



## Location of Needle Tips on Plexus Brachialis in Different Supraclavicular Block Techniques: A Cadaver Study

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**Objective:** The present study was performed on cadavers to evaluate the efficacy of the different supraclavicular block techniques (Vongvises, Dalens, plumb-bob and inter-SCM) by investigating the location of the needle tip on the brachial plexus and to determine the most suitable block techniques according to the site of the surgery.

**Methods:** The study was performed on one embalmed and nine fresh cadavers. After the dissection, the skin of the cadavers was restored in its original position. Then, they are positioned, and the needle was inserted according to the technique described by the authors in the original articles. The distances between the needle tip and the three trunks were measured, and the location of the needle tip on the brachial plexus was determined.

**Results:** A significant difference in the proximity of the needle tip to the middle of the middle truncus was noted only in the inter-SCM technique compared with the Dalens technique at both sides ( $p < 0.05$ ).

**Conclusion:** In our study, the distance between the needle tip and truncus medius was the shortest in the plumb-bob technique at both sides. Both in the plumb-bob and inter-SCM techniques, the distribution of the needle tip over the trunci of the plexus brachialis was homogenous. In Dalens technique, the needle tip reached the truncus superior or between the truncus superior and n. suprascapularis in 95% of the cases. Further, we concluded that moving the insertion point approximately 1 cm caudal and maintaining the anteroposterior needle direction in the Vongvises technique would result in a successful brachial plexus block.

**Keywords:** Plexus brachialis, supraclavicular block, needle tip location

### Introduction

Because of the risk of pneumothorax development, a supraclavicular block, which provides the blockade of the brachial plexus at the level of distal trunk/proximal divisions where the brachial plexus is most compact, is not widely applied despite its advantages, such as short duration of action and providing a full block in the entire limb (1-3). Various techniques of a supraclavicular block that have different levels and angles of needle penetration have been developed to reduce these complications. Additionally, a higher rate of success has been reported if the formation of paraesthesia is provided in the truncus medius in patients receiving a supraclavicular block (1,4). Because of the implementation of peripheral nerve blocks in the guidance of ultrasound, it has recently been possible to easily direct block needles towards the trunks together with simultaneous images without the need to identify anatomical cue points, and consequently, an increase in the rate of block success has been observed. However, as the ultrasound device may not be available in every practice setting, technical background is also required in using the apparatus.

In this study, which was performed on cadavers, the places that the needles reached on the brachial plexus consistent with four different supraclavicular block techniques were examined. Furthermore, the distance was recorded between the mid-point of the trunci and the needle tips.

### Methods

After Ethics Committee approval from Istanbul Forensic Medicine Institute was received, this study was performed on one male cadaver, which was determined fixed with 10% formalin and obtained from Ankara University, Anatomy Department

of Faculty of Medicine, and nine fresh adult cadavers (eight men and one woman) were obtained from Istanbul Forensic Medicine Institute. Measurements were made related to the demographic data of the cadavers (height, weight, distance between the processus mastoideus and incisura jugularis, clavicle length, and neck circumference) (Table 1). Neck circumference was measured at the level below the cartilage thyroidea. Dissection was performed on both the right and left sides in eight all, but two, cadavers. Dissection was performed only on the left side in the sixth patient and on the right side in the 10th patient. The pictures in the study were taken with a Nikon Coolpix P500 camera (Nikon Corporation, Shinagawa Intercity Tower C, 2-15-3, Konan, Minato-ku, Tokyo 108-6290, Japan).

A skin incision was made between the start and end points of the musculus sternocleidomastoideus (m. SCM) on the lateral edge of the muscle. The lateral edge of this muscle was followed, and the proc. coracoideus and sulcus deltoideopectoralis were reached through the upper edge of the clavicle. After the incision, the skin, fascia cervicalis superficialis, fascia cervicalis profunda and platysma were dissected respectively. Later, the adherence places of m. SCM on the sternum and clavicle and m. omohyoideus were made visible. The m. pectoralis major and m. pectoralis minor were cut and removed to make parts of the brachial plexus in the fossa infraclavicularis visible.

