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Minimum Effective Volume of Local Anaesthetic in 50% Patients Using Dixon's Up-And-Down Method for Ultrasound Guided Supraclavicular Brachial Plexus Block: One Year Hospital Based Clinical Study

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ABSTRACT

Background: Supraclavicular approach is commonly used for brachial plexus block in upper limb surgeries. This study aimed to determine the minimum dose of local. anaesthetic for a successful ultrasound guided-supraclavicular brachial plexus block in 50% of patients, undergoing upper limb surgeries.

Materials and Methods: This prospective hospital-based study included 40 patients aged 20 to 60 years, posted for elective upper limb surgery receiving a supraclavicular brachial plexus block under ultrasound guidance. The first patient in the study was administered with a volume of 30 mL. Equal volume of injection 0.5% bupivacaine and 2% lidocaine with 1:200,000 adrenaline was administrated (ratio 1:1). Depending on whether the block in the preceding patient was successful or unsuccessful, the subsequent patients received an increase or decrease in 2 mL using Dixon's up. or down method, after 30 mins of local anaesthetic injection. Sensory block and motor block were assessed.

Results: The mean volume of anesthetic used in the present study for performance of block was 18.6±5.7 mL. Successful block was observed in 77.5% of patients. The minimum effective local anesthetic volume for a successful block in 50% of patients was 16.22 ml and effective volume in 95% of patients (ED_{95}) was calculated to be 46.64 mL (95% CI 35.69-84.31 mL). **Conclusion:** The minimum effective volume in 50% patients (MEAV50) for ultrasound guided supraclavicular brachial plexus block was 16.22 mL. Lower volumes of local anaesthetic lead to reduced incidence of local anesthetic toxicity at the cost of duration of sensory and motor blockade.

Keywords: *Minimum effective volume, Supraclavicular block, Ultrasound*

1. INTRODUCTION

The success of any peripheral nerve block majorly depends on correct identification of anatomical structures and administration of an optimal dose of a local anaesthetic aroundall the nerves supplying desired surgical field in order to obtain a complete blockade.

However, risk of systemic toxicity increases with use of large volumes of local anaesthetic, which is one of the main issues with regional anaesthesia. Although systemic toxicity occursless frequently, but can be fatal and difficult to treat. This dictates the reduction in amount oflocal anaesthetic used for peripheral nerve block and perhaps reducing the direct neuronal and systemic damage of local anaesthetic toxicity.[1,2]

There is evidence from studies that ultrasound-guided blocks lead to ease in administration of block, precision in drug placement and faster onset which in turn provides safer and effective block with fewer consequences in comparison to non-ultrasound-based techniques, which depend upon anatomical landmarks to place needle. The volume needed to produce an adequate block may be minimized with ultrasound guidance by direct visualization of local anaesthetic spreads around the nerves.[2] Since ultrasound-guided. supraclavicular. brachial plexus block can anaesthetize all four distal upper extremity nerve regions (median, radial, ulnar, and musculocutaneous) at the level of clavicle, it is frequently employed for procedures involving upper extremities.[3]

However, the exact dose of local anaesthetic required to block all the nerves involved in the brachial plexus is difficult to predict. The dosage of local anaesthetics required widely depends on the age, weight, and associated co-morbid conditions of the patients.[4] There are very few studies in the literature on the dose of local anaesthetic required for a successful brachial plexus block. Thus, the present study aimed to determine the minimum dose of local. anaesthetic for a successful ultrasound guided supraclavicular brachial plexus block in 50% of patients, undergoing upper limb surgeries.

2. MATERIALS AND METHODS

This prospective observational study was done in the department of Anaesthesia for a period of 1 year, after obtaining approval from Institutional Ethical Committee with reference number MDC/DOME/99. Study included 40 patients in the age group of 20 to 60 years, of either gender, belonging to American Society of Anaesthesiologists (ASA) grade I and II posted for elective upper limb surgery receiving a supraclavicular brachial plexus block under ultrasound guidance. Patients with BMI ≥35 kg/m^2, with history of neurologic or respiratory disease, allergy to local anaesthetic, coagulopathy and infection, undergoing emergency surgery were excluded from the study. Written informed consent was obtained from each patient.

Methodology

A thorough pre-anesthetic evaluation and routine investigations were done on the day before surgery. On the day of surgery, intravenous access was secured using 18G or 20G iv cannula and iv fluids were started. Monitoring devices according to ASA standards were attached to the patient before induction of anaesthesia. These included non-invasive blood pressure, ECG and oxygen saturation. Under aseptic precautions, a preliminary scan was performed using Sonosite Ultrasound machine. A 13-6Hz linear probe was used to locate the brachial plexus. A 23-gauge needle was used to perform the block. Equal volume of injection 0.5% bupivacaine and 2% lidocaine with 1:200,000 adrenaline (ratio1:1) was administrated. An experienced anesthesiologist performed all the blocks.

