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RESEARCH ARTICLE
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# ESTIMATION OF SKIN TO SUBARACHNOID SPACE DEPTH IN INDIAN POPULATION: A PROSPECTIVE OBSERVATIONAL STUDY

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**ABSTRACT**

**BACKGROUND:** Subarachnoid block (SAB) is the most routinely practiced anesthesia technique for all patients undergoing lower abdominal and lower limb surgeries including pregnant females posted for cesarean sections. It is commonly done by an anatomical landmark-guided approach. Many factors such as Height, Weight, BMI, and BSA influence the successful tapping of CSF.

**MATERIALS AND METHODS:** After institutional ethical committee clearance and written informed consent, 300 adult ASA grade I/II patients of either sex scheduled for various procedures under spinal anesthesia were included in the study and were divided into 3 groups as Males (Group M), Females (Group F) and Pregnant Females (Group PF) of 100 each. The patient's anthropometric details like Height and weight were recorded during routine pre-anesthetic evaluation. After connecting standard monitors, with the patient in sitting position, spinal anesthesia was given at L3-L4 intervertebral space by midline approach. The SSD was measured using a sterile marking pen. BMI, BSA and Predicted SSD were calculated using pre-existing formulae. All the data were entered into an Excel sheet and statistically analyzed.

**RESULTS:** The mean SSD in our population was 6.182±0.5603cm and the SSD of males, females, and pregnant females were 6.350±0.5186cm, 5.95±0.5245cm, and 6.24±0.5650 cm respectively.

**CONCLUSION:** The mean SSD was higher in males compared to nonpregnant females. The mean of actual SSD when compared with the mean of SSD calculated using pre-existing formulae using anthropometric measurements did not show any statistically significant correlation. However, we were able to derive a new formula to calculate SSD using anthropometric data obtained from our study population.

**KEYWORDS:** Skin to Subarachnoid Space Depth (SSD), Sub-arachnoid Block (SAB), Lumbar Puncture (LP).

## INTRODUCTION

The subarachnoid block is the most routinely practiced anesthesia technique for lower abdominal and lower limb surgeries in adults and pregnant females posted for cesarean sections in ASA I and II patients. It is commonly done by an anatomical landmark-guided approach.[1] Skin-to-subarachnoid space depth (SSD) varies considerably at different levels of the spinal cord, from patient to patient at the same vertebral level as per age, sex, and BMI[2]. Since it is a blind technique it poses difficulty in patients with obesity, pregnancy, patients with edema, and anatomical abnormalities and success depends on the skill and experience of the anaesthesiologist,[3] comfort of the patient, and other factors mentioned above.

Anthropometric characteristics like Body Surface Area (BSA)/Body Mass Index (BMI) have been used in different formulae[4] to estimate SSD which helps to improve the accuracy of spinal block and estimation of skin to subarachnoid space depth reduces complications related to spinal anesthesia like repeated unsuccessful attempts, traumatic and bloody lumbar punctures.[5]

The studies focusing on SSD in the adult Indian population who have evaluated the differences based on gender are a few, hence we decided to take up this prospective observational study. We hypothesized a significant difference in SSD among males, females, and pregnant females in our population and decided to evaluate the same. Our primary aim of the study was to estimate the mean SSD at L3-L4 interspace in the overall population, males, females, and pregnant females separately, and to find the difference in SSD between them. The secondary aim was to determine whether any previously known formulae for estimating SSD (Stocker's, Craig's, modified Chong's formula, Abe's, Bonadio's,) are appropriate for our population in day-to-day practice[6].

## MATERIALS AND METHODS

After institutional ethical committee clearance and written informed consent, 300 adult ASA grade I/II patients of either sex scheduled for various surgical, gynecological, and obstetric procedures under spinal anesthesia were included in the study and were divided into 3 groups as Males (Group M), Females (Group F) and Pregnant Females (Group PF) of 100 each. Patients with known hypersensitivity/contraindication to study drugs, coagulation disorders, infection at the site of spinal injection, severe renal/hepatic/respiratory or cardiac disease, pregnant patients with hypertensive disorders, in patients where the paramedian approach of spinal anesthesia has to be used, with neurological/psychiatric/neuromuscular disorders/spine anomaly, associated medical illness with relative contraindication to spinal anesthesia were excluded from the study.

Patient characteristics including name, gender, age, body weight, and height were recorded during routine pre-anesthetic evaluation according to the hospital protocol. Patients were kept nil orally for 6 hours. On arrival of the patient to the operation theater, new intravenous line using an 18G Teflon catheter was inserted onto the dorsum of the hand, if not present already. Multichannel monitors like SPO2, NIBP, and ECG were connected to the patient, and baseline readings of the same were recorded. All patients were premedicated according to the hospital protocol if required.

