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A Prospective Observational Study to Compare the Depth of Subarachnoid Space Using Anthropometric Measurements, Ultrasonographic Measurements and Actual Depth by Needle Insertion

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Abstract

Introduction: A pre puncture estimation of subarachnoid space depth using ultrasound may guide spinal needle placement and help to reduce failure rate and complication associated with lumber puncture. Our aim of study was to determine SSD using anthropometric, ultrasonographic and actual depth by needle insertion and to compare them.

Materials and methods: A total of 120 patients who got admitted to Subharti Hospital for elective infraumbilical surgery under spinal anaesthesia from July 2016 to June 2018 were included in our study. Preoperative assessment of SSD using anthropometric by Bonodio's formula and ultrasonography was done and intraoperative actual depth was measured after needle insertion.

Results: Mean subarachnoid space depth by Bonadio formula, USG and actual depth in male was 5.12 ± 0.3, 4.27 ± 0.55 and 4.28 ± 0.57 respectively while in female it was 5.17 ± 0.3, 4.14 ± 0.60, 4.17 ± 0.5 respectively.

Conclusion: Subarachnoid space depth using Bonodio's formula did not correlate with the depth measured by ultrasound or actual needle insertion but the measurements with ultrasound and actual needle insertion showed significant correlation which proves that Bonodio's formula did not predict the correct value of subarachnoid space in comparison to ultrasound measurement. Therefore, ultrasound makes it possible to have an accurate estimation of the depth to reach intrathecal space and can help to reduce the no of attempts of needle insertion and also to reduce the failure and complication rates.

Keywords: Subarachnoid space depth; Ultrasonography

Introduction

Since the first description of spinal anaesthesia in humans by Bier; the identification of the subarachnoid space has been traditionally achieved by an anatomical landmark guided approach [1]. While surface anatomical landmarks are useful, they are nevertheless surrogate markers. They may be difficult to palpate in obese patients as well as those with oedema. Landmark-based approaches do not take into account all anatomical variations or abnormalities, and frequently lead to incorrect identification of a given lumbar interspace [2].

Porter and colleagues in 1978, used ultrasound for imaging the lumber spine and measuring the diameter of the spinal canal in diagnostic radiology [3].

Since 1980 onwards, a strong correlation between the depth of the epidural space measured on ultrasound and actual needle depth on puncture was observed. Thus, the ultrasound has been considered a useful tool to identify the depth of the epidural space from skin and its anatomical structures [4].

Anthropometric characteristics like BMI; BSA has been used in different formula to estimate the subarachnoid space depth which helps to improve the accuracy of spinal block.

Neuraxial sonography allows the operator to preview spinal anatomy, identify midline and determine the interspace for needle insertion to reduce complication.

We conducted this study to determine the subarachnoid space depth in overall population in relation to anthropometric measurement, ultrasonographic measurement and actual depth by needle insertion.

Materials and Methods

This prospective observational study was conducted in Department of Anaesthesia, Subharti Medical College, Meerut. After institutional ethics committee approval and written consent from all participants, a total of 120 patients were enrolled in between July 2016 and June, 2018. Patients with local infection, spine abnormalities and posted for emergency surgery were excluded from the study.

Preoperatively height and weight of every patient was noted down and with that BSA was calculated using Mosteller formula and noted down. With the help of BSA SSD was calculated using Bonodio's formula and noted down for every patient. The formulae by previous investigators are as follow:

- Bonadio's formula: SSD (cm)=0.77 cm+2.56 × BSA [5].
- BSA (m^2)=[Height (cm) × Weight (kg)]/3600)^{½} [6].

Preoperatively assessment of lumbar spine was done using ultrasound with the help of low frequency curvilinear probe. All measurements were done in sitting position at L3-L4 level of spine. After getting optimal image in transverse spinous process view of spine using ultrasound the image was freezed. The depth from skin to posterior complex was measured in L3-L4 space with built-in callipers in the ultrasound machine and noted down.

Intraoperative patients were placed in the sitting position with their back fully flexed. Under all aseptic precautions, the L3-L4 inter-vertebral space was identified, guided by the Tuffier's line. Dural puncture was performed with a 25 gauge Quincke B.D (3.5 inch/8.9 cm) spinal needle using the midline approach. The spinal needle was inserted perpendicular to the skin. The needle was advanced until CSF was obtained, signifying entry into the subarachnoid space and confirmed by free flow of cerebrospinal fluid. Following intrathecal injection, the spinal needle was grasped firmly between the thumb and the index finger abutting the patient's back and removed. The depth of insertion was measured using a standard scale and noted.