Ultrasound Guided Supraclavicular Brachial plexus block technique:

The patient was placed supine on the back, the head were turned to non-operating side and the arm adducted against side of body during the supraclavicular block. The linear transducer was placed in the coronal or oblique plane just above the clavicle at the midpoint. The brachial plexus divisions and trunks clustered vertically over the first rib on the lateral side of subclavian artery were visualized. Once needle was positioned and negative aspiration confirmed, equal volume of the local anaesthetic was injected under sonographic view in small aliquots. The needle repositioning was done under sonographic view to make sure sufficient spread of the drug around plexus. Spread of drug within the plexus and distribution into the divisions and trunks were visualized.

The first patient in the study was administered with a volume of 30 mL (ratio 1:1). Depending on whether the block in the preceding patient was successful or unsuccessful, the subsequent patients received an increase or decrease in 2 mL using Dixon's up. or down method, after 30 mins of local anaesthetic injection. It was decided not to exceed maximal volume of 40 mL in order to prevent local anaesthetic toxicity. If the previous patient did not respond with the maximal volume (40 mL), the next subject also received 40 mL. The minimum effective volume required for the successful block in 50% of patients (MEAV50) was estimated from the data collected. Probit regression analysis was implemented to estimate the effective volume in 95% of patients (ED95).

3. BLOCK EVALUATION

Block evaluation was done every 5 mins for first 30 mins after local anaesthetic injection. Sensory block was assessed for the musculocutaneous, median, radial, and ulnar nerves. Sensory block was evaluated on the lateral forearm, volar aspect of the thumb, lateral dorsum of the hand, and fifth finger volar aspect, in that order.[5]

A cold test with 3-point scale was used to grade the sensory block as follows:

Score	Interpretation
0	No block

1	Analgesia (patient can feel touch, not cold)
2	Anesthesia (patient cannot feel touch")

Motor block evaluation was done by flexion of elbow (musculocutaneous), abduction of thumb (radial), opposition of thumb (median), and adduction of thumb (ulnar). With the maximal score of 16 points.[5] Motor blockade was assessed with a 3-point scale as follows:

Score	Interpretation
0	No block
1	Paresis
2	Paralysis

Vital parameters were recorded for all the patients. The data obtained was tabulated and subjected to statistical analysis.

Statistical Analysis

Categorical data were represented using rates, ratios, and percentages. In order to determine whether there is a correlation between the outcome, clinical, and demographic factors, the Chi-square test, test of proportion, or Fisher's exact test were utilized. Non-parametric tests were used for discrete variables. The value of p less than 0.05 was deemed significant for all tests.

4. RESULTS

In the present study, the mean age of patients was 38.5 years and the age range was 20-62 years, with majority of patients between 20 and 29 years (35%). (Table 1) Out of 40 patients, 82.5% were male and 17.5% were female, with a male:female ratio of 4.71:1. (Table 2) The mean weight and height of the study patients were 69.02 kg and 165.02 cm, respectively.

Table 1: Age Distribution of Study Patients

AGE (in years)	**NUMBER (%)**
20 - 29	14 (35%)
30 - 39	9 (22.5%)
40 - 49	4 (10%)
50 - 59	10 (25%)
60 - 69	3 (7.5%)
TOTAL	40 (100%)

Table 2: Gender Distribution of Study Patients

GENDER	**NUMBER (%)**
FEMALE	07 (17.5%)
MALE	33 (82.5%)
TOTAL	40 (100%)

The mean BMI was 25.31, with a range of 19.3-33.8. The mean volume of anesthetic used in the present study for performance of block was 18.6±5.7 mL, with a range from 6 ml to 30 mL. Mean volume was 19.42±5.59 mL, ranging from 8-30 ml for a successful block. The 95% confidence interval for successful mean volume for success are 17.45 mL and 21.39 mL. The minimum effective volume required is calculated using Dixon and Massey formula derived by the addition of mean

volume and half of the volume interval. In the present study, the minimum volume in 50% patients was 16.22 mL. Using Probit regression analysis, the minimum effective volume for 95% of the population was 46.64 mL (95% CI 35.69-84.31 ml). (Figure 1) In the present study, successful block was observed in 77.5% of patients.

