Ultrasound Guided Estimation of Skin to Subarachnoid Space Depth in Patients Scheduled for Elective Surgeries under Subarachnoid Block

Devkota S,[1] Baral BK,[2] Poudel PR[2]

[1]Department of Anesthesiology,

Sindhuli Hospital, Sindhuli, Nepal.

[2]Department of Anesthesiology and Intensive Care,

National Academy of Medical Sciences,

Bir Hospital, Kathmandu, Nepal.

Corresponding Author

Sagar Devkota

Department of Anesthesiology,

Sindhuli Hospital, Sindhuli, Nepal.

E-mail: sagar_1dev@yahoo.com

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ABSTRACT

Background

Subarachnoid block is one of the commonly used techniques of regional anesthesia and accurate placement of spinal needle is crucial. A conventional spinal needle may be too long for a lean patient or too short in obese patients leading to multiple attempts, inadvertent nerve injuries and patient discomfort. So a pre-procedural estimation of the skin to subarachnoid space depth may be beneficial.

Objective

To estimate the skin to subarachnoid space depth using ultrasound and correlate it with the length of spinal needle to be inserted during subarachnoid block.

Method

This was a prospective, observational study conducted at Bir Hospital, Kathmandu in patients undergoing elective surgeries under subarachnoid block. A pre-procedural ultrasound of lumbo-sacral spine using 2-5 Hz curvilinear probe was done to measure skin to subarachnoid space depth (SSD) at the level of L3-L4 interspace. Then under all aseptic precautions, subarachnoid block was performed and the length of spinal needle outside the skin was measured and that length was subtracted from the standard length of needle to get the inserted length of spinal needle. These two measurements were compared.

Result

In the fifty patients included in the study, ultrasound estimated skin to subarachnoid space depth was found to be 4.24 ± 0.48 cm and the inserted length of spinal needle was 4.24 ± 0.46 cm. A significant correlation r=0.96 ($p < 0.05$) was found between the two measurements in the study population.

Conclusion

Ultrasound estimated skin to subarachnoid depth in the study population was found to be 4.24 ± 0.48 cm which correlated with the inserted length of spinal needle. So, use of ultrasound can be very helpful in performing subarachnoid block.

KEY WORDS

Skin to subarachnoid space depth, Spinal needle, Subarachnoid block, Ultrasound

INTRODUCTION

Subarachnoid block is one of the commonly used techniques of regional anesthesia where local anesthetic agent is injected into the subarachnoid space to block the spinal nerve roots running through it.[1] Based on palpation of bony structures for landmark, it may be associated with multiple attempts increasing patient discomfort which is more likely in patients with obesity, old age and spine deformity.[2] Similarly, the failure rates associated with subarachnoid block ranges from 3.1% to 9.1% with studies even revealing a failure rate of nearly 17%.[3-5]

Various modifications have been described to reduce the morbidity related to repeated attempts and needle passes. The use of Ultrasound for regional anesthesia has become a subject of major interest worldwide.[6] Recently, ultrasound has been proposed as a preoperative assessment tool predicting the feasibility of neuraxial blockade.[7] The success rate using ultrasound in first needle attempt is higher as compared to conventional blind techniques.[8]

Different studies done in Indian and Western population have predicted the skin to subarachnoid space depth and evaluated the correlation between the pre-procedural skin to subarachnoid space depth (SSD) and the inserted length of spinal needle.[9-11] However, such studies in our population are lacking and use of ultrasound is restricted to obesity and spinal deformity. This study aimed to estimate the skin to subarachnoid space depth by using Ultrasound in patients scheduled for elective surgeries under subarachnoid block and correlate it with the inserted length of spinal needle.

METHODS

This was a prospective observational study performed in the Department of Anesthesiology and Intensive Care at National Academy of Medical Sciences, Bir Hospital from November 2017 to January 2018 after obtaining ethical clearance from the institutional review board and informed written consent from all the eligible patients. Fifty consecutive ASA I and II patients scheduled for elective surgeries under subarachnoid block were included for the study. Pregnant females and patients with spinal deformity, obesity, bleeding diathesis and history of spine surgery were excluded from the study.

Demographic details of the patients were recorded in a pre-designed proforma. On the day of surgery, preloading was done after securing intravenous access. Prior to performing the subarachnoid block, ultrasound of the lumbar spine was performed using a Sonosite curved 2-5 Hz array probe by a qualified anesthesiologist. The L3-L4 interspace was identified and then the probe was manipulated to get the view (Fig. 1) of the ligamentum flavum and duramater complex. The distance from skin to this complex was measured using the inbuilt caliper and this gave the skin to subarachnoid space depth. Then, under all septic

Figure 1. **Measurement of Ultrasound-estimated SSD (SSD: Skin to subarachnoid space depth; SK: skin; PC: posterior complex; AC: anterior complex; VB: vertebral body; SAS: subarachnoid space)**

precaution, subarachnoid block was performed using a 25G Whitacre spinal needle. After free flow of CSF, the length of needle outside the skin was measured and this was subtracted from the standard length of the spinal needle which gave the length of spinal needle inserted. Both the lengths were recorded in the proforma. The primary outcome was estimation of the skin to subarachnoid space depth using ultrasound and correlation with inserted length of spinal needle.

