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Original Article

Assessing The Depth of Subarachnoid Space in Obstetric Versus Non-Obstetric Population: A Prospective Observational Comparative Study

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ABSTRACT

Background and aims: To compare the subarachnoid space depth in obstetric and non obstetric Indian female population using different formulae (Abe's, Bonadio's, Craig's, Stocker's and Chong's modified formula), to analyze the accuracy and feasibility of using the most appropriate formula and to find the relation of observed subarachnoid space depth (SSD) with arm and waist circumference.
Methods: 156 female patients were divided into group P (parturient) and group NP (non- parturient) of 78 each scheduled for elective surgery under spinal anaesthesia. SSD was measured after lumbar puncture using a standard caliper. SSD in obstetric and non obstetric female population were compared using different formula and statistically analyzed to determine the most accurate formula using pearson co-relation analysis and paired t test.
Results: Mean SSD in group P was found to be higher in group P (5.37±0.70) than Group NP (4.75±0.64) and statistically significant. Stocker's formula correlated best with the observed SSD in group P (pearson coefficient= 0.623, P=0.001) and in group NP Bonadio's formula correlate best with SSD (pearson coefficient=0.657, P=0 .001). Mean difference between observed SSD and predicted SSD by stoker's formula was found to be least (0.02±0.27) in group P and in group NP least difference was found with bonadio's formula (0.03±0.52) with non significant P values.
Conclusion: SSD in obstetric patients was significantly greater than non obstetric patients. However stocker's formula co-related best with observed SSD in group P where as in group NP Bonadio's formula found to be more accurate.

***Keywords**: Subarachnoid Space Depth, Parturient, Lumbar Puncture.*

INTRODUCTION

Spinal anaesthesia is a safe and effective method for providing regional anaesthesia which is routinely performed by anesthesiologist for caesarean sections and lower abdominal surgeries. Since, the first description of spinal anaesthesia in human by Bier, when the identification of subarachnoid space has been achieved by an anatomical landmark guided approach, there has been a great improvement in technique, equipments and drugs administration along with better understanding of physiology and anatomy. Evolution of use of spinal ultrasound offers valuable information to measure skin to subarachnoid space depth (SSD), however its role is limited due to inaccessibility to this expensive equipment and lack of skill in performing, so using simple mathematical calculations may be practical for prediction of SSD.(1,2)

Success of lumbar puncture with subarachnoid injection depends on the skill and experience of the physician, patient's spine anatomy and positioning. A conventional spinal needle may be too long for a lean patient while it may fall short of length in the obese patient, resulting in multiple and unsuccessful attempts, traumatic or bloody lumbar puncture leading to increased patient discomfort and complications. The palpation of bony landmarks required to successfully perform lumbar puncture can be masked in 33% of overweight patients and 68% of patients with obesity, due to overlaying soft tissue and can lead to lumbar puncture failure rate of 19%. Prior knowledge of how far the needle should be inserted to reach the intrathecal space may reduce the potential complications of spinal anaesthesia. The SSD varies considerably at different levels of the spinal column in an individual, interindividual variation also exists at the same vertebral level. [(3,4)] Estimation of depth of subarachnoid space is very useful in morbidly obese patient and parturients as the anatomical landmarks in them are usually obscure. So pre puncture estimation of skin to subarachnoid space depth may be a good guide for proper spinal needle placement and successful block. [(5)]

Previous investigators have suggested various formulae for predicting SSD based on physical and anthropometric parameters. Different studies have been done for estimation of SSD in different patient population using these mathematical formulae. A significant correlation between anthropometric measurements & SSD was found in their studies. [(6-10)]

The aim of the study was to estimate the distance between skin to subarachnoid space in the Indian female population including both parturient and nonparturient females and evaluate the accuracy of application of an appropriate formulae. The primary objective of the study was to compare the subarachnoid space depth in obstetric and nonobstetric female population using different formulae (Abe's, Bonadio's, Craig's, Stocker's and Chong's modified formula). Secondary objective was to analyse the accuracy and feasibility of using the most appropriate formula in the Indian female patients and to find the relation of observed depth of spinal needle (subarachnoid space depth) with arm and waist circumference.

