# Minimum Volume of LA Required to Surround Each of the Branches of the Axillary Brachial Plexus using Ultrasound Guided Technique

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## ABSTRACT

**Introduction**: The minimum volume of LA required to effectively block the four main branches of the axillary brachial plexus is unknown. The main aim of the current study was to determine the minimal volume of LA required to surround each branch of axillary brachial plexus and document its onset and duration of sensory and motor effects.

**Material and methods:** 20 patients with ASA I–II undergoing hand or forearm surgery were selected for this study. USG was used to locate each of the 4 branches of axillary plexus. 1.5% of lignocaine with 1:200 000 of adrenaline was loaded into a syringe driver and deposited with a 22 G needle and injection commenced using the bolus function (600 ml h21).

**Results:** The mean (95% of Confidence Interval) volume required for each nerve was: radial 3.32 (2.74–3.89) ml, median 2.65 (2.01–3.19) ml, ulnar 2.48 (2.04–2.93) ml, and musculocutaneous 2.20 (1.86–2.54) ml. The mean (95% of Confidence Interval) onset time for complete sensory block was: radial 21.5 (12.5–30.5) min, median 25.8 (17.5–34.0) min, ulnar 25.6 (16.8–34.4) min, and musculocutaneous 14.8 (7.35– 23.2) min. The mean (95% of Confidence Interval) last recorded time with complete block was: radial 136.1 (104.6–158.7) min, median 143.7 (122.4–165.0) min, ulnar 182.2 (157.1–207.2) min, and musculocutaneous 157.3 (130.8–183.9) min.

**Conclusions**: We concluded that it is possible to deposit 2–4 ml of local anaesthetic around each branch of axillary plexus. We also speculate that by increasing the amount of volume of LA would produce anesthesia of quicker onset and with longer.


**Keywords:** Minimum Volume of LA, Axillary Brachial Plexus, Ultrasound Guided Technique

## INTRODUCTION

In recent years there is a substantial increase in the use of ultrasound as an aid to performing regional anaesthesia.[1,2] the advantages of this technique can be speed of anesthesia,[1–3] high success rate,[4–8] and speedier time of onset.[2,4,6,8] USG anesthesia helps in direct visualization of target structures[3-4] which in turn helps in more accurate delivery of injectate[4-6] at a particular site with reduced volumes of injectate used,[4-8] in comparison with other type of nerve location techniques.[5,6,9,10] High-volume regional blocks were used classically such as the axillary brachial plexus or 3-in-1 femoral block have used high volumes of LA up to 40 ml to achieve desired surgical anaesthesia.[1,4,7] Major portion of this LA, however, may be lost into surrounding soft tissues or undergo vascular uptake and therefore not contribute to anaesthesia.[1,4,7,9] With USG, the comparable surgical anesthesia could be achieved with very small amounts of LA.[8-10] At present, the minimum amount of LA required to surround each of the four main branches of the axillary brachial plexus to achieve effective analgesia is unknown. The primary outcome measure of this study was to establish the minimum volume of LA required to surround each of the branches of the axillary brachial plexus using USG and determine the amount of LA required to produce quality anaesthesia suitable for surgery. The secondary outcome was to measure the time of onset and offset and extent and duration of both sensory block and motor block.

## MATERIAL AND METHODS

Ethical clearance was taken from the hospital administration and written informed consent was taken from all the participants. 20 subjects were enrolled in this study. This present study was conducted in the Department of Anesthesia, Govt Medical College, Srinagar.

**Inclusion criteria**

- ASA grade I or II
- Patients undergoing arm or forearm surgery
- Both genders
- Age >16 yrs

**Exclusion criteria**

- patient refusal,
- age < 16 yrs
- coagulopathy
- allergy to local anaesthetics and
- BMI > 35 kg /m$^2$.

All subjects were undergoing surgeries of upper arm (orthopedic and plastic surgeries). The nerve block was performed by the same operator in order to avoid intra-operator variability. Patients received sedation with

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**How to cite this article:** Kouser Benazir, Ubaid Ullah Gul Salmani, Javid Ahmad Dar, Mudhabir Ashraf. Minimum volume of la required to surround each of the branches of the axillary brachial plexus using ultrasound guided technique. International Journal of Contemporary Medical Research 2020;7(7):G9-G12.

