Original Article

Assessment of variation in depth of brachial plexus using ultrasound for supraclavicular brachial plexus block in patients undergoing elective upper limb surgery

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ABSTRACT

Background and Aims: Supraclavicular approach to the brachial plexus may be associated with complications such as pneumothorax, inadvertent vascular puncture, inter-scalene block and neurovascular injuries. The present study was conceived to find out the variation in depth of brachial plexus to suggest the minimum length of needle required to effectively perform the block, thus preventing possible complications. **Methods:** After approval from our Institutional Ethical Committee, informed and written consent was obtained from each of the ninety American Society of Anesthesiologists Physical Status I and II patients recruited, of either sex in the age group of 20–50 years. Supraclavicular fossa was scanned using a high-frequency linear probe, and the distances (shortest distance [SD] from skin to the most superficial neural element and longest distance [LD] from skin to the most deep neural element) were measured using on-screen callipers on optimal frozen image. Pearson correlation was used to find out the relation between these two distances and demographic parameters. **Results:** Mean SD was 0.60 ± 0.262 cm, and mean LD was found to be 1.34 ± 0.385 cm. We observed significant correlation between these two distances with weight and body mass index (BMI). **Conclusion:** Significant correlation was observed between SD and LD with weight and BMI. We suggest that a needle with a shaft length of 3 cm will be sufficient to reach the sheath of the brachial plexus during performance of the block.

Key words: Brachial plexus, depth, supraclavicular block, ultrasound

INTRODUCTION

Regional anaesthesia has been coming and going since 1885[1] for surgeries on parts of the body where general anaesthesia is not mandatory and/or perilous to the patient. With the application of ultrasound to regional blocks, there is resurgence of regional anaesthesia which can now be administered more precisely with lesser doses of local anaesthetics, more successfully and safely. Ultrasound guidance is emerging as the gold standard for regional anaesthesia.[2] Due to the cost factor and other constraints, not everyone has access to an ultrasonography (USG) machine. Hence, sound knowledge of anatomy including approximate depth of nerve would be beneficial to avoid unnecessary complications, especially for those who are still performing regional blocks using the conventional landmark or peripheral nerve stimulator (PNS)-guided techniques.

The brachial plexus block is the most popular regional block for surgeries of the upper limb by various approaches. Supraclavicular approach is the most favoured, fulfilling all surgical requirements with the

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potential disadvantages of accidental pneumothorax, inadvertent vascular puncture, inter-scalene block and neurological complications. The incidence of pneumothorax without USG monitoring is 6.1%, whereas with USG guidance, it comes down to 0.06%.[3] We hypothesised that to avoid this complication, the variation in depth of brachial plexus could be estimated to guide the needle advancement during the procedure.

Recently, USG predictors of corner pocket depth have been studied for USG-guided supraclavicular block in Indian population.[4] However, to the best of our knowledge, there was no study where the variability of depth of the neural elements of brachial plexus in supraclavicular area had been assessed with ultrasound in Indian population. Hence, this study was conceived to give some approximation of the depth of the brachial plexus from the skin.

METHODS

This cross-sectional study was conducted from April 2015 to June 2015 after approval from our Institutional Ethical Committee. The patients of either sex in the age group of 20–50 years with American Society of Anesthesiologists Physical Status I and II were included in our study. Patients not willing to participate in the study, patients with any pathology, deformity or any history of the previous surgical intervention of the supraclavicular area were excluded from the study. Pregnant patients were also excluded from our study.

The sample size was calculated based on a pilot study on ten patients with the formula[5] for cross-sectional study with the quantitative variable. Considering 5% type-1 error ($P < 0.05$), 0.1 cm as the absolute error or precision and 0.405 cm as standard deviation of variable (longest distance [LD]) from the pilot study, minimum 63 subjects were required. Considering the potential drop-outs, 90 patients were included in our study.

After thorough pre-anaesthetic check-up, patients satisfying the inclusion criteria were selected. Written informed consent was taken from each of the ninety enrolled patients for participation in the study. In the operation theatre, the patient was positioned supine with pillow between the shoulder blades and head was turned to contralateral side and arm adducted by the side of the body. Brachial plexus was scanned with a high-frequency linear probe (8–13 MHz) of the USG machine (M-Turbo®, MicroMaxx, FujiFilm SonoSite Inc., USA) in supraclavicular fossa. The footprint of the probe was placed lateral to the clavicular head of the sternocleidomastoid muscle in a coronal oblique plane with 60° angle with the horizontal plane [Figure 1].