Patients were placed in the sitting position and under aseptic precautions L3-L4 intervertebral space was identified by the palpatory method using Tuffier's line as a guide. Puncture of the dura was performed using a 25-gauge Quincke's spinal needle through the midline approach. The spinal needle was inserted perpendicular to the skin and advanced slowly till the appreciation of pop to puncture dura mater and was confirmed by the first appearance of the free flow of cerebrospinal fluid (CSF). Patients with bloody CSF and those in whom either the angle of the spinal needle was not perpendicular or angulated more than 10 degrees or the approach was changed from midline to paramedian were excluded from the study. The intrathecal local anesthetic dose was calculated depending on surgical requirements and patient characteristics.

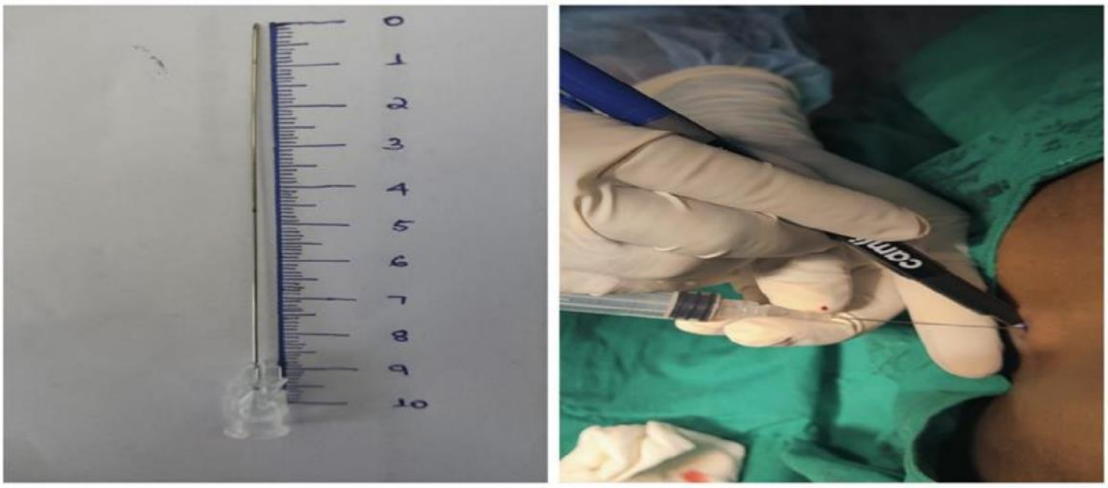



***Image 1: Skin to Subarachnoid Space Depth Measurement using Sterile Marking Pen***

After administering the intrathecal drug, the spinal needle was marked at the junction of skin and needle using a sterile skin marking pen, abutting the patient's back, and the spinal needle was removed. The depth of insertion was measured using a standard scale and was noted. The surgeons were allowed to start the procedure once the required level of the block was achieved and managed according to our institutional protocol.

BMI and BSA were calculated using Quetelet index[7] (BMI=weight in kg/height in meter$^{2)}$ and Mosteller formula[8] BSA($m^2$) = {[height(cm)×weight(kg)]/3600}$^{1/2.}$

Abe's, Bonadio's, Craig's, Stocker's, and Chong's modified formulae were applied individually to all patients to determine predicted SSD using the following formulae[9]:

- Abe's formula: SSD (cm) =17 weight
(Kg)/height (cm)+1
- Bonadio's formula: SSD (cm) =0.77cm+2.56×BSA($m^2$)
- Craig's formula: SSD (cm) = 0.03 cm × height (cm)
- Stocker's formula: SSD (mm) = 0.5 × weight (kg) +18
- Chong's modified formula: SSD (cm) = 10 weight (kg)/height (cm) +1.

All the data was entered into an Excel sheet for statistical analysis

**Statistical Analysis**

The sample size was calculated based on observations from a previous study conducted by Taman et al[9]. Taking a confidence interval of 0.95 and using a systemic sampling technique, a total sample size of 290 patients was determined. Taking a 3% failure rate of spinal anesthesia a sample size of 100 patients per group was taken for our study. The difference of <0.5cm of measured SSD and predicted SSD by using different formulae was decided to be taken as nearest to our population. Statistical Package for Social Sciences (SSPS 21.0, Chicago, IL) was used for the analysis. Descriptive statistics for the overall sample and group (Group M, Group F, and Group PF) were calculated for all the variables. Data was expressed as mean and standard deviation. Demographic parameters and SSD were compared using one-way ANOVA with post-hoc (Bonferroni correction factor) analysis to observe significant differences among the study groups. Multivariate regression analysis was performed to see important covariates influencing SSD for each group separately. The p-value $\leq 0.05$ was considered as statistically significant.