Statistically analysis

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. Normality of data was tested by Kolmogorov-Smirnov test. If the normality was rejected then non parametric test was used.

Statistical tests were applied as follows:

- Quantitative variables were compared using Independent T test/Mann-Whitney Test (when the data sets were not normally distributed) between the two groups.
- Qualitative variables were correlated using Chi-Square test/ Fisher's exact test.

A p value of <0.05 was considered statistically significant.

The data was entered in MS Excel spread sheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

Results

As seen in the below **Tables 1-5**, mean subarachnoid space depth by Bonadio formula, USG and Actual depth in male was 5.12 ± 0.3, 4.27 ± 0.55 and 4.28 ± 0.57 respectively while in female it was 5.17 ± 0.3, 4.14 ± 0.60, 4.17 ± 0.5 respectively.

There was no significant difference observed in mean subarachnoid space depth by Bonadio formula, USG and Actual depth amongst different gender.

Table 1 Mean subarachnoid space depth by using anthropometric measurements, needle insertion amongst different gender and ultrasonographic measurements.

Parameters	Male	Female	p value
	Mean	Mean	
Bonadio formula	5.12 ± 0.2	5.17 ± 0.2	0.362
USG	4.27 ± 0.55	4.14 ± 0.60	0.872
Actual depth	4.28 ± 0.57	4.17 ± 0.5	0.912

Table 2 Mean subarachnoid space depth by using anthropometric measurements, needle insertion and ultrasonographic measurements.

Mean subarachnoid space depth	Bonadio formula	USG	Actual depth
	5.12 ± 0.45	4.1 ± 0.1	4.2 ± 0.1

Table 3 Mean subarachnoid space depth by using anthropometric measurements and ultrasonographic measurements.

Mean subarachnoid space depth	Bonadio formula	USG	p value
	5.12 ± 0.45	4.1 ± 0.1	0.01

Mean subarachnoid space depth using Bonodio's formula is not correlated with USG depth as p-value is 0.01.

Table 4 Mean subarachnoid space depth by using anthropometric measurements and needle insertion.

Mean subarachnoid space depth	Bonadio formula	Actual depth	p value
	5.12 ± 0.45	4.2 ± 0.1	0.01

Mean subarachnoid space depth using Bonodio's formula is not correlated with actual depth as p-value is 0.01.

Table 5 Mean subarachnoid space depth by using ultrasonographic measurements and needle insertion.

Mean subarachnoid space depth	USG	Actual depth	p value
	4.1 ± 0.1	4.2 ± 0.1	0.634

Mean subarachnoid space depth is correlated with USG and actual depth as p-value is 0.634.

Discussion

This prospective observational study demonstrated the correlation of ultrasonographic measurement of SSD with actual needle insertion as compared to anthropometric measurements which proves that use of ultrasound for estimation of SSD is more accurate than anthropometric measurement.

There were few studies which compared subarachnoid space depth using anthropometric, ultrasonographic and actual depth measurements but few studies have compared ultrasonographic and actual depth while few have compared anthropometric and actual depth measurements.

The study done by Prakash et al. on Indian population the observed SSD in the overall study population was 4.71 ± 0.70 cm. The mean difference was least (0.01 cm) and not significant (p=0.59) when Stocker's formula was applied to their population. It correlated best with the observed SSD. The mean difference was statistically significant when Abe's, Craig's, Bonadio's and Chong's modified formulae were applied to their study population [7].

In the study done by Taman et al. in Egyptian population they found out that Mean SSD was 4.99 ± 0.48 cm in the overall population. SSD in adult males (4.93 ± 0.47 cm) was significantly longer than that observed in females (4.22 ± 0.49 cm). Craig's formula when applied to their study was correlated best with the observed SSD [8].

In the study done by Hazarika et al. on 300 patients they found out that Mean SSD was 4.37 ± 0.31 cm in the overall population. SSD in adult males was 4.49 ± 0.19 cm which was significantly longer than that observed in female's 4.18 ± 0.39 cm. In our study also Mean SSD was 4.20 ± 0.12 which correlates with their study [9].