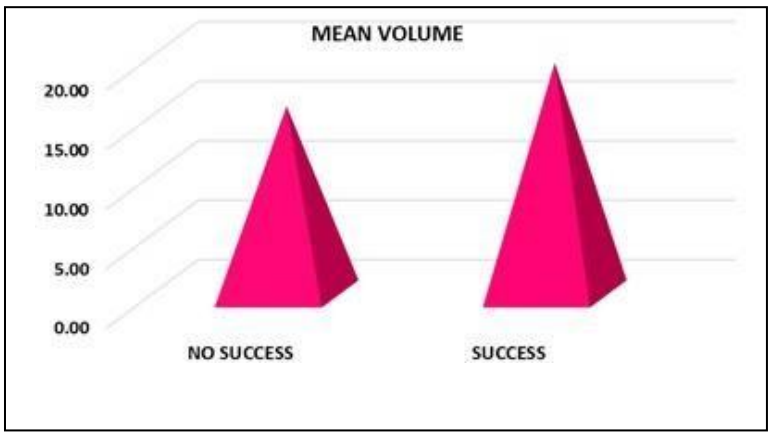

Figure 1: Mean volume of local anesthetic used in study patients

There was no significant association between age of patient and success of block. (Table 3)

Table 3: Association between Age of Patient and Success of block

AGE	NO SUCCESS		SUCCESS	
	NUMBER	%	NUMBER	%
20 - 29	5	55.56	9	29.03
30 - 39	1	11.11	8	25.81
40 - 49	2	22.22	2	6.45
50 - 59	1	11.11	9	29.03
60 - 69	0	0.00	3	9.68
TOTAL	9	100.00	31	100.00

5. DISCUSSION

Supraclavicular approach is commonly used for brachial plexus block in upper limb surgeries. Supraclavicular approach to brachial plexus is superficial and has greater success rate in arm, forearm, and hand surgeries. The Efficiency increases with the use of ultrasound guidance.[6] Various studies have proven that ultrasound guided blocks lead to quicker onset times and improve the quality of the block with lesser complications in comparison with other techniques of nerve localization which are non-ultrasound based, where needle placement is guided by anatomical landmarks.[1] Most complications observed are due to systemic toxicity which is related to higher volumes of local anesthetics used for the block. Modern regional anaesthetic practices mainly focus on reduction in dose and volume of local anesthetic which can result in prevention of such complications. The present study aimed to determine the minimum effective volume of local anaesthetic required for a successful supraclavicular brachial plexus block for upper limb surgeries.

In the present study, forty participants were included with mean age 38.5 years and a male to female ratio was 4.71:1. The age group of study patients included was 20 to 60 years, and majority of subjects belonged to 20 to 29 years age group. In a study conducted by Duggan et al[7], the minimum effective volume of local anaesthetic for 50% patients in ultrasound guided supraclavicular block was 23 mL and in 95% patients it was 42 mL. They stated that, the use of ultrasound for supraclavicular block did not help in reduction of the local anaesthetic volume requirement. Out of forty patients, nine patients had unsuccessful block in the present study. These patients received supplemental local anesthetic or additional analgesics in the form of local infiltration or intravenous fentanyl. No patient required general anesthesia in thes present study. The least volume administered was 6 mL, which resulted in unsuccessful block and Least volume for a successful block was 8mL. The maximum volume administered for a successful block was 30 mL and that for an unsuccessful block was 24 mL. Among

the successful blocks, mean volume required was 19.42±5.59 mL while that for unsuccessful blocks the value was found to be 15.78 mL with standard deviation of 5.24 mL. Analysing the data on the basis of Dixon-Massey formula and Probit Regression analysis, the minimum effective local anesthetic volume for a successful block in 50% of patients was found to be 16.22 mL and effective volume in 95% of patients (ED_{95}) was calculated to be 46.64 mL (95% CI 35.69-84.31 mL).

For drug administration, we followed the corner pocket technique, which involved deposition of drug in three to four small volumes, starting with corner pocket and moving on to other areas, reaching the desired volume as determined by the Dixon's up and down method as described previously. This technique yielded a higher number of successful blocks (31) in the present study. These results are in contrast to the study done by Hanumanthaiah D et al[8] who reported ulnar sparing in a higher percentage of subjects. Block failure mostly presented as ulnar sparing. This is associated with the inadequate infiltration of the corner pocket. Corner pocket is the area inferomedial to plexus, posterolateral to the subclavian artery and superior to the first rib.[9,10] It is believed that adequate deposition of local anaesthetic in this area gives an effective ulnar blockade.

In the present study, the lowest volume of 8mL had a successful block. However, in our studies it was observed that the lower volumes resulted in shorter sensory and motor block duration. The volume of 8 mL provided two hours of sensory and 2 hour 30 minutes of motor block. In a study done by Erdogmus NA et al[11], to find the minimum volume for axillary brachial plexus block and its effect on sensory and motor blockade, they mention that regression time of block and the time required for administration of first analgesic was shortened with minimum volumes of local anesthetics.

6. CONCLUSION

The present study concluded that the minimum effective volume in 50% patients (MEAV50) for ultrasound guided supraclavicular brachial plexus block was 16.22 mL and the calculated volume for 95% patients was 46.64 mL. Lower volumes of local anaesthetic lead to reduced incidence of local anesthetic toxicity at the cost of duration of sensory and motor blockade. Hence it is prudent to consider the type of surgery, duration of surgery and requirement of postoperative analgesia before determining the volume of the drug.

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