After the completion of dissection, the skin was returned to its previous condition, and the cadaver's head and arms were put in a suitable position consistent with the technique that was studied on it. Cue points necessary for the block were determined on the skin. After marking the insertion point on the skin, the brachial plexus was reached with a 22 G needle that was directed as described in the technique (Figure 1). In this way, four different supraclavicular block techniques [Vongvises (5), Dalens (6), Plumb-Bob (7) and Inter-SCM (8) block] were performed on each of the cadavers. In compliance with the techniques used in the study, the simulation related to the needle puncture site and direction in the skin is shown in Figure 2. The place where the needle tip met the brachial plexus, the distance of the needle tip to the midpoint of the superior, medius and inferior truncus and the distance between the needle trace and the place where the n. suprascapularis split from the truncus superior were measured and recorded. Whether the tip of the needle reached the medial side of the first rib was also recorded to detect the development of pneumothorax. These examinations were performed on two sides of each cadaver (on one side of the two cadavers).

**Statistical analysis**

The findings obtained in this study were assessed using Statistical Package for the Social Sciences version 22 (IBM SPSS, Statistics, Armonk, New York, USA) for the statistical analyses. Kruskal–Wallis one-way analysis of variance was used to evaluate the data, and the results were found at a 95% confidence lev-

Table 1. Evaluation of the demographic data of the patients (nine patients)

Demographic data	Average (Min–Max)
Height (cm)	170.22 (160.00–182.00)
Body weight (kg)	78.94 (55.00–110.00)
Body mass index	27.06 (20.20–33.21)
Age (years)	46.67 (30.00–70.00)
Proc. Mastoideus–Fossa jugularis (cm)	18.28 (16.00–20.00)
Neck circumference (cm)	41.10 (36.00–53.00)
Clavicle length (cm)	18.06 (15.50–22.00)

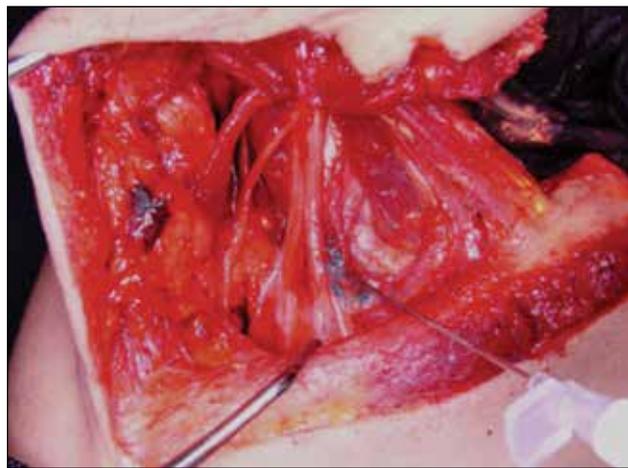


Figure 1. The place of the needle tip in the brachial plexus when the Plumb-Bob technique is applied (original)

el. The p-values for the differences are given under the relevant tables. Binary comparisons were made between the techniques for the detection of these significant differences in detail.

**Results**

When the results of the measurements made to determine the distance of the needle tip from the truncus superior were evaluated, a significant difference was not found on both sides among the techniques (Table 2). A significant difference was found between the techniques of Vongvises and Inter-SCM on the right side (p=0.032). A significant difference was found between the techniques of Dalens and Inter-SCM on the right side (p=0.033). On the left side, significant differences were detected between the Plumb-Bob and Vongvises techniques (p=0.036), between the Plumb-Bob and Dalens techniques (p=0.016) and between the Plumb-Bob and Inter-SCM techniques (p=0.039).

When the results of the measurements made to determine the distance of the needle tip from the truncus medius were evaluated, a significant difference was found both on the right and left sides between the techniques of Inter-SCM and Dalens (p=0.003 on the right; p=0.006 on the left) (Table 3).

