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Truncal Cutaneous Temperature Changes and Anthropometry in Spinal Anaesthesia - An Observational Study

Spinal Anestezide Trunkal Kutanöz Sıcaklık Değişiklikleri ve Antropometri - Gözlemsel Çalışma

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ABSTRACT

Objective: The predictability of onset of sympathetic block in spinal anaesthesia is poor. The role of the structures around the dural sac, in determining the spread of local anaesthetic in the subarachnoid space, is evaluated by studying the effect of the peri-spinal frustum volume on the change in cutaneous temperature and perception of cold sensation.

Methods: In patients planned for spinal anaesthesia with 2.5 mL of 0.5% heavy bupivacaine intrathecally, volume of frustum between T8 and L3 was calculated using abdominal circumference at T8 and L3 and the distance between these spinous processes. The speed of onset at T8 level was measured as a change of 0.5 °C in cutaneous temperature probe and loss of cold sensation.

Results: Of the 40 patients analysed, 22 patients had increase in cutaneous temperature while 14 had a decrease and 4 had no change. The onset time of loss of cold sensation in seconds was 327.68±169.65 (99% CI:234.51–420.85) and 232.64±75.47 (99% CI 180.69-284.60) in patients with increase and decrease of the skin probe respectively. The square of correlation coefficient (R^2) of frustum volume was 0.55 (99% CI -0.15-0.88, p=<0.01) in the group with decrease in skin temperature and 0.03 (99% CI -0.51-0.55, p=0.46) in group with increase in skin temperature.

Conclusion: The effect of peri-spinal volume on the speed of onset of block at T8 level is variable and somatic block correlates only in patients who had a decrease in skin temperature.

Keywords: Anthropometry, skin temperature, spinal anaesthesia, sympathetic nerve block

ÖZ

Amaç: Spinal anestezide sempatik blok başlangıcının öngörülebilirliği düşüktür. Dural kese çevresindeki yapıların, lokal anesteziğin subaraknoid boşluktaki dağılımını belirlemedeki rolü, perispinal frustum hacminin kutanöz sıcaklıktaki değişimi ve soğuk duyusunun algısı üzerindeki etkisi incelenerek belirlenmeye çalışılmıştır.

Yöntem: İntratekal olarak 2.5 mL %0,5 heavy bupivakain ile spinal anestezi planlanan hastalarda, T8-L3 arasındaki frustum hacmi, T8-L3'teki karın çevresi ve bu spinöz çıkıntılar arasındaki mesafe kullanılarak hesaplandı. T8 seviyesindeki başlama hızı, kutanöz sıcaklık probunda 0,5 °C'lik değişiklik ve soğuk duyusunun kaybı olarak ölçüldü.

Bulgular: Analiz edilen 40 hastadan 22'sinde kutanöz sıcaklıkta artış, 14'ünde azalma olurken 4'ünde değişiklik olmadı. Saniye cinsinden soğuk duyu kaybının başlama süresi, kutanöz sıcaklıkta artış ve azalması olan hastalarda sırasıyla 327,68±169,65 (%99 CI:234,51-420,85) ve 232,64±75,47 (%99 CI:180.69-284.60) idi. Frustum hacminin korelasyon katsayısı (R^2), kutanöz sıcaklıkta azalma olan grupta 0,55 (%99 CI: -0,15–0,88, p<0,01) ve kutanöz sıcaklıkta artış olan grupta grupta 0,03 (%99 CI: -0,51– 0,55, p=0,46) idi.

Sonuç: T8 seviyesinde bloğun başlama hızı üzerinde perispinal hacmin etkisi değişkendir ve somatik blok sadece kutanöz sıcaklıkta azalma olan hastalarda korelasyon gösterir.

