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SKIN TO SUBARACHNOID SPACE DISTANCE IN NON PREGNANT FEMALES AND IN PARTURIENTS WITH PREECLAMPSIA AND WITHOUT PREECLAMPSIA

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ABSTRACT

Background: Pre-puncture estimation of the Skin to Subarachnoid Space Distance (SSD) may be a good guide for proper spinal needle placement. It reduces the number of unsuccessful attempts, repeated attempts, traumatic or bloody lumbar puncture, and often acting as depth guide for proper spinal needle placement. **Aims:** To measure SSD in non-pregnant females, parturients without preeclampsia and parturients with preeclampsia and to determine if previously suggested formulae are best suited for predicting SSD in our study population. **Setting and design:** Observational study **Materials and Methods:** Five hundred and fifty-five female aged between 20 to 40 years undergoing surgery/ lower segment caesarean section under spinal anesthesia were studied at tertiary care hospital in Maharashtra. The participants were categorized into 3 groups. BMI and BSA were recorded. Prior to surgery, the subarachnoid block was performed. The depth of insertion was measured from the tip of needle up to the marked point with the help of the compass (divider) and a standard scale and noted. The SSD was compared to the predicted value of SSD by other studies. **Statistical analysis:** SPSS software version 20. One way ANOVA with post hoc analysis, multivariate regression and paired t tests. **Results:** Chong's formulae had the lowest mean difference for all 3 groups. Chong's formulae correlated best with observed SSD for group I, group II and group III. Multivariate linear regression analysis showed a statistically highly significant correlation with weight and age of patients in group I, whereas in group II, SSD was significantly correlated with weight, BSA, and height. In group III, SSD was correlated with BMI ($p<0.01$). **Conclusion:** SSD in all pregnant females was more than that in non-pregnant females. Among pregnant females, SSD was greater in preeclamptic females than that in non-preeclamptics. Among the various formulae, Chong's formulae most accurately predicted the SSD when applied to our population.

KEYWORDS : lumbar puncture, parturients, preeclampsia, skin to subarachnoid space distance

INTRODUCTION

Majority of the lower limb and lower abdominal surgeries including caesarean sections are performed under spinal anesthesia. Spinal anaesthesia procedure has 83% to 99% success rate and it is affected by several factors such as quality of injection, landmark, the skill of anesthesiologists, patient's position and lumbar flexion.[1] Successful lumbar puncture is crucial for successful spinal anesthesia. Although spinal anesthesia is simple to perform, it can sometimes be technically challenging. Prior knowledge of how far the needle needs to be inserted to reach the subarachnoid space may reduce the multiple attempts and discomfort of the patients. A conventional spinal needle may often be too long or too short depending on individual patients like pediatric, lean or obese patients. So, a pre-puncture estimation of the Skin to Subarachnoid Space Distance (SSD) may be a good guide for proper spinal needle placement and reduce the number of unsuccessful attempts, repeated attempts, traumatic or bloody lumbar puncture, and often acting as a depth guide for proper spinal needle placement.[2,3]

Spinal anesthesia is very commonly administered in parturients scheduled for caesarean section. Pregnancy and pregnancy changes of preeclampsia can affect the SSD. Prakash S et al.[4] found longer SSD in the parturient population compared with the non-pregnant female population which could be attributed to the hormonal effects of pregnancy such as weight gain, softening of tissues and ligaments, and collection of fat in the subcutaneous tissue. In addition to pregnancy, preeclampsia may lead to increased SSD as it is characterized by increased extracellular fluid which manifests as generalized edema due to endothelial injury and subsequent capillary leak. With increasing BMI, the difference in SSD between preeclamptics and non-preeclamptics also increases.[6]

Although Obstetric patients are most likely to receive spinal anesthesia, the effect of pregnancy on SSD has not been well studied in the obstetric population and particularly the effect of preeclampsia on SSD. Since the data regarding SSD in Indian population is scarce and effect of Preeclampsia on SSD has not been studied, this study was conducted to measure SSD in non- pregnant females, parturients without preeclampsia and parturients with preeclampsia and to determine which of the previously suggested formulae are best suited for predicting SSD in our study population.