**DOI:** http://dx.doi.org/10.21276/ijcmr.2020.7.7.29

midazolam 0.15–0.25 mg/ kg and fentanyl 50–100 mg i.v. before commencement of the regional block. The monitoring of the patients was done throughout with administration of supplemental oxygen. Alcoholic swab and chlorhexidine preparation were used to prepare the skin surface of the axilla and arm. A 6–13 mHz linear probe ultrasound was used to obtain an image of the axillary artery. The 4 main branches of the axillary brachial plexus were identified. Lignoiane 1.5% with 1:200 000 epinephrine was used in a 60 ml syringe and connected to a 22G needle. A 22G syringe was used to inject the solution using the bolus function, set at 600 ml/h. All the 4 main branches of brachial plexus were located and LA was deposited around each individual branch of the plexus. The delivered dose was recorded with repositioning and further bolus injection, so that the minimum volume of local anaesthetic required to surround the nerve bundle with a 'halo' was used. The total dose for each branch of plexus was then documented. Where possible the radial, median, and ulnar nerves were blocked from the one skin puncture site, the musculocutaneous nerve usually being blocked from a second puncture.

After depositing the nerve around each individual branches of brachial plexus, the information regarding the sensory and motor blockade was collected. Sensory block was assessed by using ice (cold test), and also by comparing the anaesthetized arm with the contralateral arm. The sensory blockade was graded on a three-point scale

1 - no difference between sides;

2 - some difference between arms but cold still sensed in the blocked arm;

3 - no cold sensation in the blocked arm.

Motor block was assessed by asking the patient to flex the arm (musculocutaneous nerve), extend the flexed arm and wrist (radial nerve), flex the wrist and oppose the second and third fingers and thumb (median nerve), flex and oppose the fourth and fifth fingers towards the thumb (ulnar nerve). The motor blockade was graded as

1 - no change

2 - reduced contraction

3 - no contraction.

The data was collected and noted down after every 5 min for the first 30 min, at 45 and 1 hour, and every 30 min thereafter up to 6 h.

## STATISTICAL ANALYSIS

The data was compiled, recorded and entered in a Microsoft Excel and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Statistical software SPSS and Microsoft Excel were used to carry out the statistical analysis of data. Descriptive statistics of data including percentages and means were reported. Graphically, the data was presented by bar diagrams. A P-value of less than 0.05 was considered statistically significant

## RESULTS

20 adult patients having hand, forearm or arm surgery were included in this study. The cases included 12 males and 8 females, with male: female ratio of 3:2. The mean at presentation was 29.85 years with range from 19-55 years. No technical difficulty arose while performing ultrasound-guided peripheral nerve block in any of the patients.

The mean volume of minimal LA required to deposit each of the individual peripheral nerves and time of onset and offset of effective sensory block are shown in Tables 1–3.

| Nerve | Mean | 95% CI |
|---|---|---|
| Radial | 3.32 | 2.74- 3.89 |
| Median | 2.65 | 2.21- 3.09 |
| Ulnar | 2.48 | 2.04- 2.93 |
| Musculocutaneous | 2.20 | 1.86 – 2.54 |

**Table-1:** Mean (95% CI) volume required to surround nerve (ml)

| Nerve | Mean | 95% CI |
|---|---|---|
| Radial | 21.5 | 12.5- 30.5 |
| Median | 25.8 | 17.5- 34.0 |
| Ulnar | 25.6 | 16.8- 34.4 |
| Musculocutaneous | 14.8 | 7.35- 23.2 |

**Table-2:** Mean (95% CI) time to effective sensory block (min)

| Nerve | Mean | 95% CI |
|---|---|---|
| Radial | 136.1 | 104.6- 167.7 |
| Median | 143.7 | 122.4- 165.0 |
| Ulnar | 182.2 | 157.1- 207.2 |
| Musculocutaneous | 157.3 | 130.8- 183.9 |

**Table-3:** Mean (95% CI) duration of effective sensory block (min)

Examination of the Q–Q plots indicated a normal distribution for all except in duration of sensory block for the musculocutaneous nerve with a small number of outliers, that is, there was a positive skew. 7 out of 20 patients required additional LA infiltration and two patients required an intravenous bolus of analgesic (up to 100 mg fentanyl). No patient required conversion to general anaesthesia for surgery.