Anahtar sözcükler: Antropometri, cilt sıcaklığı, spinal anestezi, sempatik sinir bloğu

INTRODUCTION

Though spinal anaesthesia has been used for more than 100 years, the predictability of the spread of subarachnoid block is still poor (1). Predictability of level of blockade is important for attaining a level appropriate for a surgical procedure and to predict cardiovascular side effects. In clinical practice, age, obesity, increased abdominal circumference, pregnancy has been recognized as factors affecting the speed of onset and has been evaluated in many previous studies (2-5). While the effect of subarachnoid block on the somatic fibres is well known, the effects on the sympathetic fibres have pro-

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duced conflicting results (6-9). In addition to hypotension, sympatholysis causes change in cutaneous temperature (6,10,11). Many modalities have been used to measure cutaneous temperature (6,10-14). As reported by Hermanns and co-workers, the truncal temperature can increase, decrease, or have no changes (10). By measuring the peri-spinal frustal volume, formed between T8 and L3 vertebral level, we can include all the external compressive factors on the spinal dural sac and therefore on the cerebrospinal fluid (CSF). We hypothesise that, by measuring the effect of a known volume of local anaesthetic on the thoracolumbar sympathetic block through the measurement of cutaneous temperature and the loss of cold sensation, the effect of the peri-spinal frustal volume on sympathetic and somatic efferent blockade in spinal anaesthesia can be estimated.

MATERIAL and METHODS

This observational study was approved by the Institutional Ethics Committee of Sri Ramachandra Institute of Higher Education and Research (SRIHER), Chennai (CSP/16/MAY/48/170) and was conducted in SRIHER study during the period from June to September 2016. Non-obstetric patients aged 17-80 years, more than 150 cm height, undergoing elective surgery in supine position, under subarachnoid block with a planned dose of 2.5 mL of 0.5% hyperbaric bupivacaine were selected and included in the study after obtaining a written informed consent. Patients who had a change of anaesthetic plan in the preoperative and intraoperative period or receiving combined epidurals were excluded from the study. The study's main objective was to analyse the correlation between volume of the frustum formed by the trunk at T8 and L3-L4 vertebral levels and the time taken to achieve T8 level measured by loss of cold sensation and change in temperature of 0.5 °C by skin probe. Secondary outcomes included analysing the correlation with other anthropometric characteristics.

Standard pre-anaesthetic assessment was carried out and the following anthropometric measurements were made

- Height in centimetres (cm)
- Weight in kilograms (kg)
- Body mass index (BMI) (kg m^{-2})
- Abdominal girth in centimetres at L3-L4 level, and T8 vertebral level at end of tidal expiration with patient in sitting position in cm
- Length of vertebral column in centimetres in sitting position along the skin from T8 to L3-L4 interspace (H) (cm)

Using these measurements, the following values were derived (Figure 1):

Circumference = 2x3.14xR

R1(Radius at T8) = Girth $_{\text{T8 Vertebral}}$ / (2x3.14)

R2 (Radius at L3) = Girth $_{\text{L3-L4}}$ / (2x3.14)

Volume of the frustum formed between T8 and L3 (V_{Frustum}) = 3.14 H ($R_1^2 + R_2^2 + R_1 x R_2$) in cm^3

In the operating room, a skin temperature probe (Philips Intellivue, Philips, Amsterdam, Holland) was attached at T8 dermatomal level to the right of the patient's midline, anteriorly, in a non-hairy part of the skin. The operating room temperature was set at 22°C and the patient was covered with a cotton gown. Subarachnoid block was performed in the sitting position with a 25 G Quincke needle and 2.5 mL of 0.5% hyperbaric bupivacaine (stored at a standard temperature) was then injected into the subarachnoid space over 25 seconds (at the rate of 0.1 mL per second). The patient was immediately put in supine position after administration of the drug. The skin temperature was recorded just before injecting the spinal drug and continuously for 20 minutes after injecting the spinal drug. The sensory block level was assessed using loss of cold sensation at 30-second intervals, on the left side, till sensory blockade reached T8 level and the time taken for T8 sensory blockade from time of injection was noted (Time $_{\text{T8 cold}}$). Using continuous skin temperature monitoring, the time taken for a 0.5 °C change at T8 dermatomal level was noted ($\text{Time}_{\text{T8 probe}}$). The final block level was assessed at 20 minutes after injection of spinal drug, using patients' subjective loss of sensation to cold sensation using ice cube.