Materials and Methods

The present study was conducted as a facility based prospective observational study at tertiary care hospital in Maharashtra during a period of 1st January 2017 to 30th October 2018 on 555 female aged between 20 to 40 years with ASA-PS I-III undergoing surgery/ lower segment caesarean section under spinal anesthesia.

The sample size was calculated based on the study of Prakash S et al (2014). [4] In the reference study mean (±SD) SSD in group I and II was 4.55±0.66 and 4.73±0.73 respectively. The mean difference was estimated to be 0.18. The confidence interval was kept at 90%, and Power (1-) of the study was 80% and assuming group I=Group. Using OpenEpi version 3 software, the sample size was estimated to be 185 in each group. All the females belonging to the age group of 20 to 40 years with ASA-PS I–III and scheduled for surgery under spinal anesthesia was included in the study. However, patients refusing for spinal anesthesia; uncooperative patients; patient with neurological disorder or history of seizure, cerebral or visual abnormalities, infection at the puncture site, sensitivity to bupivacaine; spinal anomaly; coagulopathy, thrombocytopenia; hemodynamically unstable; Hb <9; patient with any contraindication to spinal anaesthesia; hypertension due to any cause other than preeclampsia; receiving steroids; eclampsia, impending eclampsia, HELLP syndrome and presenting with severe fetal distress were excluded from the study.

The participants were then categorized into 3 groups as Group I (non-pregnant females), Group II (full term parturient without preeclampsia) and Group III (full term parturient with preeclampsia)

A written informed consent for participation in study, surgery and anesthesia was obtained from patient and enrolled in the study. Through pre-anesthetic examination was conducted for all the females. Patient characteristics were recorded including age, body weight, body height, body mass index (BMI), body surface area (BSA) and gestational age (for parturients).

After following the Institutional protocol prior to surgery, the subarachnoid block was performed by resident/consultant anaesthesiologist of minimum one year experience in obstetric anesthesia. Procedure of spinal anesthesia was explained to the patient and the patient was placed in left lateral decubitus position with their maximum possible flexed back in an attempt to open up the vertebral spaces. The L3-L4 intervertebral space was determined by palpation of the iliac crest guided by the Tuffiers line. The L3-L4 intervertebral space was also confirmed by palpating the lumbar vertebra for identification and counting them. Dural puncture was performed under aseptic precautions with a 23 gauge quincke spinal needle using the midline approach. The needle was grasped with thumb and index finger of right hand and after palpating the L3-L4 intervertebral space with left thumb needle was inserted at a slight cephalad angle of 10 to 15 degree through skin, subcutaneous tissue and supraspinous ligament and advanced until loss of resistance is achieved, signifying entry into the subarachnoid space and was confirmed by free flow of clear cerebrospinal fluid. Following this, inj. Bupivacaine 0.5 %(H) given depending on surgical procedure and physical characteristics of patients. Patients in which angle of needle required to be deviated or more than one attempt required to get the CSF or if no effect of drug is achieved to get the block were also excluded from the study.

Following Intrathecal injection spinal needle was grasped firmly between thumb and index finger abutting the patient back and removed and marked with marker immediately then depth of insertion was measured from tip of needle upto the marked point with the help of the compass (divider) and a standard scale and noted.

For the purpose of comparison we compared the observed value of SSD of our Study population with the predicted value of SSD by other studies i.e.

Smita Prakash's formula[4]: SSD (cm) = 2.71+0.09×BMI
Abe's formula[7]: SSD (cm) =17 weight (kg)/height (cm) +1
Previously suggested formulae derived from studies on pediatric population-
Bonadio's formula[8]: SSD (cm) =0.77 cm+2.56 ×BSA (m2)
Craig's formula[9]: SSD (cm) = 0.03 cm × height (cm)
Stocker's formula[10]: SSD (mm) =0.5 × weight (kg) +18
Chong's formula[11]: SSD (cm) =10{weight (kg)/height (cm)} +1

Statistical Analysis

Data was compiled using MsExcel and analysed using SPSS software version 20. Descriptive statistics for overall population and group-wise (Group I, Group II and Group III) were calculated for all the variables. One way ANOVA with post hoc (Bonferroni correction factor) analysis was applied to see significant differences among the three groups. Multivariate regression was performed to assess factors influencing SSD for each group separately. Paired t tests were performed to see significant mean differences between the predicted depth of spinal needle and observed depth of spinal needle separately. P value <0.05 was considered as statistically significant.