METHODOLOGY

After obtaining approval from Institutional Research Ethical Board (GU/HREC/EC/2019/1786) this prospective observational study was conducted over a period of 18 months. A total 156 consenting female patients of American Society of Anesthesiologists (ASA) grade 1 and 2 aged 18-60 years posted for lower abdominal surgery under spinal anaesthesia were included in this study. Patients with spinal anomaly, history of spine surgery, contraindication to spinal anaesthesia, history of seizures and neurological disorders, allergy to study drug, severe pregnancy induced hypertension were excluded from the study. Patients with traumatic lumbar puncture and those in whom either the angle of spinal needle was altered or the approach changed from midline to paramedian were withdrawn from the statistical analysis of study.

Patients were divided into two groups of 78 each. Group P (Parturient) included full term parturient scheduled for elective caesarean delivery under spinal anaesthesia and Group NP (Non parturient) included non-parturients posted for lower abdominal surgery under spinal anaesthesia.

All patients were subjected to thorough pre anaesthetic evaluation and were explained about the procedure a day prior to surgery. Demographic data like age (yr), weight in kg (with standard weighing machine), height in cm (with wall mounted standard measuring scale) and ASA grade were noted. Body mass index (BMI) was calculated using Quetelet index {BMI=weight (kg)/height (m2)} and body surface area (BSA) was calculated using Mosteller formula (m2) {BSA=Height(cm) x weight(kg)/(3600)1/2}. Anthropometric measurements like mid arm circumference (10 cm above the cubital fossa) and waist circumference (at the line that passes across the iliac crest's edge in sitting position) were measured and recorded in centimeter with standard measuring tape.

Calculation of Predicted skin to subarachnoid space depth (SSD) was done using following formula:

- Abe's formula:- SSD(cm) = 17 x weight(kg)/height(cm) + 1
- Bonadio's formula:- SSD(cm) = 0.77cm + 2.56 x BSA(m2)
- Craig's formula:- SSD(cm) = 0.03(cm) x height(cm)
- Stocker's formula:- SSD(mm) = 0.5 x weight(kg) + 18
- Chong's formula:- SSD(cm) = 10[weight(kg)/height(cm)] + 1

18G intravenous canula was inserted and an infusion of ringer lactate/normal saline at the rate of 8-10 ml/kg/hr was started in preoperative room. In operation room, standard monitoring including electrocardiogram (ECG), pulse oximetry, non-invasive blood pressure (NIBP) were attached. Baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR) and oxygen saturation (SpO2) were recorded.

Subarachnoid block (SAB) was performed under supervision by a senior consultant anesthesiologist. Dural puncture was performed under all aseptic precautions with a 25 gauge Quincke (3.5 inch/ 9 cm) spinal needle using the midline approach in sitting position. The spinal needle was inserted perpendicular to the skin. The needle was advanced until loss of resistance was obtained and entry into the subarachnoid space was confirmed by free flow of cerebrospinal fluid. The dose of intrathecal local anaesthetic was given based on surgical requirement and patient characteristics.

Following intrathecal injection, the spinal needle was grasped firmly between the thumb and the index finger at the entry point of skin and withdrawn gently and marked with marker. The skin to subarachnoid space depth (SSD) was measured using a digital vernier caliper in centimeter (figure 1).
Intraoperative Hemodynamic parameters such as HR, SBP, DBP, MAP, and SpO2 were noted at various time intervals [5,10,15,20,30,45,60,90 and 120 minutes] in both groups.

Statistical analysis was done using IBM SPSS software version 22. The data were recorded on proforma and transferred to a Microsoft excel database. Continuous variables were presented as mean ± standard deviation and categorical variables as absolute numbers and percentage. The comparison of normally distributed continuous variables among the groups was analyzed using Student's t-test. Nominal categorical data among these groups were compared using Chi-square test. Pearson correlation was used to find out any correlation of anthropometric measurements with SSD. $p< 0.05$ was significant statistically.

