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Original Research Article

ASSESSING THE VARIATION IN DEPTH OF BRACHIAL PLEXUS USING ULTRASOUND IN PATIENTS UNDERGOING UPPER LIMB SURGERY UNDER SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK

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Abstract

Purpose: The purpose of the study was to assess the variation in depth of the brachial plexus using ultrasound among patients undergoing upper limb surgery under an ultrasound-guided supraclavicular brachial plexus block. The secondary objective of this study was to find out the correlation between the depth of insertion of the needle in the supraclavicular brachial plexus block and factors like age, sex, height, weight, and BMI.

Methodology: In this cross-sectional study, the supraclavicular fossa of 100 patients with ASA status I and II, aged 20–60 years, of either gender and posted for upper limb surgeries under supraclavicular block at a tertiary care centre were scanned using a high-frequency linear probe of an ultrasound machine. An optimal image, including the subclavian artery and nerve bundles, was obtained. The shortest distance (SD) from skin to the most superficial neural element and the longest distance (LD) from skin to the deepest neural element were measured. Pearson's correlation was used to calculate the strength and significance of the relation between SD and LD from the skin to the brachial plexus and variables like age, weight, height, and BMI. For variation in SD and LD with gender, the t test was used. Analysis was done using SPSS 20.0.

Results: In this study, the mean shortest distance was 0.6± 0.2 cm and the mean longest distance was 1.5 ± 0.3 cm. The mean SD in males was 0.54 ± 0.16 cm, which was significantly lower than 0.76 ± 0.19 cm in females ($p< 0.01$).The mean LD in males was 1.34 ± 0.28 cm, which was significantly lower than 1.64 ± 0.32 cm in females ($p<0.01$). There was a significant positive correlation between SD and weight as well as BMI ($p<0.01$). There was a significant positive correlation between LD and weight and BMI ($p < 0.01$); There was a significant negative correlation between SD as well as LD with height ($p<0.01$). There was no correlation of age with SD and LD

Conclusion: The brachial plexus should be encountered somewhere between 0.6-1.5 **cm.** Extra caution has to be applied if the brachial plexus is not encountered within 1 cm from the skin. In females, the plexus might be slightly deeper compared to males.

Keywords: Brachial plexus; Longest Distance, Shortest Distance; Supraclavicular; Ultrasonography.

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Introduction

Supraclavicular brachial plexus block is now emerging as a popular regional anaesthetic technique for surgeries of the upper limb below the shoulder because of its advantages like quick onset, high success rate, and low hemodynamic complications (1, 2). It can be performed as a blind nerve block by conventional technique, using a peripheral nerve stimulator, or using ultrasound. With the advent of ultrasound, better visualisation of the structures helps to avoid complications and increases the success rate of nerve blocks.

The major disadvantages of supraclavicular brachial plexus block are the high incidence of complications such as pneumothorax, inadvertent vascular injections, phrenic nerve palsy, and Horner's syndrome. The incidence of pneumothorax without ultrasound monitoring is 6.1%, whereas with ultrasound, it comes down to 0.06% (3). While attempting blocks, knowledge about the maximum depth to which the needle can be inserted is crucial to avoid complications. Also, the minimum distance of needle insertion is important for obtaining a successful nerve block. The variation of these two distances in relation to age, sex, height, weight, and BMI will give an idea of the length of needle to be inserted to deliver the drug and block the nerve successfully without any complications.

The superficial location of the brachial plexus in the supraclavicular area makes it possible to obtain an accurate view of the target structures (including the subclavian artery, first rib, pleura, and the divisions of the plexus). The nerve bundles of the brachial plexus are situated close to each other here (cluster of grapes / hourglass phenomenon) (4). The area of anaesthesia is therefore typically extensive and hence called the " spinal of the upper extremity" (5). Exploration of the brachial plexus requires a high-frequency probe, generally between 10 and 18 MHz (6). Normally the roots, trunks and cords appear as homogeneous, hypoechoic structures. They appear oval in axial slices, as hypoechoic bundles embedded in hyperechoic supporting connective tissue, and surrounded by the hyperechoic epineurium (7).

Recently, ultrasound predictors of corner pocket depth have been studied for USG-guided supraclavicular blocks in the Indian population (8). There is a lack of sufficient studies that assess the variability of the depth of the neural elements of the brachial plexus in the supraclavicular area with ultrasound in the Indian population. So, this study is done to give information about the depth of the brachial plexus from the skin, knowledge of which helps in improving the success rate and reducing the complication rates.