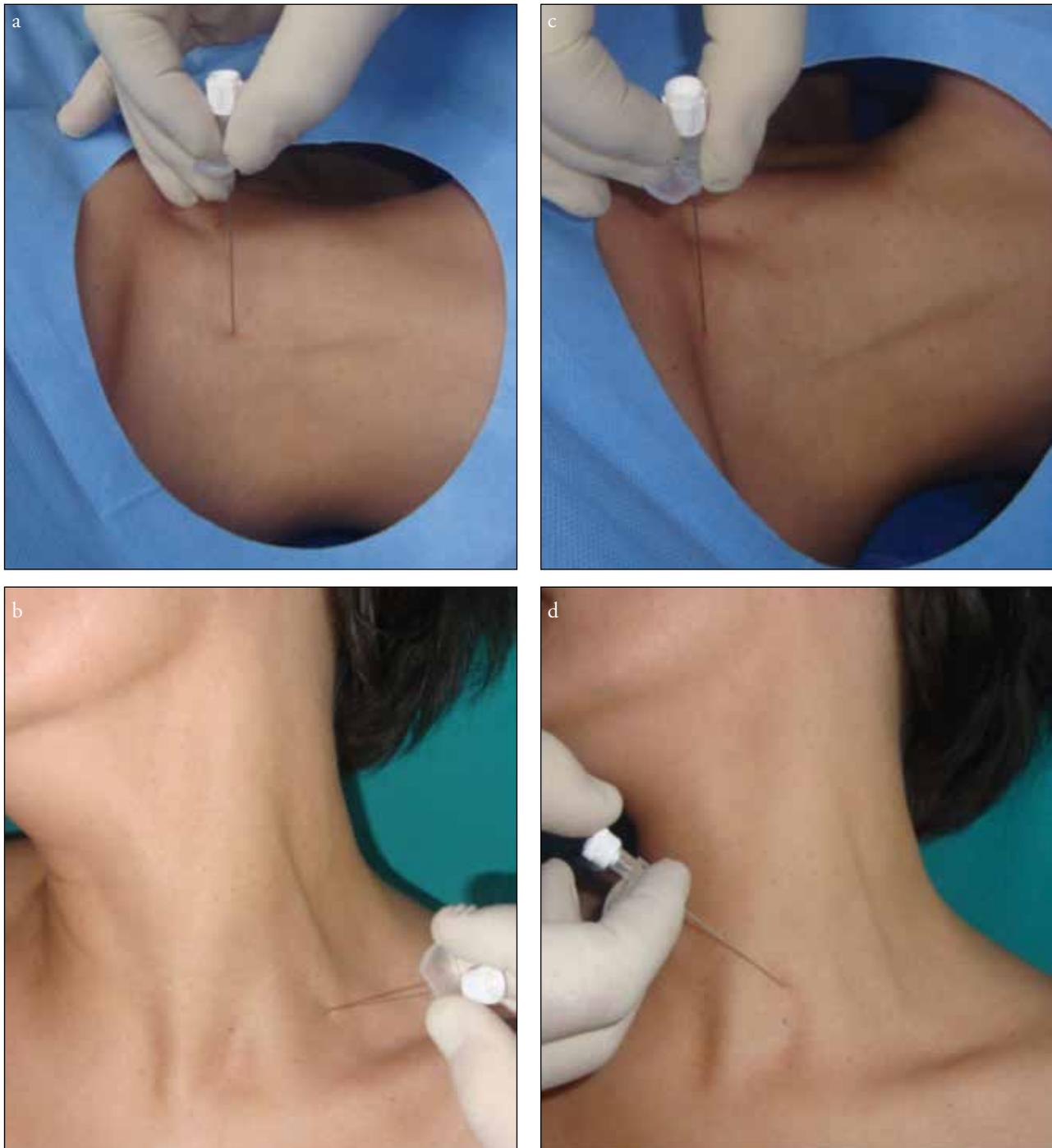


Figure 2. a-d. Supraclavicular block techniques: (a) Vongvises Block Technique. (b) Dalens Block Technique. (c) Plumb-Bob Block Technique. (d) Inter-SCM Block Technique

When the results of the measurements made to determine the distance of the needle tip from the truncus inferior were evaluated, a significant difference was found on both sides between the techniques of Dalens and Inter-SCM ( $p=0.000$  on the right;  $p=0.004$  on the left) (Table 4).

When the results of the measurements made to determine the distance of the trace of the needle from the place that n. suprascapularis split from, there was no significant difference between the techniques on the right. On the left side, there was a signif-

icant difference between the techniques of Dalens and Plumb-Bob ( $p=0.002$ ) and between those of Dalens and Vongvises ( $p=0.008$ ). There was no significant difference between the techniques of Plumb-Bob and Vongvises ( $p=0.495$ ) (Table 5).

There was no significant difference between the techniques of Dalens and Vongvises ( $p=0.119$ ) and between those of Vongvises and Plumb-Bob ( $p=0.094$ ) on the right side. A significant difference was found between the Dalens and Plumb-Bob techniques ( $p=0.027$ ).

