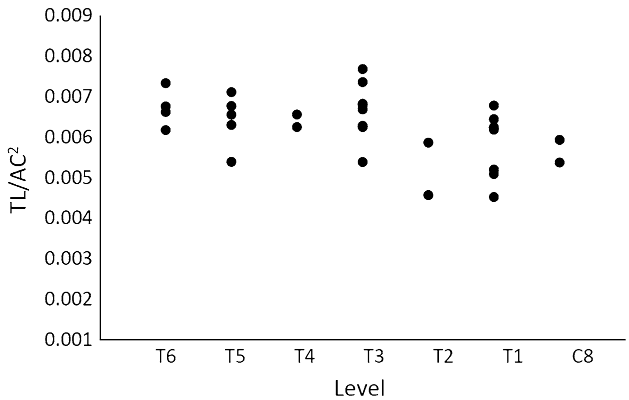

Fig. 1 Relationship of trunk length/abdominal circumference^2 (*TL/AC*^{2}) to spinal level

Table 3 Prediction probability of trunk length/abdominal circumference^2 (TL/AC^2) for spinal level

	Prediction probability (P_K)
TL/AC^2 vs. spinal level	0.685
TL/AC^2 vs. high (>T2) or low (<T3) sensory level	0.856

TL/AC^2 and spinal level is shown in Fig. 1. The correlation coefficient between maximal dermatomal level and AC, TL, TL/AC, and TL/AC^2 was 0.36, −0.21, −0.36, and −0.45, respectively. The correlation of sensory level with TL/AC^2 was significantly different from $r = 0$ ($p < 0.02$).

The prediction probability of TL/AC^2 is shown in Table 3. The prediction probability of TL/AC^2 for exact maximal spinal level was $P_K = 0.685$, which revealed a medium power of prediction. If the parturients were partitioned into a higher sensory level group (above or equal to T2) and a lower sensory level group (below or equal to T3), the TL/AC^2 can discriminate the two groups with a P_K value as high as 0.856.

Discussion

In this study, we investigated the relationship of abdominal circumference and trunk length with the level of spinal anesthesia. Our data showed that the combined parameter, the TL/AC^2, had a better and significant relationship to the sensory blockade level ($r = -0.45$ with $p < 0.02$). The most important implication of our results was that under the same clinical technique and the same dosage of local anesthetics injected, a parturient with shorter trunk length and larger abdominal transection area would tend to have a higher sensory blockade level.

There have been many studies on the relationship of various patient characteristics with the extent of spinal anesthesia [1, 2]. Cephalad spread of local anesthetics was not related to the degree of weight gain during pregnancy but was greater in twin compared with singleton pregnancies [4–12], perhaps caused by an effect on intraabdominal pressure. Sagittal abdominal diameter has been reported to be associated with higher intraabdominal pressure, and the correlation was even better than waist–hip ratio [13]. Hartwell et al. thought that most of the difference in height between adults is the result of the length of the lower limb long bones, not the length of the spine [7]. When trunk length (TL) was related to the block height, they found a much better correlation. However, Norris found nonsignificant results with $r^2 = 0.0288$ [8]. The relationship between TL and the maximal level of spinal anesthesia was also not very high in our study ($r = -0.21$).

We thought that the body shape metrics and their influences on the anatomy of spinal canal should be viewed in three dimensions. We thought the lack of three-dimensional analyses could explain why patient characteristics considered only in one dimension alone, such as the AC or the TL, did not have sufficient correlation to the level of sensory blockade. Thus, we tried to analyze the effects of combinations of the AC and TL values. If we simulate the transection of the abdomen as a circle or an ellipse, the AC value actually will have the same trend as the diameter of this circle, and the AC^2 has the same trend as the area of this circle, or the maximal transection area of the abdomen. Thus, the TL/AC could be regarded as a measure of the ratio between long and short axes of the body, and the TL/AC^2 was the measure of the ratio between the long axis and transection area of the abdomen. Because the effect of the TL and AC on the level of spinal anesthesia was in the reverse direction, their ratio might have an additive effect on the correlation with the spinal level. This finding may explain the better relationship of TL/AC^2 to the sensory blockade level. The TL/AC^2 parameter accounted for the influence on all three dimensions and had the best performance among our parameters. For a correlation coefficient of $r = -0.45$, the coefficient of determination for the parameter TL/AC^2 was $r^2 = 0.2$, which means this parameter contributed one fifth for the determining factors to the sensory blockade level. Considering the complexity of the dynamics of intrathecal drug spread, it may be unrealistic to anticipate any single factor to have very high determining power.

On the other hand, the power of prediction may be practically more meaningful than the correlation or comparison of the two groups. As already stated, a parturient with shorter trunk length and greater abdominal transection area would tend to have the higher sensory blockade level, which was demonstrated by a high prediction probability

(P_K). The prediction probability is a good measure of the prediction power. For a pair of data, a concordance means the order of the parameter is the same as that of the outcome (for example, both the parameter TL/AC^2 and the spinal level of case A are less than those of case B). A discordance means the opposite condition (case A has a higher TL/AC^2 but lower spinal level than case B). The prediction probability (P_K) counts the ratio of concordance in all data pairs and has a value between 0 and 1. A P_K of 0.5 means that the prediction power of the parameter for the outcome was no more than random guesses. As the P_K biased away from 0.5 toward 0 or 1, the prediction power increased. A P_K of 0 or 1 means a total prediction power. The prediction power of TL/AC^2 for the exact spinal level was not very high ($P_K = 0.685$). However, if the spinal anesthetic level was lumped as only high or low, our results demonstrated a rather powerful P_K of 0.856 for TL/AC^2 to predict this trend.

The clinical settings in our study, including the dosage, the concentration and the volume of local anesthetics, and the intervertebral space into which the spinal needle was injected, were the same for every parturient. Plain solution of local anesthetics has been reported to have more variable performance even at the same clinical settings because it could be relatively hypobaric or isobaric in different patients [11–13]. In our practice, hyperbaric solution was routinely used, and thus this problem could be largely avoided. However, this finding also indicated that our results may be applied only when hyperbaric solution is used. Patient characteristics such as height, weight, and age were also variable in our subjects. As previous research has showed, however, none of these factors has been proved to have any significant influence on the level of spinal anesthesia [14, 15].

In conclusion, our observational study showed that the combination of abdominal circumference and trunk length, the TL/AC^2 (which simulated the ratio of the long axis and the transection area of the abdomen), had some correlation to and some prediction power for the level of spinal anesthesia. A parturient with shorter TL and larger AC may tend to obtain a higher spinal level.

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