The primary objective of the study was to assess the variation in depth of the brachial plexus using ultrasound among patients undergoing upper limb surgery under an ultrasound-guided supraclavicular brachial plexus block. The secondary objective of this study was to find out the correlation between the depth of insertion of the needle in the supraclavicular brachial plexus block and factors like age, sex, height, weight, and BMI.

Materials and methods

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Study Design: It was a cross-sectional study.
***Study Setting*:** Major elective and emergency operation theatres at GMC, Thiruvananthapuram.
***Study Population*:** Patients undergoing upper limb surgery under an ultrasound-guided supraclavicular brachial plexus block
***Study Subjects*:** Patients posted at the elective and emergency operation theatres for upper limb surgery under ultrasound guided supraclavicular brachial plexus block satisfying inclusion and exclusion criteria

Selection Criteria

Inclusion Criteria

- Patients belonging to American Society of Anaesthesiologists Physical Status (ASA-PS) Classes I and II
- Patients within the age group of 20 to 60 years

Exclusion Criteria

- Patients with any neurological deficit in the upper limb or lung pathology like COPD or pneumothorax
- Patients with any deformity or local infection in the supraclavicular area
- Patients on anticoagulant therapy or bleeding disorders
- Patients are not willing to participate in the study.

Sampling Technique

All cases meeting the eligibility criteria will be included in the study.

Sample Size

Sample size is calculated using the formula

$$N = \frac{Z\infty^2 \times Sd^2}{d^2}$$

According to the study by Mistry T et al titled "Assessment of variation in depth of brachial plexus using ultrasound for supraclavicular brachial plexus block in patients undergoing elective upper limb surgery" (9)

Sd of longest distance = 0.385 is taken for calculating sample size. Substituting this value in the equation

$$N = \frac{(1.96)^2 \times (0.385)^2}{(0.077)^2}$$

N = Sample size $Z\infty$= 1.96 (at 95% confidence interval)
Sd =0.385, d = allowable error = 20% of Mean = 0.077
Hence sample size is taken as 100.

Variables studied

LD: The longest distance from the skin to the deepest hypoechoic nodule or neural element of the brachial plexus.

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SD is the shortest distance from the skin to the hypoechoic nodule or neural element that is closest to the skin.
Other variables collected were age, sex, height, weight, and BMI.

Study Procedure

After getting approval for the study from the institution's Research Methodology and Ethics Committee, 100 patients with ASA status I or II and ages 20–60 years who were scheduled for upper limb surgeries under supraclavicular brachial plexus block were included in the study. Patients were selected as per the inclusion and exclusion criteria. A valid written consent was obtained from each patient. After a thorough pre-anaesthetic evaluation, age, gender, height, weight, and BMI were noted.

In the operating room, the patient was positioned supine and monitors were attached. The patient was then positioned with a pillow between the shoulder blades, with the head turned to the opposite side and the arm adducted to the side. The consultant scans the brachial plexus using a Sonoscape S8 Exp/ S7/ S9 Pro/ SSI-980 portable digital colour doppler ultrasound machine. The depth of the USG machine was set at 4cm for all patients. A high-frequency linear probe is used. The transducer is positioned in the transverse plane immediately superior to the clavicle at approximately its midpoint. The footprint of the probe was placed lateral to the clavicular head of the sternocleidomastoid muscle in the supraclavicular fossa in a coronal oblique plane with a 60 degree angle to the horizontal plane. Then a cross-sectional view of the subclavian artery was obtained. The brachial plexus was seen as a collection of hypoechoic oval structures lateral and superficial to the artery. A midline was drawn perpendicularly on the screen of the ultrasound. Once an optimal image, which includes a pulsating, hypoechoic subclavian artery lying above the hyperechoic first rib, pleura, and nerve bundles of the brachial plexus (usually appearing as a bundle of hypoechoic round nodules or bunch of grapes) was simultaneously in view in the middle of the screen, the image was frozen. The measurements were taken with an onscreen caliper. The following two distances were measured:
SD –distance from skin to the mostsuperficial hypoechoic nodule/ neural element and
LD – distance from skin to the deepest hypoechoic nodule/neural element.