Table 2. Distance of the needle tip to the truncus superior

Technique	Right average (mm)	Left average (mm)
	Mean (minimum–maximum) distance mm±SD	Mean (minimum–maximum) distance mm±SD
Dalens	3.18 (0.00–8.53)±2.36	4.80 (1.50–8.85)±2.21
Vongvises	4.46 (0.00–8.82)±3.19	5.00 (0.00–10.66)±3.75
Inter-SCM	7.05 (1.00–17.53)±4.91	6.87 (1.00–13.94)±3.91
Plumb-Bob	7.42 (0.00–24.03)±6.90	10.22 (2.39–20.89)±6.27

p=0.026. SD: standard deviation

Table 3. Distance of the needle tip to the truncus medius

Technique	Right average (mm)	Left average (mm)
	Mean (minimum–maximum) distance mm±SD	Mean (minimum–maximum) distance mm±SD
Inter-SCM	3.67 (0.00–11.46)±3.50	5.75 (3.10–9.91)±2.63
Plumb-Bob	5.61 (1.00–18.40)±5.10	6.47 (3.05–13.07)±3.18
Vongvises	6.24 (1.32–10.20)±2.67	9.32 (5.13–15.15)±4.10
Dalens	8.98 (4.58–15.52)±3.28	11.03 (3.48–18.70)±4.30

p=0.000. SD: standard deviation

Table 4. Distance of the needle tip to the truncus inferior

Technique	Right average (mm)	Left average (mm)
	Mean (minimum–maximum) distance mm±SD	Mean (minimum–maximum) distance mm±SD
Inter-SCM	7.10 (0.00–16.58)±4.55	9.91 (3.20–14.09)±3.47
Plumb-Bob	9.34 (0.00–21.18)±7.44	9.07 (0.00–15.46)±5.08
Vongvises	14.06 (3.81–27.40)±6.40	15.61 (0.00–23.50)±7.06
Dalens	15.34 (9.19–27.61)±5.41	15.46 (7.50–23.31)±4.97

p=0.000. SD: standard deviation

## Discussion

In the original and classical definition of the supraclavicular block technique (Kulenkampff, 1928) (9), the needle is moved in an oblique axis almost in parallel to the long axis of the patient's neck. In the subclavian perivascular technique developed by Winnie and Collins (10), insertion is done over a. subclavia, which is located in the inferior of the needle and interscalene interval and the needle is moved directly through the caudal direction. Lanza et al. (11) stated that although the levels of needle insertion on the skin are different in these techniques (in the C7 level in the Kulenkampff technique and in the C6 level in the subclavian perivascular technique of Winnie), the needle tips are in similar places.

It was suggested that supraclavicular blocks performed with the techniques of parascalene block (Vongvises and Panijayanond), 'modified' parascalene block (Dalens), 'Plumb-Bob' (Brown) and the Inter-SCM developed in the later

years have reduced the pneumothorax incidence (1). In the other three techniques, except for the Inter-SCM technique, although the directions of the needles (anteroposterior) are similar, there are differences in the places of the needle insertion into the skin. When compared with the parascalene block technique (Vongvises), the needle puncture site is located higher and in the lateral position in the modified paediatric parascalene technique of Dalens and lower in the Plumb-Bob technique of Brown (12). The anterior and tangential approach to the path that the brachial plexus follows constitutes the main difference in the Inter-SCM block technique (8).

Pneumothorax was not observed only in the Inter-SCM technique among the techniques we examined. It was determined that pneumothorax might develop due to the cupula pleura puncture in the block techniques of Plumb-Bob and Vongvises et al and due to the insertion through the 1st intercostal interval in the Dalens block technique. However,

Table 5. Distance of the needle trace to the place that n. suprascapularis splits from

Technique	Right average (mm)	Left average (mm)
	Mean (minimum–maximum) distance mm±SD	Mean (minimum–maximum) distance mm±SD
Dalens	9.07 (0.00–19.94)±7.40	8.94 (0.00–23.43)±9.72
Inter-SCM	12.59 (6.20–17.39)±3.60	17.05 (8.74–27.69)±7.80
Vongvises	12.75 (0.00–20.06)±7.04	23.93 (18.34–30.52)±4.22
Plumb-Bob	13.87 (5.45–24.35)±6.45	20.43 (13.68–37.03)±7.53