Collected data were entered in and analyzed using statistical software IBM-SPSS (Statistical Package for Social Sciences) version 20.0. Analyzed data were presented as mean ± standard deviation for continuous variables and as numbers and percentages for categorical variables. Student's t-test was applied for continuous variables like age, weight, BMI and distance from skin to subarachnoid space using inserted length of needle and by using ultrasound. Paired t-test was used to measure the difference between ultrasound estimated SSD and the inserted length of needle. Pearson's correlation was used to show the association between the inserted length of spinal needle and the ultrasound estimated SSD. Bland Altman analysis was done to assess the limit of association between ultrasound estimated SSD and inserted length of spinal needle. Analyzed data was presented in the form of tables, graphs and charts. The P-value of less than 0.05 was considered significant.

RESULTS

A total of fifty patients who were scheduled for elective surgeries under spinal anaesthesia were enrolled in the study. The mean age of the study population were 41.67 ± 17.22 years. Similarly, mean BMI was 23.80 ± 5.91 kg/m^2. The demographic details of the study population were presented in tabulated form (Table 1).

The mean ultrasound estimated SSD was found to be 4.25 ± 0.48 cm (95% CI, 4.4126 to 4.0813). The SSD in males was 4.34 ± 0.44 cm and that in females was 3.89 ± 0.51 cm. This difference in estimated values in males and females was found to be statistically significant (p-value of 0.020).

Table 1. Demographic data of the patients

Patient characteristics	(Mean ± SD) (N=50)
Age (yrs.)	41.67 ± 17.22
Weight (kg)	58.30 ± 9.94
Height (cm)	158.14 ± 13.86
BMI (kg/m^2)	23.80 ± 5.91

Table 2. Ultrasound estimated SSD

SSD (N=50)	Mean ± SD	P-value
Male (N=28)	4.34 ± 0.44 cm	< 0.05*
Female (N=22)	3.89 ± 0.51 cm	

*Independent samples t-test

The inserted length of spinal needle was measured which was found to 4.24 ± 0.46 cm (95% CI, 4.4007 to 4.0882). The inserted length of spinal needle in males was 4.33 ± 0.41 while 3.92 ± 0.49 cm in females and this difference was statistically significant (p-value 0.022).

Table 3. Inserted length of spinal needle

SSD (N=50)	Mean ± SD	P-value
Male (N=28)	4.33 ± 0.41 cm	<0.05*
Female (N=22)	3.92 ±0.49 cm	

*Independent samples

The dotted line in figure 3 is the regression analysis showing the ultrasound estimated SSD versus inserted length of spinal needle. The equation for the line of best fit is inserted length of needle = 0.4 + 0.91 X (Ultrasound estimated SSD).

Table 4. Ultrasound estimated SSD and inserted length of spinal needle

	Ultrasound estimated SSD (cm) (Mean ± SD)	Inserted length of spinal needle (cm) (Mean ± SD)	P-value	Correlation coefficient (r)
SSD in overall population	4.25 ± 0.49	4.24 ± 0.46	0.914**	0.960*

*Pearson's correlation
**Paired t-test

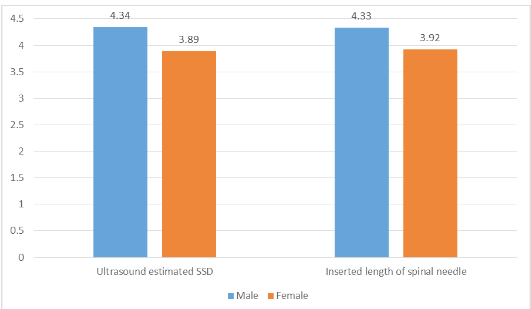

Figure 2. Ultrasound estimated SSD and inserted length of spinal needle in males and females

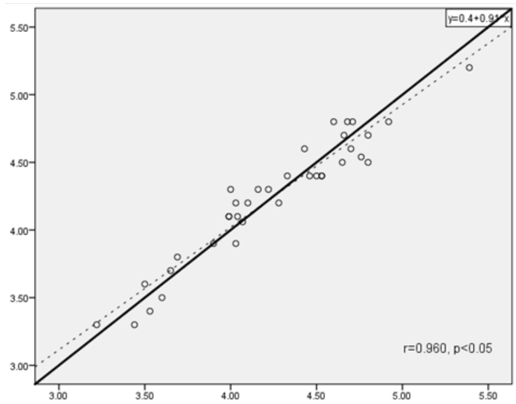

Figure 3. Scatter plot showing correlation between ultrasound estimated SSD and inserted length of spinal needle in the study population

Bland Altman analysis was also done which plotted the difference between the inserted length of needle and ultrasound estimated SSD against the mean of those two values. This analysis showed agreement between the two values with linear regression analysis revealing no any proportional bias (p=0.234). The mean difference (bias) was 0.0025 cm (95% CI 0.049 to -.0440). The limits of agreement were -0.26 cm to 0.27 cm.