RESULTS

A total of 156 female patients who underwent lower abdominal surgery under spinal anaesthesia were enrolled. Out of these 3 patients in each group were not included in statistical analysis because of use of paramedian approach and failure to give spinal block (Figure 2).

Number of parturient were maximum (50.67%) in between 20-29 years of age while most of non-parturient (37.33%) were in age group of 40-49 years. Maximum number of parturients (37.33%) was between weight 66-75kg while maximum non parturient (38.67%) were between weight 46-55kg. Height of maximum number of patient in both group was between 150 to160 cm. BMI of maximum parturients (46.67%) was within 25-29.9 kg/m2. In non parturient maximum patients (60%) were of normal weight that is BMI within 18.5-24.9kg/m2. BSA was within 1.5-2m2 for maximum number of patients in both groups. Mean age of parturients was 30±5.44 years and of nonparturient was 45.43±11.16 years which was found to be statistically significant ($p<0.001$).

Anthropometric measurements like weight BMI, arm circumference, waist circumference were found to be statistically significant and greater in parturients than nonparturient ($p<0.05$), however height was comparable in both groups ($p=0.924$) **(Table 1).**

Baseline haemodynamic parameters were recorded and compared in both group. Baseline mean heart rate (bpm) in group P was higher (85.37±9.43) than group NP (82.07±9.32) which was found to be statistically significant ($p=0.03$). The mean SBP was lower in group P than group NP which was found to be statistically significant ($p=0.03$). However DBP & MAP were comparable in both groups were non-significant statistically.

The mean value of observed SSD in parturients was 5.37±0.70cm. The mean value of predicted SSD by Stocker's formulae was found to be nearest to observed SSD in group P with mean difference of 0.02±0.27cm ($p=0.262$). Followed by Chong's formulae ($p=0.113$) in parturients. (Figure 3& 4)

The mean value of observed SSD was 4.75±0.64cm in group non parturients. The mean value of predicted SSD by Bonadio's formulae was found to be nearest to observed SSD in non parturients with mean difference of 0.03±0.52cm ($P=0.306$). Followed by Craig's formulae ($p=0.179$). **(Table 2a and Table 2b)**

Predicted depth by Stocker's formulae is strongly correlated with observed SSD in parturients ($r=0.926$). While in non parturients Bonadio's formulae is strongly correlated with observed SSD($r=0.583$). **(Table 3)**

In present study various anthropometric variables (weight, height, BMI, BSA, mid arm and waist circumference) were measured and compared. Weight, BMI, mid arm and waist circumference showed positive Pearson correlation with SSD and was statistically significant in both the groups. However height was not strongly correlated in both the groups and found statistically non-significant ($p>0.05$) **(Table 4).**

Table 1: Comparison of demographic and anthropometric variables in two groups

Variables	Group P (n=75)			Group NP (n=75)			P value
	Min	Max	Mean ±SD	Min	Max	Mean ± SD	
Age(yr)	21	48	30±5.44	25	76	45.43±11.16	.0001 (HS)
Height(cm)	138	169	155.61±6.36	145	173.7	155.52±5.39	0.924 (NS)
Weight(kg)	46	111	69.14±10.31	40	92	55.94±9.86	0.0001(HS)
BMI(Kg/m^2)	17.97	40.31	28.61±4.27	15.63	36.85	23.17±4.12	.0001 (HS)
BSA(m^2)	1.42	2.27	1.72±0.14	1.046	2.009	1.54±0.15	0.0001(HS)
MidarmCircumference (cm)	19	33	26.01±2.34	15.5	35	24.96±3.30	.024 (S)
Waist Circumference (cm)	88	148	104.35±10.26	65	128	89.00±16.90	.0001 (HS)

Data are mean ±SD, n=number of patient, HS=highly significant, NS=nonsignificant, S=significant

Table 2a: Predicted skin to subarachnoid space depth (SSD) according to various formulae and their difference with observed SSD in parturients.