**RESULTS**

From a total of 300 eligible patients, all the participants completed the study. Patients' characteristics for the overall population are shown in Table 1.

| Patient characteristics | Overall population (n=300) |
|---|---|
| Age (years) | 38.98±16.39 |
| Height (cm) | 157.8±9.85 |
| Weight (kg) | 63.40±13.65 |
| BMI (kg/m2 ) | 25.52±5.42 |
| BSA (m2 ) | 1.66±0.20 |

***Table 1: Patient characteristics of the overall study population***

The demographic characteristics of individual study groups are shown in Table 2.

| Patient characteristics | Male group(n=100) | Female group(n=100) | Pregnant Female Group(n=100) | P-Value<br>P-Value |
|---|---|---|---|---|
| Height (cm) | 167.744±7.596 | 152.66±6.724* | 153.00±5.92† | 0.0005 |
| Weight (kg) | 66.740±12.93 | 58.190±12.747* | 65.290±13.809 | 0.0005 |
| BMI (kg/m2) | 23.730±4.428 | 24.973±5.304 | 27.868±5.664† | 0.205 |
| Age (years) | 45.640±17.31 | 46.120±13.75 | 25.190±5.813 | 0.0005 |
| BSA (m2) | 1.756±0.189 | 1.562±0.183* | 1.657±0.188† | 0.0005 |

Data are presented as mean± SD. *P<0.05 significant when the male group compared with the female group.

†P<0.05 significant when the male group compared with pregnant female group

***Table 2: Patient Characteristics of the Three Study Group***

In our population height and BSA were higher in male patients when compared to females and were statically very significant with p-value <0.05 (0.0005). The weight of the male group was higher when compared to the female group and was statistically significant (p-value 0.0005), but was comparable with pregnant females. BMI of pregnant females although was higher when compared to the other two groups, was statistically not significant. There was a statistically significant difference in age among the pregnant females and the other two groups.

The measured mean SSD obtained from our population is depicted in Table 3

| **Patient characteristics** | **Male group(n=100)** | **Female group(n=100)** | **Pregnant Female Group group(n=100)** | **P-Value** |
|---|---|---|---|---|
| Skin to subarachnoid space depth | 6.35±0.52 | 5.95±0.52* | 6.24±0.56 | 0.0005 |

**Table 3: The skin-to-subarachnoid space depth measured in overall population and all three groups.**

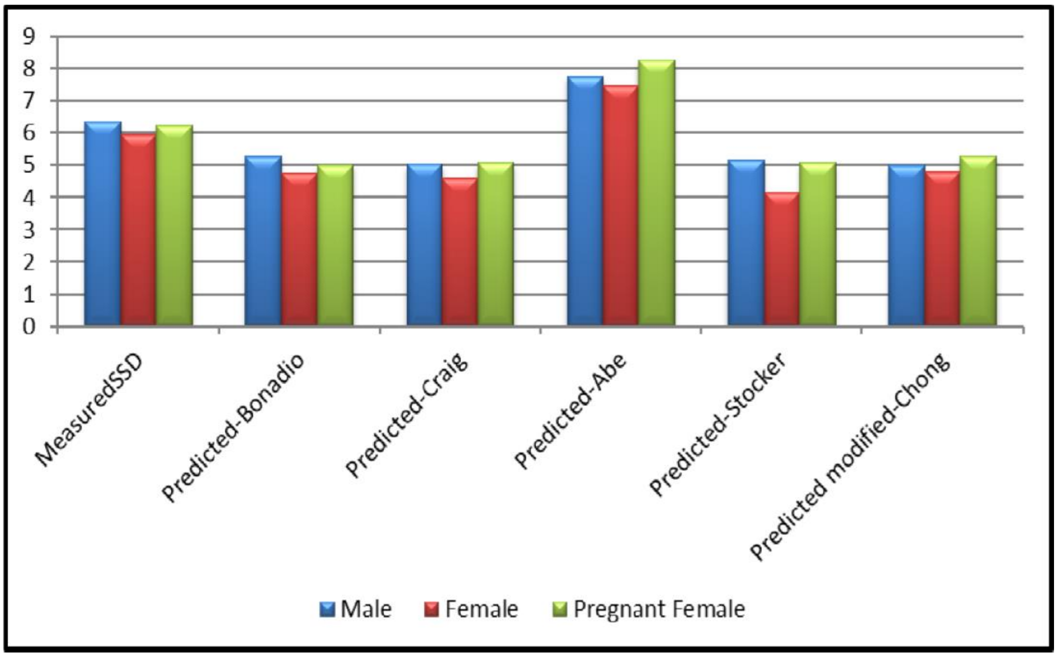
***Data are presented as mean±SD. *P<0.05 significant when the male group compared with nonpregnant female group, †P<0.05 significant when the male group compared with pregnant female group. SD=Standard deviation***