Fig 1: Position of ultrasonography probe on right supraclavicular fossa (R).(9)

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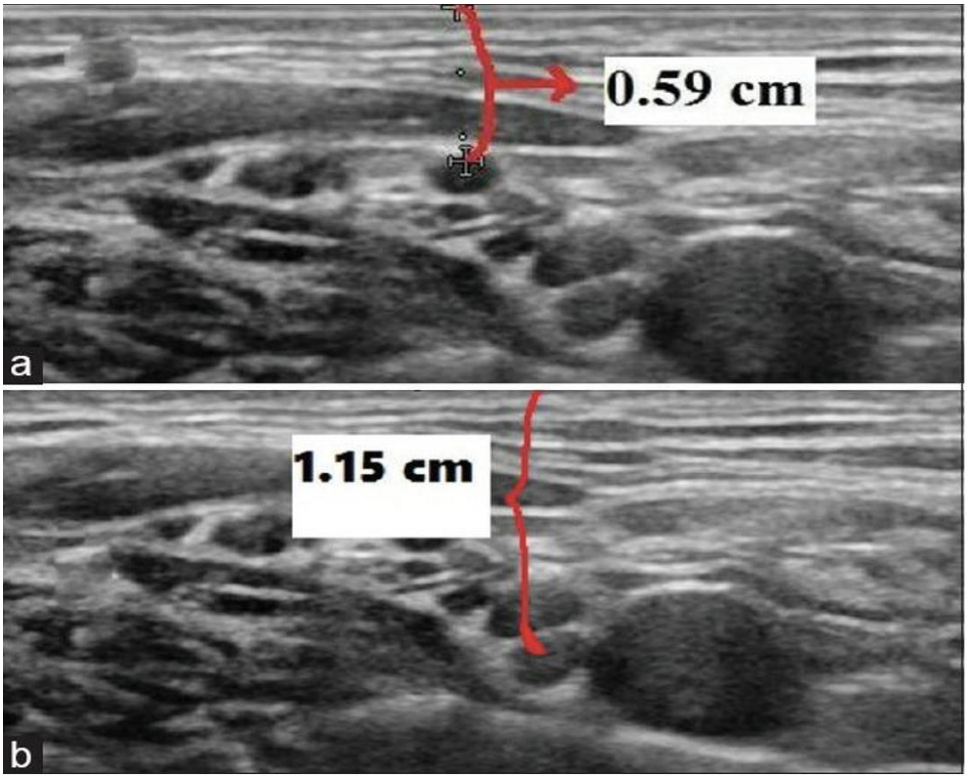

Fig 2: (a) Shortest distance = distance from skin to the most superficial hypoechoic nodule/neural element. (b) Longest distance = distance from skin to the deepest hypoechoic nodule/neural element.(9)

Material

- Ultrasound Machine: Sonoscape S8 Exp/S7/S9 Pro/SSI-980 portable digital colour Doppler.
- Ultrasound probe: High frequency linear transducer (8-14MHz)

Monitors

- Five lead ECG
- Pulse oximeter
- Noninvasive blood pressure

Statistical Analysis

Data was entered and analysed using appropriate statistical software. Quantitative variables were summarised as Mean and SD. Categorical variables summarised as proportions. Pearson's correlation was used to calculate the strength and significance of the relation between SD and LD from the skin to the brachial plexus and variables like age, weight, height, and BMI. For quantitative variables (SD and LD with gender), 't' test was used as a test of significance. p value of < 0.05 was considered statistically significant. Statistical analysis was performed using the statistical software package SPSS Version 20.0.

Results

This cross-sectional study was done on 100 patients, of whom 51 were males and 49 were females. The majority of the patients were in the age group of 31–40 years (32%), followed

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by 21–30 years (25%), 51–60 years (25%), and 41–50 years (18%), respectively. Mean±SD of age was 39.6 ± 11.7 years. (Table 1)

Table 1: Percentage distribution of the sample according to gender and age

Variable	Characteristics	Number	%
Gender	Male	51	51.0
	Female	49	49.0
Age	21 - 30	25	25.0
	31 - 40	32	32.0
	41 - 50	18	18.0
	51 - 60	25	25.0
	Mean ± SD 39.6 ± 11.7		

The mean height of the patients was 166.4 ± 8.8 cm (minimum 152 cm and maximum 182 cm). The mean weight of the patients was 72.6 ± 9.4 kg (minimum 52 and maximum 108 kg), and the mean BMI of the patients was 26.2 ± 2.8 (minimum 20.3 and maximum 32.6). (Table 2)

Table 2: Descriptive statistics for height, weight and BMI

Variables	Mean	SD	Median	Minimum	Maximum
Height	166.4	8.8	165.0	152.0	182.0
Weight	72.6	9.4	72.0	52.0	108.0
BMI	26.2	2.8	26.4	20.3	32.6