Statistical Analyses

All data were recorded on a predefined proforma, and appropriate statistical analysis was carried out using SPSS software version 16. The descriptive data is presented as mean and standard deviation (SD) for continuous variables. Mann-Whitney U test was used to compare time of onset in the groups. Spearman correlation and square of correlation coefficient (R^2) was used to analyse correlation. A p value of <0.01 was considered significant for the anthropometric variables and p of <0.05 was considered significant for comparing the time of onset of block. 48 patients were found eligible for the study.

From the previous studies, we used a correlation R value of 0.8, alpha of 0.01, power of 0.8, and the sample size was calculated as 13 (3-5). In view of the large variation, 48 patients were recruited for the study. Three patients with inability to stand were excluded from the study. T8 level could not be measured accurately in 5 patients (Figure 2).

RESULTS

Of the 48 patients recruited, 40 were analysed. In 8 patients, the measurements were incomplete. Of the 40 patients included into the study, 35 (87.5%) were male and 5 (12.5%) were female. The average age (years), height (cm), weight (kg), and BMI (kg m^{-2}) were 43.25±16.85, 165.85±6.35, 67.28±14.14 and 24.41±4.65 respectively. At the end of 20 minutes after intrathecal injection of bupivacaine, the level of blockade was found to be T4 in 17 patients (42.5%), T5 in 14 patients (35%), T6 in 7 patients (17.5%), T7 in 1 patient (2.5%) and T8 in 1 patient (2.5%). The mean time for loss of cold sensation at T8 dermatomal level was 284.25±140.77 seconds and the mean time taken for 0.5 °C change in skin temperature at T8 dermatomal level was 428.31±299.74 seconds. The R^2 value for correlation were 0.089 and 0.149 respectively. Of the 40 patients, 14 patients (35%) had decrease in the skin temperature while 22 patients (55%) had an increase. There was no difference in age in median years (min-max), 41 (18-75) and 43.5 (18-78) for increase and decrease respectively (p=0.90), weight (0.90), height (1), BMI (p=0.80), volume (p=0.92) and volume per unit length (p=0.66) among these groups (Median values given in Table I and II). The correlation between the volume and speed of onset of block (based on change in cold sensation and in the temperature probe) is given in Table I and II. Four patients had no change in temperature probe readings. The comparison between the groups which had increase and decrease of cutaneous temperature and within group correlation of the time of onset of loss of cold sensation and change in cutaneous temperature are given in Table III. The final level achieved in the group which had an increase in temperature (n=22) were T4 in 7 patients, T5 in 8 patients, T6 in 5 patients and T7 and T8 in one patient each. The final level achieved in the group which had a decrease in temperature (n=14) were T4 in 8 patients, T5 in 5 patients, T6 one patient.

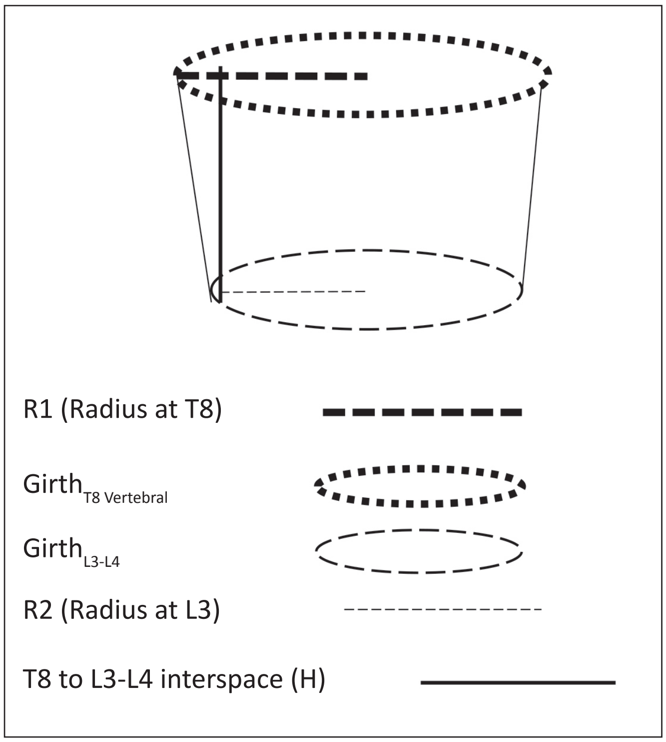

Figure 1: Frustrum as modelled in the study between T8 and L3 vertebral levels.