DISCUSSION

Subarachnoid block is a commonly used regional anesthesia technique and correct identification of intervertebral space is very essential. An imaginary line connecting both iliac crests posteriorly, called Tuffier's line is used as an anatomical landmark which is believed to pass through the L4 vertebral body.[12-15]

The use of ultrasound has become a subject of interest worldwide for anesthesiologists but its use has been confined only to patients with difficult identification of the intervertebral spaces due to obesity, spinal deformity or previous spinal surgeries.[16] Recently, ultrasound has been proposed as a pre-operative assessment tool for predicting the feasibility of neuraxial blockade which has shown improved rate of block success, improved the quality of anesthesia and has led to better patient satisfaction.[17] A conventional spinal needle may be too long for a lean patient while may fall short in an obese patient resulting in multiple punctures, unsuccessful attempts leading to increased patient discomfort.[18] An estimation of skin to subarachnoid space depth prior to lumbar puncture will help in selection of appropriate length of spinal needle and further reduce the risk of traumatic or bloody puncture and decrease unsuccessful and repeated attempts. So, pre-puncture estimation of the SSD may be a good guide for accurate spinal needle placement.

Multiple studies done in the Western population have shown the efficacy of ultrasound in accurate estimation of skin to epidural space depth but such studies for spinal anesthesia are limited.[19-22] No such studies have been documented yet in Nepalese population. This study, with the estimation of skin to subarachnoid space depth and correlation with inserted length of spinal needle, gives a window into the SSD in our population.

In this study, the mean ultrasound estimated SSD was found to be 4.25 ± 0.48 cm (95% CI, 4.4126 to 4.0813). Gnaho et al. found the ultrasound estimated SSD to be 5.15 ± 0.95 cm.[12] Similarly, the utility of ultrasound for lumbar puncture and observed the SSD using ultrasound was assessed by Ferre et al. and they found SSD to be 5.22 ± 1.2 cm (95% CI 4.82 to 5.61).[23] The finding of this study was less as compared to the above studies done in Western population which might be because of the anthropometric differences among the study populations. Also, Tyagi et al. found the ultrasound estimated SSD to be 4.1 ± 0.1 cm which was almost similar to this study.[24] The similar findings might be attributed to almost comparable built among the study populations. The mean SSD using the inserted length of spinal needle in this study population was found to be 4.24 ± 0.49 cm. Similar findings were seen in studies done by Prakash et al. (4.71 ± 0.70 cm).[10] Hazarika et al. in their study, found SSD based on inserted length of spinal needle to be 4.37 ± 0.39 cm.[11] Similarly, Tyagi et al. found SSD based on inserted length of needle to be 4.2 ± 0.1 cm in their study.[24] These findings were comparable with the present study and the similarities might be most likely due to almost similar anthropometric distribution among the study populations.

Based on the findings of this study, the ultrasound estimated SSD was 4.25 ± 0.48 cm and the inserted length of spinal needle was 4.24 ± 0.46 cm. This difference between the two measured values was not statistically significant (95% CI 0.04897 to -0.04397, p=0.914). Meanwhile, the two measured values were strongly correlated with correlation coefficient of 0.960 (95% CI 0.93 to 0.98) which was statistically significant ($p < 0.05$). Similarly, Gnaho et al. in their study reported that estimation of SSD using ultrasound was accurate with a positive correlation of 0.982 with the needle depth ($p < 0.05$).[12] Likewise, Ferre et al. found a positive correlation of 0.803 (p=0.000) between the two measured values.[23] Tyagi et al. also demonstrated statistically significant correlation between the ultrasound estimated SSD and the actual SSD measured using the length of the needle inserted.[24] Similarly, Suttagati et al. found the ultrasound estimated SSD to be significantly correlated with length of spinal needle inserted which was shown by a very narrow limits of agreement on Bland Altman analysis (-0.70 to 0.09).[25] The findings of all these studies support the results of the present study thereby, highlighting the use of pre-procedural ultrasound in correct prediction of length of spinal needle to be inserted during subarachnoid block.

The limitation of the study was taking into consideration only the midline approach for the subarachnoid block, so the findings may not be valid for other approaches like paramedian. Similarly, the angle of insertion of spinal needle was not measured thereby relying on visual impression of needle being perpendicular to the skin which may not be always accurate.

CONCLUSION

Based on this study conducted among fifty ASA I and II patients scheduled for elective surgeries under subarachnoid block, the ultrasound estimated skin to subarachnoid space depth (SSD) was found to be 4.25 ± 0.48 cm which strongly correlated with inserted length of spinal needle. Therefore, pre-procedural estimation of skin to subarachnoid space depth using ultrasound correctly predicts the length of spinal needle to be inserted while performing a subarachnoid block.

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