This table shows that the SSD measured in the male group showed a statistically significant difference when compared to the nonpregnant female group and was comparable with the pregnant female group.
Table 4 shows the mean difference between the actual measured SSD compared to predicted SSD using various pre-existing formulae.

| | Mean | Difference |
|---|---|---|
| **Actual Skin to subarachnoid space depth** | 6.182 | |
| Predicted-Bonadio | 5.016 | 1.166 |
| Predicted-Craig | 4.734 | 1.448 |
| Predicted-Abe | 7.826 | 1.644 |
| Predicted-Stocker | 4.97 | 1.212 |
| Predicted modified-Chong | 5.015 | 1.167 |

***Table 4: Mean Difference between the Predicted Skin to Subarachnoid Space Depth using Various Formulae and the Observed Mean Subarachnoid Space Depth.***

The above table shows that none of the pre-existing formulae were able to predict the actual or approximate value of SSD in our population (difference of <0.5 cm as defined earlier).
Graph 1 shows the comparison between the measured SSD and the predicted SSD using different formulae in individual study groups.




***Graph 1: Comparison between the Measured SSD and the Predicted SSD***

None of the above existing formulae were able to predict actual SSD in each study group.
A multivariate regression analysis was performed to determine covariates that determined SSD as shown in Table 5, which showed that SSD in all groups correlated well with BMI, BSA, height, and weight.

| | Overall population | | Male | | Female | | Pregnant Female | |
|---|---|---|---|---|---|---|---|---|
| Patient characteristics | Regression coefficient | P-Value | Regression coefficient | P-Value | Regression coefficient | P-Value | Regression coefficient | P-Value |
| Constant | 2.100 | 0.0005 | 1.200 | 0 | 3.028 | 0 | -.613 | 0.0005 |
| Height (cm) | .009 | 0.0005 | .005 | 0.0005 | | | .024 | 0.0005 |
| weight (kg) | .030 | 0.0005 | | | .030 | 0.0005 | | |
| BSA (m2) | .150 | 0.0005 | 1.889 | 0.0005 | .714 | 0.0005 | .739 | 0.0005 |
| BMI(kg/m2) | .020 | 0.0005 | .040 | 0.0005 | .003 | 0.0005 | .072 | 0.0005 |

***Table 5: Multivariate Regression Analysis to Determine Covariates that Influence Skin to Subarachnoid Space Depth in the Studied Group***

Table 6 shows the new formulae derived from our study population for predicting SSD.

| | |
|---|---|
| Overall population | SSD (cm)=2.1 + (0.009 × height) + (0.03 × weight) + (0.02 × BMI) + (0.15× BSA) |
| Males | SSD (cm)=(0.005 × height) + (0.04 × BMI) + (1.889 × BSA) +1.2 |
| Females | SSD (cm)=3.028+(0.03 × weight )+(0.003 × BMI) +(0.714 × BSA) |
| Pregnant females | SSD (cm)= – 0.613 +(0.024 × height)+(0.072 × BMI)+ (0.739 × BSA) |

***Table 6: Formula for Predicting Skin to Subarachnoid Space Depth Derived from our Study***

## DISCUSSION

Subarachnoid block (SAB) is done by depositing local anaesthetics like bupivacaine, ropivacaine, and chloroprocaine with or without adjuvants into intrathecal space after confirming free flow of CSF using a spinal needle. Hence lumbar puncture is an important step while administering SAB. Many factors like Height, Weight, BMI, and BSA determine the success of lumbar puncture. Therefore, we aimed to determine the mean SSD in our overall population, in each gender and pregnant patients separately so that it will help in our day-to-day practice for successful lumbar puncture. We also aimed to apply a few pre-existing formulae to determine the SSD by applying anthropometric measurements of the patients and know whether any of them will suit our population

In this prospective observational study, we measured the mean SSD in our population which was 6.182±0.5603cm, and also measured the SSD separately for males, females, and pregnant females which were 6.350±0.5186cm, 5.95±0.5245cm and 6.24±0.5650 cm respectively. The measured SSD was found to be higher in pregnant females compared to females, and almost comparable to males. This may be due to the hormonal effects of pregnancy, weight gain, subcutaneous deposition of fat, and softening of ligaments and tissues. The various anthropometric measurements such as weight, height, BSA, and BMI have shown statistically significant differences among male and female groups ($p<0.005$). This might be the reason for the difference observed in skin to SSD among study groups.