Results

A total of 555 patients posted for surgery under spinal anaesthesia were included in this study and divided into 3 groups of 185 each.

Table 1: Distribution according to Baseline variables

Baseline variables		Group I (n=185)		Group II (n=185)		Group III (n=185)		P value
		n	%	n	%	n	%	
Age group (years)	20-25	29	15.7	110	59.5	112	60.5	0.001
	26-30	40	21.62	56	29.89	52	28.11	
	31-35	34	18.38	15	8.15	19	10.27	
	36-40	82	44.32	4	2.17	2	1.08	
BMI (kg/m2)	14-20	59	31.89	17	9.19	10	5.41	0.001
	20-25	88	47.57	105	56.76	70	37.84	
	25-30	32	17.3	48	25.95	74	40	
	30-35	5	2.7	11	5.95	28	15.14	
	35-45	1	0.54	4	2.16	3	1.44	
BSA (m2)	1.06-1.3	20	10.91	7	3.78	2	1.08	0.001
	1.31-1.5	99	53.51	61	32.97	27	14.59	
	1.51-1.7	53	28.65	87	47.03	100	54.05	
	1.71-2	11	5.95	30	16.22	53	28.65	
	2.01-2.21	2	1.08	0	0	3	1.62	

Majority of patients were in range of 26-40 in group I i.e. 156 (84.32%).While for group II and group III, majority of patients were in range of 21-30 which were 166 (89.7%) and 164 (88.6%) respectively. Mean age of patients of group I was 33.18±6.69 years, whereas that of group II was 25.40±3.96 and group III was 25.37±3.96. Distribution of patients in each group according to age was statistically highly significant (P< 0.001).

Among group I patients, maximum patients had BMI in range of 14-25 kg/m2 i.e. 147 (79.46%).While in group II and group III, BMI of majority of patients was in range of 20.01-30 kg/m2 i.e. 153 (82.71%) and 144 (77.84%) respectively. However, BSA for majority of patients of group I and II was in range of 1.31-1.7 m2 i.e. 152 (82.16%) and 148 (80%) respectively. While for group III, BSA for majority of patients was in range of 1.51-2 m2 (82.7%). The present study documented statistically highly significant difference in BMI and BSA of participants of 3 groups (P< 0.001).

Table 2: Observed and Predicted values for Skin to Subarachnoid Space Distance (SSD) by various formulae in three study groups

SSD (cm)	Group I (n=185)	Group II (n=185)	Group III (n=185)	P-value
Observed SSD	4.18±0.46	4.69±0.51	5.09±0.60	0.0001
Predicted-Abe	6.72±1.04	7.28±0.97	7.89±1.14	0.0001
Predicted-Bonadio	4.54±0.40	4.74±0.37	4.97±0.39	0.0001
Predicted-Craig	4.61±0.19	4.62±0.20	4.66±0.16	0.0078
Predicted-Stocker	4.39±0.50	4.65±0.48	4.96±0.55	0.0001
Predicted-Chong	4.35±0.64	4.70±0.58	5.04±0.67	0.0001
Predicted-Smita Prakash	4.67±0.35	4.87±0.34	5.04±0.37	0.0001

In present study, observed SSD for patients of group III was greater when compared to SSD of group I and group II. Similarly predicted SSD which were calculated by Abe's, Bonadio's, Craig's, Stocker's, Chong's and Smita Prakash's formula was greater for patients of group III when compared to group I and group II individually.