p=0.017. SD: standard deviation

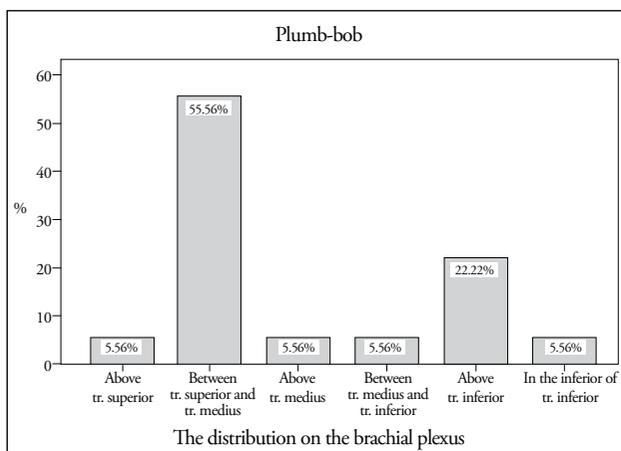


Figure 3. The place of the needle tip on the brachial plexus in the Plumb-Bob technique

it was concluded that it should not be disregarded the fact that the Dalens block technique is mainly implemented on paediatric cases.

Smith (13) reported that if paraesthesia is provided in the areas where the n. medianus disperses, the success rate is higher than that where paraesthesia is provided in the n. radialis or n. ulnaris in patients who have undergone a supraclavicular block.

In the study they conducted in 156 adult patients, Hickey et al. (4) determined that the most successful surgical anaesthesia was provided by paraesthesia formation in the truncus medius, and they explained their findings by arguing that a homogeneous diffusion occurred from the truncus medius to the other trunci.

In our study, when the techniques were evaluated in terms of the distance of the needle tip to the truncus medius, it was determined that this distance was the shortest on both sides in the Inter-SCM technique (average 3.67 mm on the right, average 5.75 mm on the left) and the longest in the block technique of Dalens (average 8.98 mm on the right, average 11.03 mm on the left). A significant difference was found between the Dalens and Inter-SCM techniques on both sides ( $p < 0.05$ ) (Table 3).

In our study, in addition, the distance between the needle tip and truncus superior was determined to be the shortest

on both sides in the Dalens block technique (average 3.18 mm on the right, average 4.80 mm on the left), while in the Plumb-Bob technique it was determined to be the longest (average 7.42 mm on the right, average 10.22 mm on the left) (Table 2).

When the techniques were assessed in terms of the distance of the needle tip to the truncus superior, statistically significant differences were found between the Inter-SCM and both Vongvises and Dalens techniques on the right side and between the Plumb-Bob and the other three techniques on the left side.

When the techniques were evaluated in terms of the distance of the needle tip to the truncus inferior, this distance was determined to be the shortest (average 7.10 mm on the right, average 9.91 mm on the left) on both sides in the Inter-SCM technique and the longest (15.34 mm on the right, 15.46 mm on the left) in the Dalens block technique. A significant difference was found between the Dalens and Inter-SCM techniques on the right side ( $p < 0.05$ ), while there was no significant difference between the techniques on the left side (Table 4).

The needle tip was observed to reach the truncus medius in 39% of the patients in the Inter-SCM technique and in 6% of the patients in the Plumb-Bob and Vongvises techniques. The distribution of the needle tip on the trunci was found to be more homogeneous in the Inter-SCM and Plumb-Bob techniques. The needle tip was observed to be in the range covering the truncus superior and truncus inferior in all cases in the Inter-SCM technique and in 80% of cases in the Plumb-Bob technique. The needle tip was observed to remain above the truncus medius in all cases in the Dalens block technique. The needle tip was observed to be on or above the truncus superior in 95% of the patients in the Dalens block technique and in 55% of the patients in the Vongvises block technique (Figures 3–6).

Vongvises and Panijayanond (5) reported that they achieved a successful anaesthesia in the entire arm of 97% of the patients with the method they performed on 100 patients and that n. intercostobrachial needed to be blocked additionally in two patients.