In study done by Gnaho et al. they found that spinal anaesthesia in sitting position at lumbar L3-L4 level the skin to anterior ligamentum flavum distance and spinal needle depth as (5.154 ± 0.95 cm) and (5.14 ± 0.97 cm) respectively and the estimated depth US and estimated depth normal were respectively 5.15 ± 0.95 cm and 5.14 ± 0.97 cm; these distances were not significantly different (p>0.0001). A significant correlation r=0.982 [95% CI 0.963-0.992, p>0.0001] was observed between the ED-US and ED-N measurements. Also in our study we found out that ultrasound and actual depth were 4.20 ± 0.12 and 4.19 ± 0.13 respectively which show significant correlation [10].

In a cohort study by Abe et al. on 175 patients aged 25 days to 80 years, in patients undergoing CT scan for a variety of reasons, the LP depth in CT was measured and a formula for calculating LP needle depth was presented in the form of LP depth=1+(17 × W/H). Their study showed that the Abe formula was a more reliable predictor for estimating the required LP needle depth, in comparison with other published formulas (R2=0.81) [11].

In a study done by Conroy et al. they conducted single center prospective observational study among patients undergoing lower limb orthopedic surgery. Their primary outcome measure was the success rate of CSF acquisition under real time ultrasound guidance with CSF being located in 97 out of 100 consecutive patients within three median needle passes. Median time from spinal needle insertion until intrathecal injection completion was 1.2 minutes demonstrating the feasibility of this technique in routine clinical practice [12].

In study done by Duniec et al. they studied one hundred and twenty two patients of age more than 18 years posted for orthopaedic surgery of lower limb. Lumbar intervertebral spaces were identified by ultrasound in all cases. There was concordance of intervertebral space identification between clinical and ultrasound examination in 78 cases which proved that spinal ultrasound can reduce the incidence of inappropriate lumbar puncture level in orthopaedic patient [13].

In another study by Chong et al. on 279 Chinese patients aged six months to 15 years, multiple regression tests showed a strong relationship between the lumbar puncture depth of needle insertion and the weight/height ratio. By using a predictive regression model, the ideal depth of needle insertion (cm) was determined as 10 [weight (kg)/height (cm)] +0.93, with a regression coefficient of r=0.77 [14].

In a study by Craig et al. on patients aged 1 month-16 years, to predict the lumber puncture (LP) depth of needle insertion, the relationship between depth of needle insertion and the height, weight, and age of the patients was analysed. A linear relationship was found between the child's height and the depth of needle insertion; as a result, the mean depth of insertion could be determined by 0.03 × height (cm) [15].

In study done by Reza et al. they studied 385 patients with ASA class I–II, aged 18-65 years and undergoing elective surgery of the lower abdomen and extremities under spinal anaesthesia. The patient's demographic characteristics, body mass index (BMI), and anthropometric characteristics (height, weight, waist circumference, and arm circumference) were recorded. There was a strong correlation between the depth of needle insertion and BMI (24.9 ± 3.9), and between depth and weight/height ratio (r=0.95 and r=0.92, respectively) [16].

In the study done by Sargin et al. two hundred and fifty patients of ASA physical status I, II, and III scheduled to undergo elective surgery under spinal anaesthesia, were studied and they observed mean values of SSD at the L3-4 interspace were 55.43 ± 6.47 mm (range 35-74). Statistically significant correlations were observed between SSD with BMI and body weight (ρ=0.650, p<0.001 and ρ=0.651, p<0.001, respectively). Statistically significant correlation was not found between SSD with 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) [17].

Thus it is evident from our study that ultrasonographic measurement and actual depth measurement of subarachnoid space depth shows no significant difference and there is significant difference in anthropometric measurement of subarachnoid space depth in comparison to ultrasound or actual depth. These finding may help to correctly identify the depth of subarachnoid space and reduce the failure rate, no of attempts and reduce the complication rates.

Conclusion

Subarachnoid space depth using Bonodio's formula did not correlate with the depth measured by ultrasound or actual needle insertion but the measurements with ultrasound and actual needle insertion showed significant correlation which proves that Bonodio's formula did not predict the correct value of subarachnoid space in comparison to ultrasound measurement. Therefore, ultrasound makes it possible to have an accurate estimation of the depth to reach intrathecal space and can help to reduce the no of attempts of needle insertion and also to reduce the failure and complication rates.

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