DISCUSSION

Our study shows that subarachnoid block can produce increase, decrease or no change in truncal cutaneous temperature and correlation with the peri-spinal frustal volume is seen only in patients having a decrease in truncal cutaneous temperature after the block. We discuss known factors and probable reasons for the finding.

Prediction of speed of onset of subarachnoid block and the height attained has always been difficult. At least 25 factors

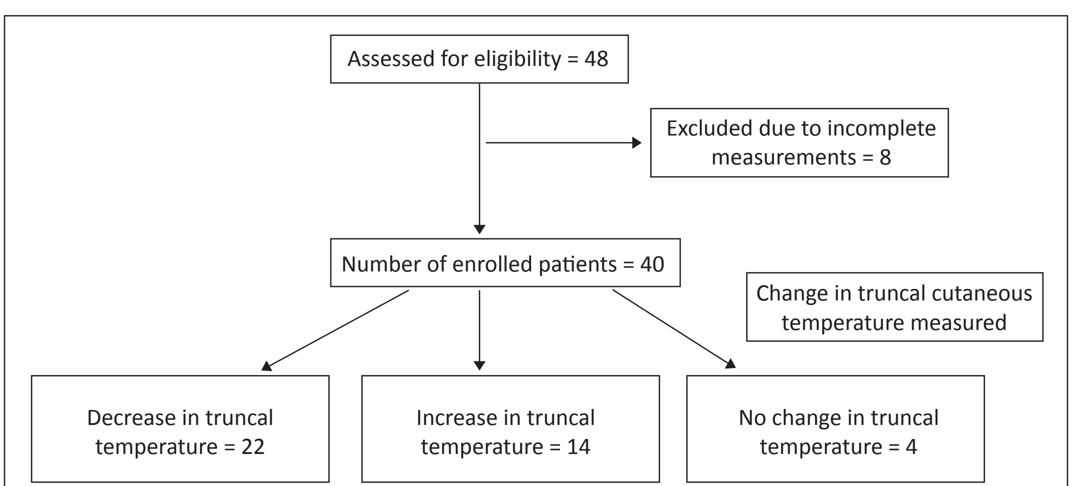

Figure 2: Patient flowchart.

Table I: Correlation of anthropometric parameters with the time taken (in seconds) for loss of cold sensation and 0.5 °C increase from baseline skin temperature at T8

Parameters	Median [min, max, IQR]	Loss of cold sensation R^2 (p)	Skin Temperature R^2 (p)
Weight (kg)	66.1 [43,99,15.25]	0.14 (0.086)	0.26 (0.016)
Height (cm)	167.5 [154,176,10.75]	0.12 (0.114)	0.13 (0.098)
BMI (kg m^{-2})	24.68 [16.38,32.02,6.16]	0.07 (0.224)	0.158 (0.067)
Volume (cm^3)	169.36 [79.9,243.63,67.38]	0.03 (0.463)	0.13 (0.096)
Volume per unit length (cm^2)	7.07 [3.97,9.2,1.66]	0.03 (0.446)	0.04 (0.367)

***Min:** Minimum; **Max:** Maximum; **IQR:** Inter quartile range; **BMI:** Body mass index.*

Table II: Correlation of anthropometric parameters with the time taken (in seconds) for loss of cold sensation and 0.5 °C decrease from baseline skin temperature at T8

Parameter	Median [min,max,IQR]	Loss of cold sensation R^2(p)	Skin Temperature R^2 (p)
Weight (kg)	64.7 [40,104,14.75]	0.68* (0.000)	0.15 (0.176)
Height (cm)	166.00 [154,176,10.5]	0.00 (0.875)	0.02 (0.629)
BMI (kg m^{-2})	25.25 [15.63,34.91,5.76]	0.77* (0.000)	0.13 (0.212)
Volume (cm^3)	153.43 [93.57,305.27,55.5]	0.55*(0.002)	0.22 (0.090)
Volume per unit length (cm^2)	6.99 [4.07,10.53,1.66]	0.64*(0.001)	0.19 (0.125)