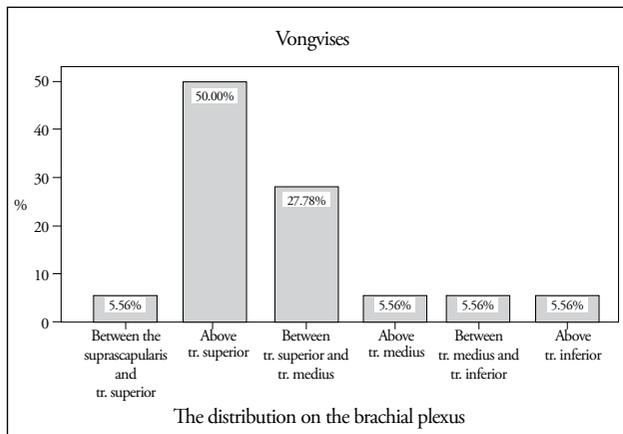


Figure 4. The place of the needle tip on the brachial plexus in the Vongvises technique

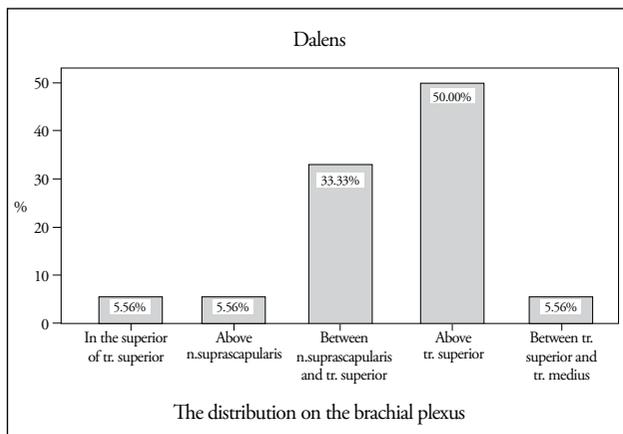


Figure 5. The place of the needle tip on the brachial plexus in the Dalens technique

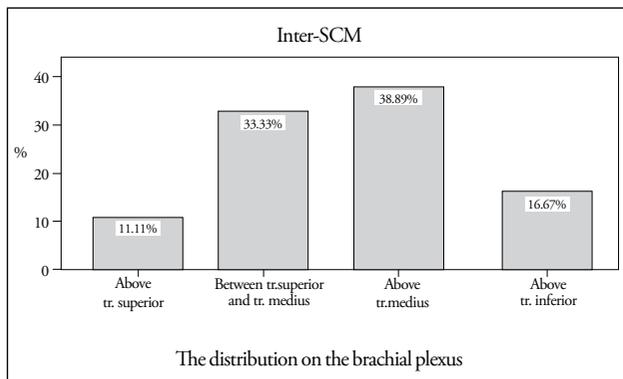


Figure 6. The place of the needle tip on the brachial plexus in the Inter-SCM technique

Although Vongvises and Beokhaimook (12) detected that the distance between the needle or marker and the cupula pleura was  $9 \pm 4$  mm (5–15 mm) in the study they conducted in company with computed tomography, they did not propose to move the needle puncture site to a higher point. In this case, they suggested that the needle could be above the truncus superior of the brachial plexus and a contact with the

clavicula could not be provided as an additional cue point. In our study, when the technique of Vongvises et al. was applied, because the needle tip came across the truncus superior in 50% of the patients, if the needle puncture site is moved higher, we suggest that the rate of success in the block will reduce.

Dalens et al. (6) implemented the block technique that they developed on paediatric patients between 8 months and 17 years of age; they stated that full analgesia was provided in 97% of the patients with this technique and that the block occurred not only in the brachial plexus but also in the areas innervated by the lower branches of the cervical plexus.

In our study, the needle tip was observed to be above the truncus superior in 50% of the patients, between the n. suprascapularis and truncus superior in 33% of the patients and above the n. suprascapularis in 6% of the patients with this technique. Our findings support the results of the research of Dalens et al. (6). However, the researchers reported that sensory block also occurred in the n. ulnaris at a rate of 98%. However, in our study, the needle tip was observed to be on or above the truncus superior in 95% of the patients and was between the truncus superior and medius in only 5% of the patients. Therefore, we have doubts that sufficient block occurs in the n. ulnaris in most patients as Dalens et al. (6) reported. However, clinical studies performed in adults are required to support this finding as it should not be disregarded that Dalens et al. (6) performed their study on paediatric patients.

Shoulder surgery was not implemented in the patients who were included in the study of the researchers. However, we believe that this technique can also be used successfully in adult patients undergoing shoulder surgery and would be a good alternative to the interscalene block technique, because the n. suprascapularis can easily be blocked and as the needle tip stays away from the n. phrenicus with this technique. When the distance between the places where n. suprascapularis splits from the truncus superior and the needle trace was evaluated, this distance was determined to be the shortest on both the right and left sides in the technique of Dalens et al. (6).