Once an optimal image was obtained, the brachial plexus (usually appearing as bundle of hypoechoic round nodules or bunch of grapes) was kept in the middle of the screen and the image was frozen. The measurements were taken by on-screen calliper.

The following two distances were measured: SD, distance from skin to the most superficial hypoechoic nodule/neural element [Figure 2a] and LD, distance from skin to the deepest hypoechoic nodule/neural element [Figure 2b].

The demographic parameters and the distances (in centimetres) were expressed as mean ± Standard Deviation. Pearson correlation was used to calculate the strength and significance of the relation between SD and LD from skin to the brachial plexus with the demographic parameters such as height, weight and body mass index (BMI). P value of <0.05 was considered as statistically significant and <0.001 was considered as statistically highly significant.

RESULTS

Sonographic assessment and analysis were done in 87 patients, out of which 69 patients were male and 18 patients were female. Three patients did not co-operate during the procedure. Hence, they were excluded from the final analysis. The mean age, weight, height and BMI of the study population are given in Table 1.

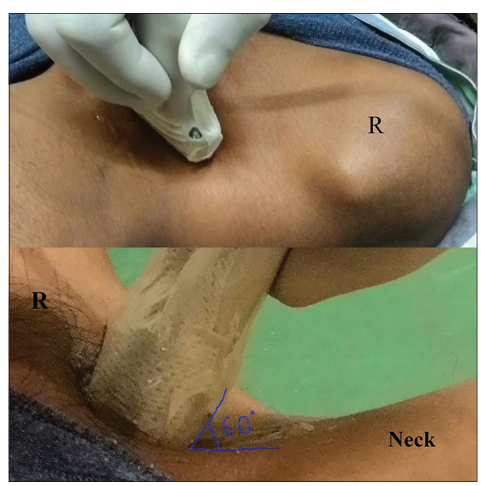

Figure 1: Position of ultrasonography probe on right supraclavicular fossa (R)

The mean SD was 0.60 ± 0.262 cm (minimum 0.21 cm, maximum 1.0 cm) and mean LD was 1.34 ± 0.385 cm (minimum 0.72 cm, maximum 2.14 cm).

The demographic profile parameters and depth measurements according to gender are presented in Table 2. The mean BMI for female (23.99 ± 2.682 kg/m²) was significantly higher than male (22.54 ± 2.464 kg/m²) ($P < 0.05$).

The distribution of population according to the range of depths is displayed in Table 3.

The strength of correlation between these two measured distances and different demographic variables was calculated. We found significant correlation between weight, BMI and SD ($P < 0.00001$) [Table 1]. Similarly, we also found significant correlation between LD and weight as well as BMI ($P < 0.00001$) [Table 1]. The statistically significant correlations are plotted in the graphs [Figures 3-6]. We did not find any statistically significant correlation between age, height and the two distances.

Table 1: Demographic variables and its correlations with the depths of brachial plexus

Variables	Mean±Std.D	SD		LD	
		r	*P*	*R*	*P*
Age (year)	30.13±7.315	0.088056	0.417646	0.1302	0.22937
Weight (kg)	62.31±6.942	0.784315	<0.00001	0.851709	<0.00001
Height (m)	1.65±0.068	0.141616	0.190786	0.189518	0.078758
BMI (kg/m²)	22.90±2.725	0.617739	<0.00001	0.65804	<0.00001

Std.D – Standard deviation; SD – Shortest distance; *r* – Pearson coefficient or correlation coefficient; LD – Longest distance; BMI – Body mass index

Table 2: Analysis of data with regards to gender

Variables	Male (*n*=69), (mean±Std.D)	Female (*n*=18), (mean±Std.D)	*P*
Weight (kg)	61.88±6.871	63.84±7.167	0.288
Height (m)	1.66±0.066	1.63±0.071	0.094
BMI (kg/m²)	22.54±2.464	23.99±2.682	0.032
SD (cm)	0.60±0.260	0.64±0.273	0.567
LD (cm)	1.34±0.377	1.40±0.424	0.559

Std.D – Standard deviation; SD – Shortest distance; BMI – Body mass index; LD – Longest distance