Males had a mean height of 173.7cm± 5.1, while females had a mean height of 158.9cm ± 4.5($t = 15.47$, $p < 0.01$). Males had a mean weight of 76.6 kg ± 9.2, while females had a mean weight of 68.4 kg ± 7.8. ($t = 4.83$, $p < 0.01$). Males had a mean BMI of 25.4 ±2.4, whereas females had a mean BMI of 27.1 ±2.9 ($t = 3.24$, $p = 0.002$). Males and females were shown to have statistically significant differences in their height, weight, and BMI. (Table 3)

Table 3: Comparison of selected variables based on gender

Variables	Male			Female			t	p
	Mean	Standard deviation	N	Mean	Standard deviation	N		
Height	173.7	5.1	51	158.9	4.5	49	15.47**	p<0.01
Weight	76.6	9.2	51	68.4	7.8	49	4.83 **	p<0.01
BMI	25.4	2.4	51	27.1	2.9	49	3.24**	0.002

The study population's mean shortest distance was 0.6±0.2 cm. The shortest distance was between 0.4 and 0.8 cm for 64% of the population. SD was greater than 0.8 cm in 22% of

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patients, whereas it was less than 0.4 cm in 14% of patients. The study group's mean longest distance was 1.5 ±0.3 cm. 61% of the study population had LD between 0.9 and 1.5 cm, whereas the remaining 39% had LD greater than 1.5 cm. (Table 4)

Table 4 Distribution of patients according to shortest distance and longest distance

Variable	Characteristics	Number	%
SD (cm)	<0.4	14	14.0
	0.4 - 0.8	64	64.0
	>0.8	22	22.0
	Mean ± SD	0.6 ± 0.2	
LD (cm)	0.9 - 1.5	61	61.0
	>1.5	39	39.0
	Mean ± SD	1.5 ± 0.3	

There was a statistically significant positive correlation between weight and BMI with SD ($p< 0.01$). There was a significant positive correlation between weight and BMI with LD ($p< 0.01$). There was a significant negative correlation between height and SD and also height and LD ($p < 0.01$). There was no statistically significant correlation between age and the two distances. (Table 5)

Table 5: Correlation Between Depth of Insertion of Needle in Supraclavicular Brachial Plexus Block and factors like Age, Height, Weight, and BMI

Variable	SD		LD	
	r	p	r	p
Age(year)	0.009	0.931	0.021	0.836
Height(cm)	-0.418	p<0.01	-0.366	p<0.01
Weight(kg)	0.329	p<0.01	0.326	p<0.01
BMI(kg/m^2)	0.828	p<0.01	0.775	p<0.01

The mean SD value in males was 0.54 ± 0.16 cm, while in females it was 0.76 ± 0.19 cm. There was a statistically significant difference between them ($t=5.96$, $p < 0.01$). The mean LD value in males was 1.34 ± 0.28 cm, while in females it was 1.64 ± 0.32 cm. The difference was statistically significant ($t = 4.94$, $p < 0.01$). (Table 6)

Table 6: Comparison of depth of insertion of needle in Supraclavicular brachial plexus block based on gender

Variables	Male			Female			t	p
	Mean	SD	N	Mean	SD	N		
SD (cm)	0.54	0.16	51	0.76	0.19	49	5.96	p<0.01
LD (cm)	1.34	0.28	51	1.64	0.32	49	4.94	p<0.01

Discussion

Ultrasonographic assessment was done on 100 subjects in the study. The shortest and longest distances to the brachial plexus were measured. Out of 100 subjects, 51 were males and 49 were females. 32% of patients were in the age group of 31–40. There were no geriatric (> 65

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years old) subjects in this study. The mean height of the population was 166.4 ± 8.8 cm (minimum of 152 and a maximum of 182). The mean weight was 72.6 ± 9.4 kg (with a low of 52 and a high of 108). The mean BMI was 26.2 ± 2.8 (minimum of 20.3 and a maximum of 32.6) The mean height of males was 173 ± 5.1 cm and that of females was 158.9 ± 4.5 cm, and the difference was statistically significant ($t = 15.47$, $p < 0.01$). The mean weight of males was 76.6 ± 9.2 kg, and that of females was 68.4 ± 7.8 kg. ($t = 4.83$, $p < 0.01$). The mean weight of males was significantly higher than that of females. The mean BMI of males was 25.4 ± 2.4, while in females it was 27.1 ± 2.9 ($t = 3.24$, $p = 0.002$), and the difference was significant.