Group P (n=75)					
SSD(cm)	minimum	maximum	Mean ±SD	Difference of observed and predicted depth (mean ±SD)	P value
bserved depth	4.12	8.26	5.37±0.70	-	-
edicted Abe's	5.89	12.23	8.56±1.08	-3.19±1.05	0.001 (HS)
Predicted Bonadio's	4.40	6.81	5.20±0.40	0.17±0.66	.01 (S)
redicted Craig's	4.14	5.56	4.69±0.24	0.68±0.74	0.001 (HS)
Predicted Stoker's	4.20	7.99	5.35±0.68	0.02±0.27	.262 (NS)
Predicted Chong's	3.88	7.60	5.48±0.66	-0.11±0.76	.113 (NS)

Data are mean ±SD, n=number of patient, HS=highly significant, NS=nonsignificant, S=significant

Table 2b: Predicted skin to subarachnoid space depth (SSD) according to various formulae and their difference with observed SSD in non-parturients.

Group NP (n=75)					
SSD(cm)	Min	Max	Mean ±SD	Mean difference with Observed depth	P value
Observed depth	3.18	7.56	4.75±0.64	-	-
Predicted Abe's	4.25	9.90	6.13±1.11	-1.38±0.91	<0.001(HS)
Predicted Bonadio's	3.45	5.91	4.72±0.39	0.03±0.52	0.306(NS)
Predicted Craig's	4.35	5.62	4.68±0.20	0.07±0.66	0.179(NS)
Predicted Stoker's	3.80	6.40	4.63±0.59	0.12±0.59	<0.003(HS)
Predicted Chong's	3.50	6.82	4.63±0.62	0.12±0.64	0.049(S)

Data are mean ±SD, n=number of patient, HS=highly significant, NS=nonsignificant, S=significant

Table 3: Correlation between observed and predicted skin to subarachnoid depth by various formulae in two groups

	Group P (n=75)		Group NP (n=75)	
Various formulae	Pearson correlation (r value)	P value	Pearson correlation (r value)	P value
Abe's	0.369	<0.001	0.570	<0.001
Bonadio's	0.371	<0.001	0.583	<0.001
Craig's	-0.002	<0.05	0.030	>0.05
Stoker's	0.926	<0.001	0.533	<0.001
Chong's	0.382	<0.001	0.537	<0.001

n=number of patient, P<0.001=highly significant, P > 0.05=nonsignificant

Table 4: Relation between skin to subarachnoid space depth (SSD) and various anthropometric variables

	Group P (n=75)		Group NP (n=75)	
Variables	'r' value	P value	'r' value	P value
Age(yr)	0.296	<0.05 S	-0.012	>0.05 NS
Height (cm)	0.117	>0.05 NS	0.093	>0.05 NS
Weight (kg)	0.392	<0.001 HS	0.625	<0.001 HS
BMI (kg/m^2)	0.314	<0.001 HS	0.574	<0.001 HS
Mid Arm Circumference (cm)	0.212	<0.05 S	0.390	<0.001 HS
Waist circumference (cm)	0.320	<0.001 HS	0.488	<0.001 HS

N = number of patient, HS=highly significant, NS = nonsignificant, S = significant