Table 3: Distribution of patients according to shortest distance and longest distance

SD (cm)	*n* (%)	LD (cm)	*n* (%)
<0.4	14 (16.09)	<0.9	5 (5.74)
0.4-0.8	58 (66.67)	0.9-1.5	60 (68.96)
>0.8	15 (17.24)	>1.5	22 (25.3)

n (%) – Number of patients (percentage). SD – Shortest distance; LD – Longest distance

DISCUSSION

In our study, we observed that the difference between mean LD and mean SD was 0.74 cm. In majority of the patients, the range of SD and LD were 0.4–0.8 cm and

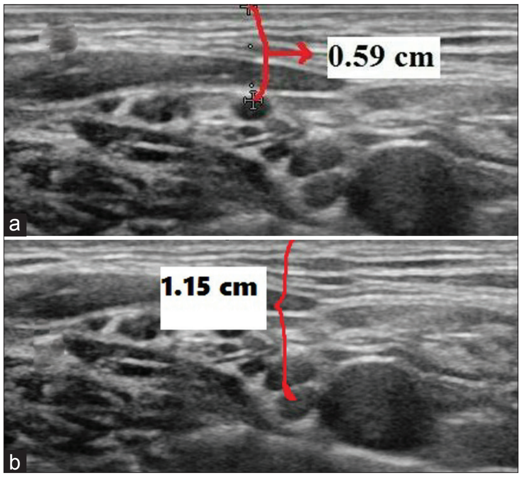

Figure 2: (a) Shortest distance = distance from skin to the most superficial hypoechoic nodule/neural element. (b) Longest distance = distance from skin to the deepest hypoechoic nodule/neural element