***p<0.01 considered significant. Min:** *Minimum;* **Max:** *Maximum;* **IQR:** *Inter quartile range;* **BMI:** *Body mass index.*

Table III: Difference of onset of block between the groups with increase and decrease of skin temperature from baseline at T8 (time in seconds)

	Increase median [min,max,IQR]	Decrease median [min,max,IQR]	p
Time to loss of cold sensation	309.5 [160,959,131]	217.5 [119,363,111.5]	0.035*
Time to change in skin Temperature	375.5 [66,1270,425.25]	317.5 [110,1035,172.5]	0.436
Correlation R^2	0.39 (p=0.002)*	0.07 (p=0.354)	

p<0.05 considered significant* ***Min:* *Minimum;* ***Max:*** *Maximum;* ***IQR:*** *Inter quartile range.*

have been recognized to affect the spread of local anaesthetic in the CSF. In our study the pharmacological factors (drug volume, concentration, speed of injection), and procedural factors (space, needle size and type, position) were kept constant. Studies on the effect of weight, height, and age on the intrathecal spread of the drug have produced conflicting results. Zhou et al., in their multiple linear regression analysis, showed that age, weight and height had low value for predicting the dosage of intrathecal bupivacaine for the level of anticipant spinal anaesthesia (4). Studies suggest that the primary determinant of intrathecal drug spread is the lumbosacral CSF volume. A high variability in CSF volume has also been reported, without correlation with either weight, height or BMI (15). A wide variation in the size of the root among individuals may also be a determining factor for the response to local anaesthetics (16). Sullivan et al. further proved that only weak correlations existed between the volume of lumbosacral cerebrospinal fluid and height, weight or BMI (17). Our study agrees with the study, showing only a weak correlation with the spread of drug, when all cases were considered, with the anthropometric parameters. Cerebrospinal fluid volume in the intrathecal space could be reduced by engorged epidural veins, due to compression by abdominal contents or by the influence of epidural fat, both of which are probably found in obesity. Parturient abdominal girth and vertebral column length have been found to determine the spread of spinal anaesthesia with hyperbaric bupivacaine in a term parturient (5).

To assess the immediate surroundings, T8 to L3 level was chosen, modelling it as a frustum. L3-L4 is the commonly used site for dural puncture, as the spinal cord terminates in the lower border of L1. The spinal cord has decreased transverse diameter at T8 and the nerve roots in thoracolumbar region do not affect the CSF flow. The dura mater has been shown to have both elastic and viscous behaviour (18). The posterior lumbar dura mater is easily distensible only in the transverse direction (19). Epidural volume expansion can also provide insight into the effect of external compression. Hogan et al. had reported that the CSF volume of obese subjects was significantly less than that of nonobese subjects and that abdominal compression decreased CSF volume by around 3.6 mL (20). Lee et al. found that hyperventilation, abdominal compression, and hyperventilation with abdominal compression resulted in a decrease of CSF volume by 3.7, 10.1, and 14.9 ml, respectively (21). At lower volumes, the dural sac compression was variable and the finding is supported by this study (22). Broad variation has been observed in the volume of lumbosacral CSF between individuals, which decreased following an increase in intra-abdominal pressure (20). Greater abdominal girth was associated with a more notable increase in the intra-abdominal pressure. Logic might suggest that increased peri-spinal volume will exert more pressure on the lumbosacral volume.