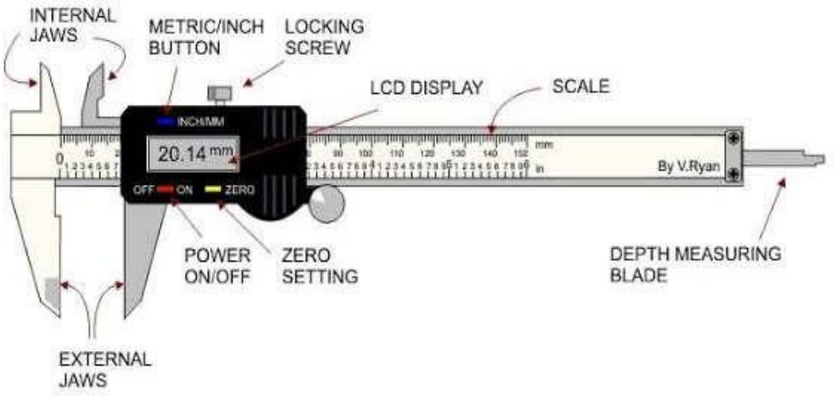

Figure 1. Digital Vernier's caliper

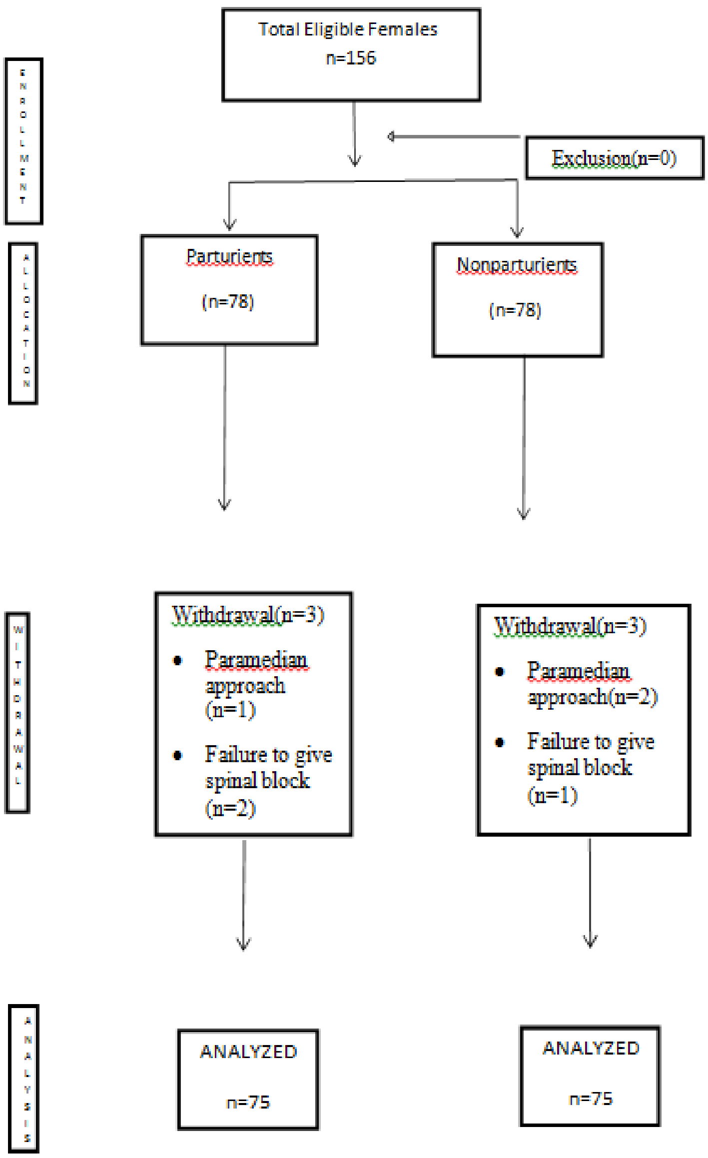

Figure 2. Consolidated Standards Of Reporting Trials [Consort Diagram]