The mean shortest distance in the population was 0.6 ± 0.2 cm. The majority of patients (64%) had the shortest distance between 0.4-0.8 cm, while 22% had more than 0.8 cm, and 14% had < 0.4 cm. The mean longest distance was 1.5 ± 0.3 cm. 61% had LD in the 0.9–1.5 cm range, while the remaining 39% had >1.5 cm. The difference between the mean SD and the mean LD was 0.9 cm. On further analysis based on sex, the mean SD in males was 0.54 ± 0.16 cm, which was significantly lower than 0.76 ± 0.19 cm in females ($p< 0.01$) .The mean LD in males was 1.34 ± 0.28 cm, which was significantly lower than 1.64 ± 0.32 cm in females ($p<0.01$).The strength of the correlation between SD, LD, and demographic variables was calculated. There was a significant positive correlation between SD and weight as well as BMI ($p<0.01$).

There was a significant positive correlation between LD, weight, and BMI ($p< 0.01$). However, there was a significant negative correlation between SD and height, as well as LD and height ($p<0.01$). There was no correlation between age and SD or LD. This was in contrast to the study by Mistry et al. (9) where they observed a correlation of SD and LD with weight and BMI. They observed no correlation of SD and LD with age or height. The mean SD in their study was 0.60 ± 0.262 cm (minimum 0.21 cm, maximum 1.0 cm), and the mean LD was 1.34 ± 0.385 cm (minimum 0.72 cm, maximum 2.14 cm). The SD and LD ranges for the majority of patients were 0.4–0.8 cm and 0.9–1.5 cm, respectively. The results were almost identical to the values in this study except for the mean LD, which was 1.5±0.2 cm in the current study compared to 1.34 ± 0.385 cm in the study by Mistry et al.

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 (10). The mean distances between the skin and the superficially 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 in this study. This difference might be attributed to the difference in the surface landmark, the ethnicity of the study population, and the demographic profile between the two studies.

In a study by Peralas et al. on 15 healthy volunteers, a high-resolution ultrasound probe was used to scan the supraclavicular region in the coronal oblique plane (11). The mean skin-to-nerve distance was found to be 0.9 ± 0.3 cm.

In another study by Royse et al. on 20 healthy volunteers, sonographic assessment revealed that the brachial plexus is relatively superficial in the supraclavicular region with a depth of 1–2 cm (12), but the distance between the skin and the superficial and deep neural elements was not measured separately. These studies were done in a Western population, and the findings may not be applicable to the Indian population.

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Yadav et al. (8) scanned the right-sided supraclavicular region of volunteers, and the depth of the corner pocket from the skin was measured (SD). Thereafter, the longest distance (LD) approximating the needle trajectory was calculated. A significant correlation was found between weights, BMI versus two lengths. In this study, too, there was a significant correlation between the distances, weight, and BMI.

Supraclavicular brachial plexus block is a very convenient and effective method of block for upper limb surgeries, but it can be complicated by pneumothorax due to needle advancement beyond the plexus and injury to the pleura. A preprocedural scan and measurement of the depth would be ideal for selection of the needle size and advancement of the needle during an ultrasound-guided brachial plexus block. Also, better knowledge of the average depth to be inserted helps in the provision of adequate blockage and the avoidance of complications like pneumothorax.

The study didn't include those less than 20 or more than 60 years of age. Variations in the depth of brachial plexus in the elderly cannot be predicted from this study. The study was done on 100 subjects; more are needed for a definite analysis. More people in the obese group have to be studied to assess whether the depth is increased in obese patients. Measurement of neck circumference and neck length can give additional information about the variation in the depth of the brachial plexus.

Conclusion

This study shows that the difference between the most superficial and deep neural elements of the brachial plexus when approached via the supraclavicular route was 0.9 cm. The brachial plexus should be encountered somewhere between 0.6 and 1.5 cm. Hence, the needle length should be ideally around 3 cm. Extra caution has to be applied if the brachial plexus is not encountered within 1 cm of the skin. In such cases, especially when using PNS or conventional technique, meticulous advancement of the needle or reassessment of landmarks is recommended. Ultrasound is always recommended over PNS or conventional techniques. In females, the brachial plexus might be slightly deeper compared to males. A significant positive correlation exists between weight and BMI and the depth of the brachial plexus, and a negative correlation exists between height and the depth of the brachial plexus.

Conflict of interest: Nil

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