## DISCUSSION

In current study, we found that US guided nerve block of the axillary brachial plexus can be used to deposit very low volumes of LA and provide the effective surgical anaesthesia in comparison with the traditionally larger volumes used with nerve stimulation or trans-arterial techniques. By using this technique, we found the onset of anaesthesia was relatively slow and duration of action was short. One of the main advantages of this ultrasound guided regional nerve block is that it allows visualization of nerves, surrounding structures, needle placement, and importantly, the real time interaction between nerves and LA. The accuracy with which the individual nerves can be located and the spread of LA deposited has led to greater success of the nerve blocks.[4–8] The USG has also been shown to reduce the time for onset of the nerve block by locating the nerves in real time and knowing the exact site of deposition of LA.[2,4,6,8]

Our data is similar to other recent works using smaller volumes of LA in nerve and plexus blocks.[11] O'Donnell and Iohom[11] were able to achieve the adequate anestheisa in axillary plexus nerves with as little as 1 ml of lidocaine 2%. This small volume of LA injectate requires a high degree of operator skill for accurate placement of the injection.[11] This is also raises some question like whether drug concentration or drug dosage is most important in establishing an adequate and effective nerve block,[11] although it is beyond the scope of current study to discuss about this.[11] There are many other recent studies who have also used minimal or lower volumes for nerve or plexus anaesthesia in the upper limb.[12] Eichenberger and colleagues[12] injected small volumes of mepivacaine 1% in and around the ulnar nerve in the forearm, to identify the minimum volume required to provide anaesthesia. In contrast, Duggan and colleagues[13] found that using ultrasound did not significantly reduce the required volume of anaesthetic for supraclavicular blocks.

In current study, we encountered some difficulties in accurately identifying the radial branch of the brachial plexus when performing the nerve blocks. To help in identifying this branch, we retraced the course of this branch from distal to proximal round of the shaft of the humerus back to the axilla.[14] Nevertheless, more LA was needed to surround this branch for effective anesthesia. Several of the patients required block supplementation because of insufficient radial nerve block and more accurate localization may have resulted in greater overall block success.[14,15] The greater amount of LA required to anesthetize the radial branch might be due to relative difficulty in identifying this branch in the axilla and ensuring that it was surrounded with anaesthetic.[11,12,13] The nerve stimulation may be helpful and aid in localizing this branch when performing the blocks for this reason, as suggested for the radial nerve by Wong and colleagues[14] recently. In contrast to this, the musculocutaneous branch is easily located and blocked and tends to be anesthetized with a relatively low volume of LA, which is probably explained by its location between the two fascial planes of biceps and coracobrachialis.[12-14] We also saw in most of the cases, there was a relatively selective sensory block with sparing of motor fibres, the exception being the musculocutaneous nerve where a complete motor block was usually achieved within 15 min of injection which was similar to Harper et al.[15] we concluded that this rapid and complete effect could be due to the location of the musculocutaneous nerve between the facial planes of the biceps and coracobrachialis muscles.[15] In the majority of cases, we found that anaesthesia was sufficient for surgery.[14,15] 7 out of 20 patients needed some kind of block augmentation and two patients further required i.v. fentanyl to facilitate surgery.[14,15] In all of the above cases, however, there was some residual block after surgery and we think that the perceived block failure was possibly due to the slow onset of action rather than an absolute absence of block.[15] Nevertheless, the findings of our study were similar to Harper et al.[15] suggest that injecting such small volumes may not be completely reliable in the clinical setting.[15]

In this study, we found that low volumes can be used to anesthetise the nerves and achieve the required sensory anaesthesia for surgery and at the same time minimizing the duration of the nerve block. This could have an impact on outpatient surgeries where we want anesththesia to wear off early before hospital discharge. However, slower onset of motor block may be a limiting factor and larger volumes may be needed to have faster onset of motor blockade. We need future studies to investigate the ideal minimal volume of LA required to surround each individual branch and plexus using USG injections.

## CONCLUSION

With the help of Ultrasound, the individual branches of axillary brachial plexus can be reliably located and surrounded with very low volumes of LA. This small volume can provide anaesthesia sufficient in most cases for surgery, but further study is required to determine the optimum volume to use.

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**Source of Support:** Nil; **Conflict of Interest:** None

**Submitted:** 23-05-2020; **Accepted:** 16-06-2020; **Published:** 14-07-2020