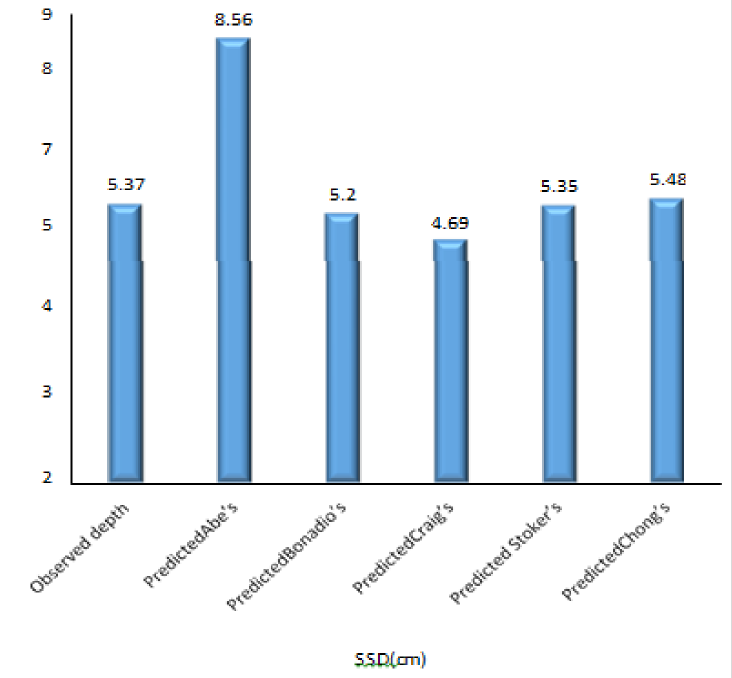

Figure 3. Graphical representation for predicted skin to subarachnoid space depth (SSD) according to various formulae and their difference with observed SSD in parturients.

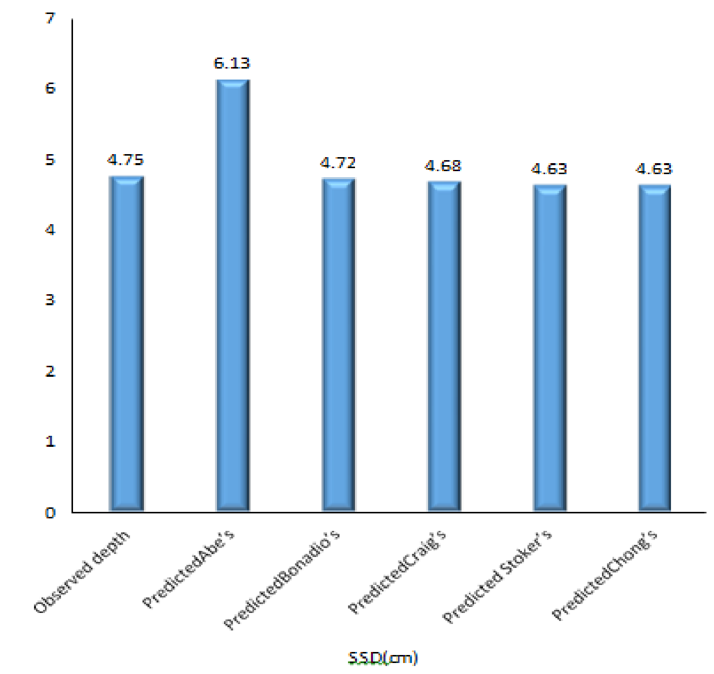

Figure 4. Graphical representation for predicted skin to subarachnoid space depth (SSD) according to various formulae and their difference with observed SSD in non-parturients.

DISCUSSION

Subarachnoid block is a common technique of anaesthesia for lower abdominal surgeries, however an accurate placement of spinal needle in subarachnoid space in different population requires knowledge of anatomy and technical skills of the procedure. Estimation of skin to subarachnoid space depth (SSD) before the procedure helps to guide spinal needle placement, reduces traumatic lumbar puncture and unsuccessful attempts, which also enhances the patients' comfort and satisfaction. [11]

Various studies have been done for estimation of both skin to subarachnoid and epidural space distance using ultrasonography or by mathematical calculations based on different anthropometric characteristics in different study population.[6-10,12,13]

This study evaluated that the skin to subarachnoid space depth in parturients was significantly greater as compared to the general female population**.** In present study mean age in group P was 30±5.44 years, while in group NP it was

45.43±11.16 and the difference as found to be statistically significant(p<0.001). However the mean height was comparable between the two groups (p=0.924). Mean weight and body mass index (BMI) was greater in group P than group NP and was found to be statistically highly significant (p<0.001). Similar results were also observed by **Prakash S et al** [11] **and Hazarika R et al** [14] in which they found the difference in age, weight, BMI in between parturients and non parturients was statistically significant(p<0.001).