None of the pre-existing formulae were able to predict the SSD with a difference of <0.5cm in our population and individual groups. However, we could derive new formulae for the overall population and individual groups by applying multivariate regression analysis which requires further validation. According to a study conducted by Taman et al.[9] in the Egyptian population, the mean SSD was 4.99 ± 0.48 cm. The study found that adult males had a significantly longer SSD (4.93 ± 0.47 cm) compared to females (4.22 ± 0.49 cm). When Craig's formula was applied to the study, it showed the best correlation with the observed SSD, but compared to our population, the mean SSD of the Egyptian population is shorter than our population. (Mean SSD 6.182±0.560cm), maybe because of the difference in anthropometric measurements (body composition) of our population.

According to a study conducted by Hazarika et al.[10] on 300 patients, the mean SSD was 4.37 ± 0.31 cm in the overall population. The study also revealed that the SSD in adult males was 4.49 ± 0.19 cm, significantly longer than in females, whose SSD was 4.18 ± 0.39 cm, which was not consistent with our findings as the results obtained from our study showed higher mean values for the overall population and individual groups.

Prakash et al.[5] conducted a similar study and found that the mean SSD for the overall population was 4.71±0.31cm. Their study measured the mean SSD of 288 male patients, 205 non-pregnant female patients, and 190 parturient female patients, which was 4.8±0.68 cm, 4.55±0.66cm, and 4.73±0.73cm, respectively. When they applied Stocker's formula[11] to their population, the mean difference was least (0.01 cm) and insignificant (p=0.59), and it correlated best with their observed SSD. Craig [12], Modified Chong's[13], Abe's[14], and Bonadio's[15] formulae was applied to their population and the mean difference obtained from their formula was statistically significant. Similar findings were found in our study as well, where we also observed a statistically significant mean difference when these formulae were applied to our population.

Craig et al[12] conducted a study on 279 Chinese patients aged between six months and 15 years. They found a strong relationship between the depth of the lumbar puncture needle and the weight/height ratio. Similarly, Chong et al.[13] also conducted a study on patients aged one month to 16 years to predict the depth of needle insertion for lumbar puncture. They derived a formula from the pediatric population and found a relationship between the depth and age, weight, and height of the patients. However, this formula may not be consistent with our study population as our age group included 18 years to 60 years.

A cohort study was conducted by Abe et al,[14] on patients aged from 25 days to 80 years who underwent CT scans for various reasons. During the study, the depth of lumbar puncture (LP) in CT was measured, and a formula for calculating the required LP needle depth was obtained. The study results showed that the Abe formula was a more reliable predictor for estimating the necessary LP needle depth compared to other existing formulas. This is because it considered a larger sample size and more promising CT scan data when compared to our study, where we used anthropometric data. However, this formula also didn't suit our population maybe because of age group involved is different with differences in anthropometric measurements.

A study conducted by Sargin et al.[16] involved 250 patients with ASA physical status I, II, and III who underwent surgery under spinal anesthesia. The study found that the mean of SSD at the L3-4 interspace was 5.543 ± 6.47 cm. The study also showed a statistically significant correlation between SSD and BMI and body weight (ρ=0.650). However, no significant correlation was found between SSD and age, gender, and body height (ρ=0.120, p=0.058; ρ=-0.047, p=0.4568 and ρ=0.089, p=0.159 respectively).[16]

In our study, we found that BMI and BSA were all statistically significant factors in the overall population, as well as in individual groups.

## LIMITATION

In our study, we measured SSD using a midline approach by inserting a spinal needle perpendicular to the patient's skin, with no more than 10 degrees of inclination. To ensure the needle was perpendicular to the skin, we relied on visual impressions. It was a non-randomized study. The sample size chosen is small to validate the formulae for our population which further requires large multicentric studies.

## CONCLUSION

Thus, our study results showed that mean SSD was higher in males compared to nonpregnant females. The mean of actual SSD when compared with the mean of SSD calculated using pre-existing formulae using anthropometric measurements did not show any statistically significant correlation. Large multicentric trials with a large sample size are required to validate the newly derived formulae from our anthropometric data before applying it for general population.
FUTURE SCOPE: As the usage of USG has become a routine in the day-to-day practice of an anesthesiologist, finding the SSD using USG might be more reliable and useful than using anthropometric measurements.

**CONFLICT OF INTEREST:** Nil

**FUNDING:** None

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