Subarachnoid block can result in block of somatic and sympathetic fibres. The fibres blocked depends on the height of subarachnoid block achieved. A-delta and C-fibres are involved in transmission of cold sensation and their blockade in spinal anaesthesia follow a dermatomal pattern (23). Autonomic blockade levels do not follow dermatomal pattern, due to the presence of paravertebral ganglia and the interconnections. The order of blockade has varied in the previous studies (6,9,11). Though A-fibres are more susceptible to local anaesthetics than the preganglionic sympathetic B-fibres, level of sympathetic block is usually higher than the sensory block. This has been attributed to the increased sensitivity of the B-fibres compared to the A-delta, and C-fibres (24). Sympathetic blockade can lead to cardiovascular and vasomotor changes leading to changes in skin temperature (6,10,11,24-26). Most of the studies have been done by measuring the sympathetic blockade in the lower limbs with less studies on the truncal temperature. Truncal skin has less arterio-venous shunts (10,12,25). The skin blood flow increase, maybe affected by core and skin temperature. In our study, the time taken for change in skin temperature is significantly more than that taken for blocking cold sensation, with large variations. There was correlation between the blockade of these two types of nerves only in the group which had an increase in skin temperature. This could be attributed to the poor correlation among the nerve types to the blockade by the local anaesthetics.

Vasodilation of the vessels of legs can lead to a decrease in skin temperature of the arm due to vasoconstriction in the upper extremities. Reflex sympathetic innervation of the cutaneous blood flow is mediated by a tonically active sympathetic noradrenergic vasoconstrictor system, and a non-noradrenergic active vasodilator system, with no resting tone. Vasoconstriction is due to release of both norepinephrine and co-transmitters (27). Active cutaneous vasodilation occurs via cholinergic nerve co-transmission (28). A slower-onset sympathetic block allows more time for physiologic compensation (29). Therefore, the ascension rate is important to determine not just the height of block, but also the risk of hypotension. In this study, the quicker onset resulted in a probable sympathetic reflex, resulting in a decrease of skin temperature.

Contradictory results have been published regarding skin temperature in the thoracic and abdominal region in patients receiving thoracic epidural anaesthesia. Either no change in skin temperature at the thorax, abdomen or thigh was found, or a decrease was observed. Changes observed were usually less than 1°C, which was less in comparison to the extremities. Freise and colleagues demonstrated a small decrease in skin temperature after initiation of thoracic epidural anaesthesia (9). Chamberlein and Chamberlein suggested that the most cephalad dermatome at which skin temperature elevation occurred showed the upper limit of diminished sympathetic activity in spinal anaesthesia (6). Penno et al. commented that an initial drop in the temperature is not suitable for a prediction but can be used for the fading process of analgesia (11). The advantage of using skin temperature is its objectivity. Subjective perception differences, communication, anxiety and sedation can affect the loss of sensitivity to cold or pinprick. Nishiyama found that the transcutaneous oxygen tension increased in the anesthetized area after spinal anesthesia but had a large variance in values (24). The duration and level of sympathetic block were far lesser than that of analgesia and motor block in their study.

We hypothesised that measuring this volume could help in predicting the speed of onset and height of block. But, in our study, though the effects on skin temperature was different between the groups, there was no difference in peri-spinal volume between the groups. So, though the anthropometric parameters other than height showed correlation in the group with decreased skin temperature, it may not be the causative fact.

Limitations of our study are that the patients included in the study were of a wide age group and did not have large variations in height. Also, a very small number of female patients were included. Gender differences in musculoskeletal anatomy and physiology can affect the spread of block. Obese patients were not included in the study and hence the effect of volume in them cannot be commented. The hemodynamic parameters were not analysed in our study and could have provided more insight into the sympathetic blockade. Further studies on the composition of peri-spinal volume using MRI and ultrasonography and measuring the pressure effect on the dura could provide further insights into the effect on the spread of the drug.

CONCLUSION

Our study concludes that the effect of peri-spinal volume on the speed of onset of sympathetic block is variable and the somatic block correlates only in patients who had a decrease in skin temperature and that the effect of subarachnoid block on truncal cutaneous temperature change is variable.

AUTHOR CONTRIBUTIONS

Conception or design of the work: SKEJ

Data collection: SKEJ, JR

Data analysis and interpretation: SKEJ, JR, GG, AMR

Drafting the article: SKEJ, JR, GG, AR

Critical revision of the article: SKEJ, JR, GG, AR

Other (study supervision, fundings, materials, etc): AR

All authors (SKEJ, JR, GG, AMR) reviewed the results and approved the final version of the manuscript.

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