It was determined in our study that the needle tip moved towards the 1<sup>st</sup> intercostal interval in three patients (the 3<sup>rd</sup>, 4<sup>th</sup> and 9<sup>th</sup> patients) in whom the Dalens technique was applied and that pneumothorax might develop if the 1<sup>st</sup> intercostal interval is passed through, not the cupula pleural region as with the other supraclavicular block techniques. Though the needle is primarily supposed to contact with the brachial plexus, it was found that pneumothorax could develop if stimulation does not occur in the plexus while the needle enters between n. suprascapularis and the truncus superior and continues to progress.

In the Plumb-Bob technique developed by Brown et al. (7), the needle is directed in such a way that it creates an approx-

imately perpendicular angle to the one in the definition of the conventional supraclavicular block (Kulenkampff). In the study in which they analysed the MR images of 10 volunteers, Klaastad et al. (14) proposed that the angle of the needle should initially be 45° or the needle puncture site should be in a more cranial or lateral position when the Plumb-Bob technique is applied. They emphasised that moving the needle puncture site 2 cm towards the cranial – towards the interscalene groove – in the anteroposterior direction was consistent with the parascalene technique defined by Vongvises and Panijayanond.

Vade-Boncou and Weinberg (15) stated that the main difference between the Plumb-Bob technique and the classic supraclavicular approaches (i.e. Kulenkampff and subclavian perivascular technique) was the angle given to the needle while approaching the brachial plexus. They stated that, in classic supraclavicular block techniques, the needle often contacts the truncus superior, and if the truncus superior is touched in a slightly oblique manner, it may not be possible to access the truncus medius because the needle may be directed outwards from the brachial plexus sheath while the needle is moved. They stated that this problem could easily be overcome by slightly directing the needle towards the caudal or cranial in the Plumb-Bob technique, in which the widest dimension of the brachial plexus is entered at a perpendicular angle. In our study, in the Plumb-Bob technique, the needle tip was observed to be between the truncus superior and truncus medius in 56% of the patients, in the truncus inferior in 22% of the patients and, more importantly, in the caudal of the truncus inferior in 5% of the patients. Similar to other researchers, we also believe that potential complications such as an a.-v. subclavian puncture and pneumothorax should decrease by determining the needle puncture site at more cranial levels or by initially inserting the needle at an angle of 45°.

Pham-Dang et al. (8) identified the Inter-SCM block technique to eliminate the disadvantages of the supraclavicular block techniques. Considering the distribution of anaesthetic drugs, the researchers have reported that there are similarities between other supraclavicular techniques and this technique but that the fundamental difference relates to the anterior and tangential approach to the path brachial plexus follows. Furthermore, this technique was said to be very suitable for synovial debridement under arthroscopy or decompressive acromioplasty. It has been reported that if the procedure is implemented correctly, the n. phrenicus or truncus superior is first reached with the needle.

Unlike those researchers, in our study, in only 11% of the patients was the needle tip above the truncus superior, while the needle tip was in the truncus medius in 39% of the patients and between the truncus superior and medius in 33% of the patients. Considering this distribution, we believe that a successful anaesthesia can be achieved in the entire arm with the implementation of the Inter-SCM technique.

## Conclusion

In our study, the distance between the needle tip and the truncus medius was found to be the shortest on both sides with the Inter-SCM technique and the longest in the Dalens block technique. The distribution of the needle tip on the trunci was more homogeneous in the Inter-SCM and Plumb-Bob techniques. The needle tip was observed to be in the range covering the truncus superior and truncus inferior in all patients in the Inter-SCM technique and in 80% of the patients in the Plumb-Bob technique. The fact that it is stated that the Inter-SCM technique has been applied successfully both in shoulder and hand surgeries in the literature supports our findings. The needle tip was observed to be on or above the truncus superior in 95% of the patients with the Dalens block technique and in 55% of the patients with the Vongvises block technique.

When the Plumb-Bob technique was applied, it could be concluded that the needle puncture site at a more cranial position on the skin or initial insertion of the needle at an angle of 45° may decrease possible complications such as pneumothorax.

In the results of our examinations, it was determined that the brachial plexus can be blocked successfully by inserting the needle 1 cm below the needle puncture site in the technique of Vongvises et al and by pushing it in an anteroposterior direction perpendicular to the table plane.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of İstanbul Institution of Forensic Medicine.

**Peer-review:** Externally peer-reviewed.

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