Other anthropometric variables in present study like mid arm circumference & waist circumference were recorded and compared in two groups. The mean midarm circumference in group P was 26.01±2.34cms and in group NP was 24.96±3.30cms and the difference was statistically significant (p=0.024). The mean waist circumference of parturients was significantly more(104.35±10.26cms) than nonparturients (89.00±16.90cms) and the difference was found to be highly significant(p<0.001). **Razavizadeh M et al** [15] measured arm and waist circumference in male and general female population and they reported that correlation between arm circumference and depth of needle insertion was significant but weak(r=0.630) in both the groups however the correlation between waist circumference and depth of needle insertion was more significant(r=0.657) in both groups.

Previous investigators have suggested various formulae for predicting SSD based on physical and anthropometric parameters. In present study SSD was predicted by these different formulae for accurate estimation of the depth to reach subarachnoid space which could be an alternative for spinal ultrasound. SSD predicted in parturients was 8.56± 1.08 cm, 5.20± 0.40 cm, 4.69± 0.24 cm, 5.35□± 0.68 cm, 5.48± 0.66 cm as per Abe's,

Bonadio's, Craig's, Stocker's and Chong's formula respectively. Mean observed SSD of parturients was significantly greater (5.37□± 0.70 cm) than that in nonparturients (4.75□± 0.64cm)(p<0.001). Similar results were observed by **Prakash S et al** [11] where mean observed SSD was significantly longer in parturient population (4.73□± 0.73) than that of the nonparturient population (4.55□± 0.66cm)(p<0.001).

In terms of accuracy Stocker's formulae when applied to parturient group was found to be most accurate in present study. The mean difference calculated between observed & predicted was least(0.02± 0.27cm) with stocker's formulae, which was statistically non significant (p=0.262) and showed strongest Pearson correlation with observed SSD(r=0.926) in parturients. Similarly **Prakash S et al** [11] reported the predicted SSD by Stocker's formulae was 4.73□± 0.54cms and observed SSD 4.73□± 0.73cm in their study and the mean difference was least (0.01 cm) and non significant when Stocker's formulae was applied to their parturient population. In contrast **Bassiakou et al** [16] in their study observed the SSD in 332 parturient posted for caesarean section and reported that the SSD in parturients was 6.5 ± 1.2 cm and nearly 1.13 cm longer than that observed in parturients population of present study, this could be attributed to ethnic differences of population.

The longer SSD in the parturient population (5.37 ± 0.70 cm) compared with the nonpregnant

population (4.75 ± 0.64 cm) 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 non-parturients predicted SSD by different formulae was 6.13± 1.11, 4.72± 0.39 cm, 4.68□± 0.20 cm, 4.63□± 0.59 cm,4.63□± 0.64 cm as per Abe's, Bonadio's, Craig's, Stocker's and Chong's formula respectively. Mean observed SSD in group NP was 4.75□± 0.64cm. The mean difference calculated between observed & predicted was least (0.03± 0.52cm) with Bonadio's formulae and this difference was found to be statistically nonsignificant (p=0.306) with strongest positive Pearson correlation(r=0.583). Predicted depth by Craig's formulae was also close to observed depth(0.07± 0.66cm) and statistically non significant(p=0.179) in non parturient group. In contrast in a study by **Tyagi V et al** [2] mean SSD by Bonadio's formulae was reported as, 5.17 ± 0.3 cm among female population which is greater than the predicted SSD by Bonadio's formulae (4.72 ± 0.39cm) in non-parturients of present study. This can be attributed to the differences in anthropometric measurements in different study population.

Abe et al [6] reported that the use of their formulae resulted in needle selection that was too short in 6% and too long in 31% cases. In present study SSD using Abe's formulae significantly over estimated approximately 3 cm in parturients and 2 cm in nonparturients which could result in selecting a relatively longer spinal needle. This may cause difficulty in controlling needle while injecting a drug, thus increasing technical difficulty and also risk of traumatic tap. **Taman H et al** [17] found mean difference between observed SSD and predicted Craig's formulae was minimum which is contrast to present study. SSD in general Egyptian population was 4.99 ± 0.48cm, that was 0.41cm shorter than SSD measured in Turkish population(5.40 ± 0.66 cm) by **Basgul et al** [18]. The shorter SSD in non parturient population(4.75 ± 0.64 cm) may be attributed to anthropometric difference between the study subjects, as our patients are shorter in height with less BMI and weight as compared to the western population.