In group I mean difference was least (0.17±0.60cm) when Chong's formula was applied. When stocker's formula was applied mean difference was 0.21±0.58 cm which was closest to Chong's formulae. Similarly, in group II mean difference was least (0.01±0.58 cm) when Chong's formula was applied. In contrast in group III mean difference was least (0.05±0.54 cm) when Smita Prakash's formula was applied. In terms of accuracy Chong's formulae correlated best with observed SSD for group I group II and group III.

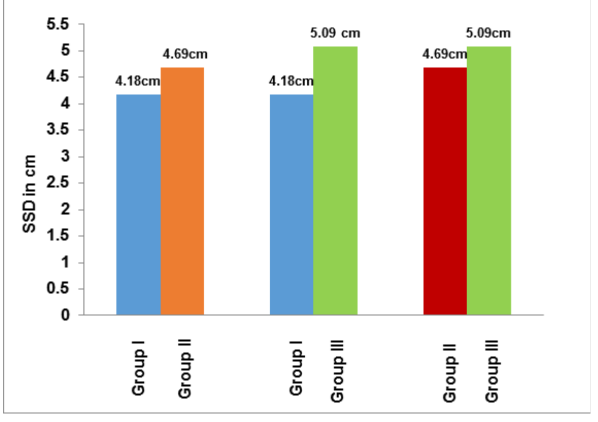

Figure 1: Pair-wise comparisons of observed SSD between group I, group II and group III

Table 3: Multivariate linear regression models

Group	Variables included in the regression model	Regression coefficient (β)	95% CI for β	P-value
Group I	Weight	0.0269	0.0022-0.0323	0.0001
	Age	0.0017	-0.0064-0.0098	0.01
	Constant	2.7332		
Group II	Weight	0.0223	0.0068-0.0379	0.005
	BSA	1.7229	0.5740-2.8717	0.003
	Height	-0.0059	-0.0143-0.0025	0.01
	Constant	1.6547		
Group III	BMI	0.0939	0.0785-0.1793	0.0001
	Constant	2.6511		
Overall	BMI	0.1057	0.0968-0.1145	0.0001
	Constant	2.1212		

Table 4: Formulae for predicting Skin to Subarachnoid Space Distance (SSD) derived from our study

Study groups	Formula for predicting SSD
Group I	SSD (cm) = 2.73 + 0.03×Weight +0.002×Age
Group II	SSD (cm) = 1.65 + 0.02×Weight + 1.72× BSA - 0.006×Height
Group III	SSD (cm) = 2.65 + 0.09×BMI
Overall	SSD (cm) = 2.12 + 0.11×BMI

Above table represents the formulae derived from this study for predicting SSD in the three study groups and in the overall study population.

DISCUSSION

An estimation of Skin to Subarachnoid Space distance (SSD) has been shown to reduce the number of unsuccessful attempts, repeated attempts, traumatic or bloody lumbar puncture, and often acting as depth guide for proper spinal needle placement. Pregnancy and pregnancy changes of preeclampsia can affect the SSD. In the later stage of pregnancy, the size and weight of uterus progressively displace the body's centre of gravity and lumbar lardosis occurs as a compensatory mechanism.[12,13] In addition, preeclampsia may lead to increased SSD as it is characterized by increased extracellular fluid which manifests as generalized edema due to endothelial injury and subsequent capillary leak. With increasing BMI, the difference in SSD between preeclamptic and normotensive parturients controls also increases.[5]

The present study included patients with age range of 20 to 40 years so as to match the age group of non-pregnant females to that of obstetric patients. Demographic data and observed SSD in non-pregnant females of our study population correlates well with that of non-pregnant Indian females of previous studies done by Prakash S et al[4] and Hazarika R et al[14].
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SSD observed in non-pregnant females (group I) in present study was 4.18±0.46 cm. Prakash S et al[4] and Hazarika R et al[14] found mean SSD of 4.55±0.66 cm and 4.18±0.39 cm respectively in non-pregnant females of Indian population. There are no studies in non-Indian population who have documented the results about SSD in non-pregnant females specifically. Most studies have given the results about SSD in overall population which included male and female. Therefore, our results could not be compared with that of SSD in non-Indian females and correlate with ethnicity, weight, BMI and height.