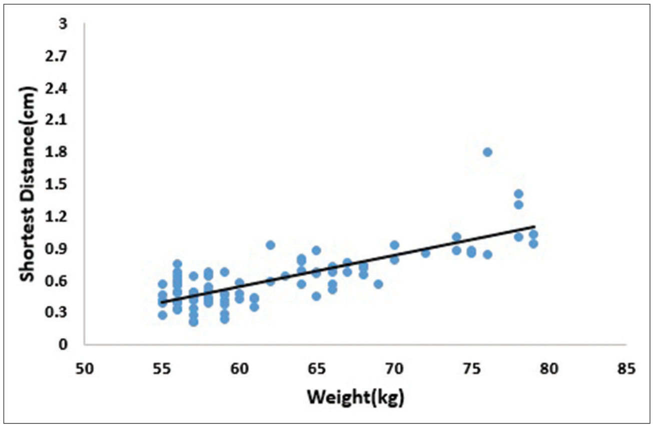

Figure 3: Distribution of shortest distance with weight

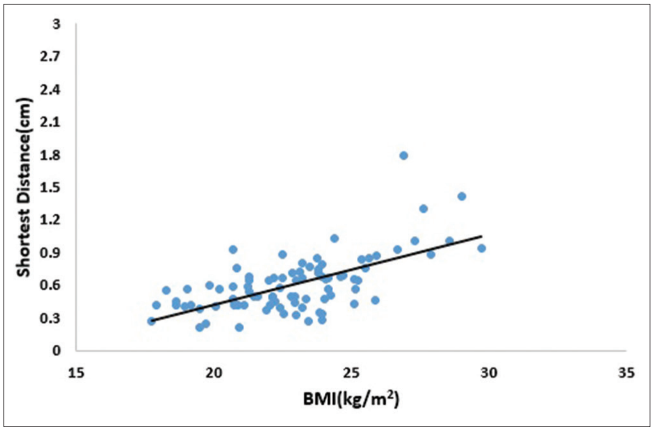

Figure 4: Distribution of shortest distance with body mass index

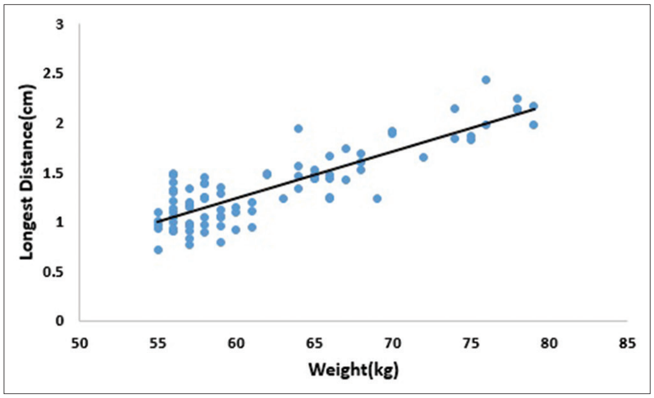

Figure 5: Distribution of longest distance with weight

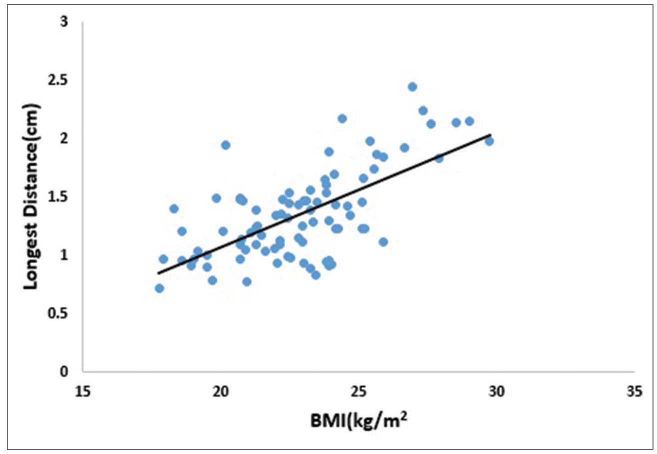

Figure 6: Distribution of longest distance with body mass index

0.9–1.5 cm, respectively. There were no statistically significant correlations between age, height and depth of brachial plexus ($P > 0.05$). Significant correlation was observed between the depths (SD as well as LD) and weight and BMI ($P < 0.0001$).

An anatomic study on cadavers was performed by Apan *et al*. and the results were correlated with a surface landmark-based technique later, using ultrasound and magnetic resonance imaging on healthy volunteers.[6] The mean distances between skin and superficial lying part of the brachial plexus were found to be 16.5 ± 0.7 mm in male and 14.5 ± 0.5 mm in female volunteers, which are longer than the SD we have observed in our study. This dissimilarity might be due to the difference in the surface landmark, the ethnicity of the study population and the demographic profile between the two studies.

In a study on 15 healthy volunteers, the high-resolution ultrasound probe was used to scan the supraclavicular region in coronal oblique plane.[7] The mean skin-to-nerve distance was found to be 0.9 ± 0.3 cm. In another study on 20 healthy volunteers, sonographic assessment revealed that the brachial plexus is relatively superficial in supraclavicular region with a depth of 1–2 cm.[8] However, the distance between the skin and the superficial and deep neural element was not measured separately. Moreover, all these studies were done in Western population and the findings may not be applicable to the Indian population.

The deposition of drug at the corner pocket is practised by some sonography users for ultrasound-guided supraclavicular brachial plexus block.[9] Significant correlations have been observed between weight, BMI and the depth of corner pocket in a study on Indian population.[4] We also found significant correlation between the weight, BMI and SD and LD between skin and the neural element.

Supraclavicular brachial plexus block is effective but may sometimes be complicated by pneumothorax because of needle advancement beyond the plexus and injury to pleura. Pre-procedural scan and measurement of the depth would be beneficial for selection of the needle size as well as advancement of needle during ultrasound-guided brachial plexus block.

We suggest that use of needle with 3 cm shaft would be sufficient to reach the sheath of the brachial plexus and proximal to the neural elements during performance of the block in patients with weight and BMI ranging from 55 to 79 kg and 17.75 to 28.54 kg/m^2, respectively.

Our study population did not have older (>50 years) or obese (BMI > 30 kg/m^2) patients. We studied the variation in depth on 87 patients only. A study on larger number is needed to derive a formula that can predict the depth of neural element based on weight and/or BMI. Additionally, measurement of neck circumference would probably be helpful in predicting the depth of brachial plexus and needle size to be used.

CONCLUSION

The difference between the most superficial and deep neural elements of brachial plexus was <1 cm. If brachial plexus is not encountered within 1 cm from skin during conventional or PNS-guided technique, it is advisable to be cautious before further advancement of the needle tip. A significant correlation exists between weight and BMI and the depth of brachial plexus.

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Conflicts of interest

There are no conflicts of interest.

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