In present study there was a positive Pearson correlation of SSD with weight, BMI, midarm circumference and waist circumference in both parturients and non parturients. **Hazarika R et al** [14] also reported positive correlation of SSD with weight(r=0.702, r =0.739) and BMI(r=0.730, 0.873) in both parturients and non parturients respectively, However there was a linear correlation of SSD with age(r=0.031, r=0.081) and height(r=-0.116,r=0.181), the values were not found to be significant in their study which is in accordance to present study.

Subcutaneous tissue is the most variable layer that is related to weight of the patient, which is considerable during lumbar puncture. Various studies have been done from India, USA, Iran, Turkey, Belgium and France and reported statistically significant correlation of the SSD with body mass index(BMI) which is in accordance to present study.[5,11,15,19]

Sargin et al [20] **and Ping ma H. et al** [21] observed significant correlation between SSD with weight and BMI in their study population. Similarly **Bassiakou et al** [16] also reported correlation between SSD, BMI and body weight in parturients which is in agreement with the results of present study. **Razavizadeh MR et al** [15] observed strong positive correlation with observed SSD and height, weight, BMI, mid arm and waist circumference, which was similar to present study. The relationship between depth of needle insertion and BMI was expressed as $0.56+(0.18\times BMI)$ in their study.

However the difference in strength of correlation in different studies may be attributed to the mother's weight and decrease in height due to lumbar lordosis changes which could affect the accuracy of study results and prevent generalization in the general population. In addition weight gain in pregnancy is not constant and equal in all females as it differs by 7-14 kg.[22]

In present study a weak positive correlation of height with SSD was observed in both parturients ($r=0.117$) and non parturients ($r=0.093$) and was statistically non significant ($p>0.05$), which is in contrast to the study done by **Craig et al** [8]. They observed a linear relationship between the patient's height and the depth of needle insertion, and concluded that the mean depth of insertion could be determined by $0.03\times$height(cm).

The anthropometric variables like midarm circumference and waist circumference were also correlated with SSD in female population of present study. A significant positive correlation was observed in both the groups. **Razavizadeh MR et al** [15] also found a positive correlation of observed SSD with mid arm circumference and waist circumference in female population and was found to be statistically significant($p<0.05$). However the correlation of SSD was stronger with waist circumference than arm circumference which is similar to present study.

There are few limitations in this study. Variations in demographic and anthropometric characteristics in different study population preclude the use of this data to be interpreted as an absolute guideline. An accurate estimation of skin to subarachnoid space depth (SSD) could be possible using ultrasonography, however nonavailability of equipments and lack of proper skill may limit its role in routine practice. The diameter of subarachnoid space could vary in different spaces and in different individuals, which can affect the depth of the needle insertion. This could limit generalization of these observations. The formulae to predict SSD in parturients is applicable only for midline approach. Further studies are required to predict SSD using different approaches. Large sample size with different study population is required to establish the accuracy of the different formulae.

CONCLUSION

In conclusion, strong correlation of skin to subarachnoid space depth (SSD) was observed with anthropometric variables especially weight, BMI, mid arm and waist circumference in all females, both parturients and non parturients. The skin to subarachnoid space depth in parturients was significantly greater as compared to the general female population. Stocker's formulae using weight of the parturients was the most appropriate to predict the skin to subarachnoid space depth in this population. Bonadio's formulae using body surface area (BSA) was found to be more appropriate to predict the skin to subarachnoid space depth (SSD) in non parturients. Thus, Stocker's formulae may provide better estimate of spinal needle length for subarachnoid block in full term parturients, while in non parturients Bonadio's formulae may provide better estimate of spinal needle length for subarachnoid block.

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