In parturients without preeclampsia, observed SSD was 4.69±0.51 cm whereas it was 4.73±0.73 cm and 4.43±0.19 cm in parturient females of Prakash S et al[4] and Hazarika R et al[14] who have also done their study in Indian population. Similar studies have been done by Basaran B et al[6] in population of Turkey and by Bassiakou E et al[15] in population of Greece. The mean SSD found in their parturient population was 5.301±0.834 cm and 6.5±1.2cm respectively. Parturients of Turkey and Greece population had more weight and BMI than that of parturients of Indian population which could be the reason for longer SSD found in parturients in reference studies. The shorter SSD observed in our study population was possibly because of short height of patients in our population compared to western population who were much taller and heavy weighted. Hormonal effect of pregnancy such as weight gain, softening of tissues and ligaments and collection of fat in the subcutaneous tissues may be the reason behind increased in SSD in parturients.[4] Preeclampsia may further lead to increased SSD as it is characterized by increased extracellular fluid which manifests as generalized edema due to endothelial injury and capillary leak.[5] Observed SSD in parturients with preeclampsia (group III) of our study was 5.09±0.60 cm (p=0.001). Only Basaran B et al[6] studied the effect of preeclampsia on SSD. Similar to our study, they also documented SSD to be higher in in preeclamptics (6.187±0.967cm) as compared to non preeclamptic parturients (5.301±0.834 cm).

Our study documented that SSD in parturients without preeclampsia was 0.51 cm larger than that observed in non-pregnant females which was found to be statistically significant while observed SSD in preeclamptic parturients was 0.4 cm larger than that observed in parturients without preeclampsia which was also statistically significant (p=0.001). Basaran B et al[6] also found that there is increase in SSD in preeclamptic parturients as compared to non-preeclamptics by 0.89 cm.

When we compared the mean difference between observed SSD and predicted SSD calculated by Abe's, Bonadio's, Craig's, Stocker's, Chong's, and Smita Prakash's formulae in group I, group II and group III, we found that Chong's formulae had lowest mean difference which was 0.17±0.60cm, 0.01±0.58 cm and 0.05±0.68 cm for group I and group II and group III respectively. In terms of accuracy Chong's formulae correlated best with observed SSD for group I, group II and group III. After Chong's formula, stocker's formula correlates well with observed SSD for group I and group II with mean difference of 0.21±0.58 cm and 0.04±0.51 cm respectively. While Smita Prakash's formula correlates well with observed SSD for group III after Chong's formula with mean difference of 0.05±0.54 cm.

Abe et al[7] reported that use of their formula resulted in needle selection that was too short in 6% of cases and too long in 31% of cases. In our study when we applied Abe's formula to our study population, predicted SSD was significantly overestimated by 2.54 cm, 2.59 cm and 2.8 cm for group I, group II and group III respectively. Hence, calculating the predicted SSD using Abe's formula could results in selecting a longer spinal needle. Excessive spinal needle projection beyond the skin may cause difficulty in controlling the spinal needle while injecting the drugs intrathecally, and may increase the technical difficulty. And it can also propel the anesthesiologists to insert the spinal needle too anteriorly and increasing the risk of traumatic tap or nerve injury.

Limitations

Our results may not be applicable if paramedian approach used. We used 10 to 15 degree angle to skin, no instrument was used to measure exact angle. Length of needle inside subarachnoid space could not be known which might have affected measurement of SSD.

CONCLUSION

It can be concluded that skin to Subarachnoid space distance in all pregnant females was more than that in non-pregnant females. Among pregnant females SSD was greater in preeclamptic females than that in non preeclamptics. Among the various formulae, Chong's formulae most accurately predicted the SSD when applied to our population. Weight and BMI were the consistent variables affecting Skin to Subarachnoid space distance in all groups. Derived formulae from our study for predicting SSD need to be further validated for its accuracy in prospective study and can also be validated using USG and to also find out whether our derived formula is applicable for predicting SSD in obese and pediatric population also.

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