ANESTHESIOLOGY

Median Effective Volume of 0.5% Ropivacaine for Ultrasound-guided Costoclavicular Block

A Dose-finding Study

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ABSTRACT

Background: The median effective dose of ropivacaine required for producing an effective costoclavicular block has not yet been determined. The authors conducted this dose-finding study with the objective of determining the median effective dose of 0.5% ropivacaine required to produce a successful costoclavicular block for surgical anesthesia in 50% of the patients (ED50) as well as the calculated dose required for effective blockade in 95% of the patients (ED95).

Methods: This single-armed prospective study was conducted on 40 American Society of Anesthesiologists physical status I or II patients, aged 18 to 60 yr, with a body mass index of 18 to 30 kg/m^2, scheduled to undergo forearm and hand surgeries under ultrasound-guided costoclavicular block. A volume of 0.5% ropivacaine administered in the costoclavicular space was determined using the sample up-and-down sequential allocation study design of binary response variables. The first patient received a volume of 26 ml of 0.5% ropivacaine. After a successful or unsuccessful block, the volume of local anesthetic was decreased or increased, respectively, by 2 ml in the next patient. Evaluation of sensory and motor block was performed every 5 min for 30 min and graded using a 3-point scale. Surgical anesthesia was considered to be successful if a minimum score of 14 was achieved and the surgeon was able to proceed with surgery without needing to supplement anesthesia.

Results: The volume of local anesthetic administered ranged from 8 to 26 ml. Centered isotonic regression with a bias-corrected Morris 95% CI derived by bootstrapping showed ED50 of 13.5 ml (95% CI, 11.5 to 15.4 ml) and ED95 of 18.9 ml (95% CI, 17.9 to 27.5 ml).

Conclusions: A 19-ml dose of 0.5% ropivacaine is likely to produce an effective ultrasound-guided costoclavicular block for providing adequate surgical anesthesia to 95% of the patients.

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EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- The costoclavicular block is an approach to brachial plexus anesthesia featuring rapid onset
- The optimal volume for ultrasound-guided costoclavicular blockade has not been defined

What This Article Tells Us That Is New

- Forty patients were enrolled in a dose-finding study using 0.5% ropivacaine and an up-and-down sequential allocation study design
- It was determined that 19 ml of 0.5% ropivacaine is likely to produce adequate surgical anesthesia for 95% of patients using this block technique

The brachial plexus block provides good surgical anesthesia and postoperative analgesia for upper limb procedures.[1] It can be performed at various levels using different approaches.[1] The infraclavicular approach anesthetizes the brachial plexus at the level of its cords and has a fast onset, few adverse effects, and high surgical effectiveness for forearm and hand surgeries due to good-quality analgesia of the median and ulnar nerves.[2] Various approaches for performing the infraclavicular brachial plexus block include the coracoid, lateral sagittal, and vertical approaches.[3–5] An ultrasound-guided lateral sagittal infraclavicular block is one of the commonly used infraclavicular block techniques and targets the lateral infraclavicular fossa, where the cords are present at a depth of 3 to 6 cm surrounding the second part of axillary artery.[3] The main problem associated with this approach is the need for multiple injections and administration of larger volumes of local anesthetic for achieving a successful block.[5,6]

A more recently described approach of infraclavicular brachial plexus block is the costoclavicular block, which involves administering the block in the costoclavicular space,[7] a well-defined intermuscular space lying deep and posterior to the clavicular midpoint, between the subclavius muscle anteriorly and the serratus anterior (upper slip) muscle posteriorly. At this level, cords of the brachial plexus share a consistent relation to one another and to the axillary artery. They lie more superficially and are clustered together lateral to the artery.[8,9] This compact topography allows use of less local anesthetic and a single injection technique for producing an effective block.[10] As compared to the lateral sagittal approach, costoclavicular block results in a faster onset of sensory blockade.[10]

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Previously, variable volumes, concentrations, and types of local anesthetics have been used for administering costoclavicular block.[8–11] In a recent dose-finding study, the median effective volume of lidocaine (1.5%) with epinephrine required to effectively produce a block in 90% of the patients was found to be 35 ml.[11] Lidocaine, a short-acting local anesthetic, is less suitable for providing long duration of anesthesia or analgesia. Ropivacaine, a long-acting local anesthetic, has also been used for administering costoclavicular block; however, its median effective dose required for producing an effective costoclavicular block has not yet been determined. We conducted this dose-finding study with the primary objective of determining the median effective dose of 0.5% ropivacaine required to produce a successful costoclavicular block for surgical anesthesia in 50% of the patients (ED50). Our secondary objectives included the calculated dose required for effective blockade in 95% of the patients (ED95), block onset time (time required to achieve a minimum sensorimotor composite score of 14/16 points), block performance time (time interval from contact of ultrasound probe with the patient to the end of local anesthetic injection), number of needle passes, pain experienced during the costoclavicular block procedure (assessed using numeric rating scale for pain where 0 = no pain and 10 = worst imaginable pain), time to first rescue analgesia, 24 h postoperative rescue analgesic consumption, and occurrence of any adverse events during the study period, beginning from the time of patient recruitment in the study to the end of the follow-up period (*i.e.*, 24 h postoperatively).

Materials and Methods

Study Design and Population

This single-armed prospective study was conducted in the Department of Anesthesia and Intensive Care, Postgraduate Institute of Medical Education and Research (Chandigarh, India), after obtaining approval from the Institutional Ethics Committee (reference No. NK/4662/MD/503, dated September 12, 2018). The trial was registered with the Clinical Trial Registry of India (http://ctri.nic.in; registration No. CTRI/2019/01/017316; date of registration, January 31, 2019; date of patient enrollment, February 1, 2019). All patients who came to the trauma outpatient department were assessed for eligibility. Written informed consent was taken from all eligible patients. Fifty American Society of Anesthesiologists (Schaumburg, Illinois) physical status I or II patients, in the age group of 18 to 60 yr, with a body mass index between 18 and 30 kg/m^2, scheduled to undergo forearm and hand surgeries were assessed for eligibility. Patients with local infection at the block site, coagulopathy, sepsis, body mass index greater than 30, allergy to local anesthetics, uncontrolled hypertension or ischemic heart disease, renal or hepatic dysfunction, pre-existing neurologic deficits, previous surgery in the infraclavicular fossa, or psychiatric illness; patients who failed to understand the scoring systems used in the study; and patients who refused to give consent for the study were excluded.

Study Procedure

Patients were informed about the numeric rating scale for pain (0 to 10, where 0 = no pain and 10 = worst imaginable pain) as well as about the technique of using the patient-controlled analgesia (PCA) pump. On the day of the surgery, patients were shifted to the operating room and monitored for heart rate, noninvasive blood pressure, electrocardiogram, oxygen saturation, and temperature using multichannel monitors (Datex-Ohmeda S/5 Avance; Datex Ohmeda Inc., USA). An IV access was secured, and all the patients were placed in the supine position, with the ipsilateral arm in 90° abduction. A soft padding was placed behind the patient's back, in the interscapular area, with the head turned slightly to the contralateral side.

Blinding Method

All blocks were performed by an experienced operator who had performed at least 20 ultrasound-guided costoclavicular blocks using a high-frequency (5 to 12 MHz) ultrasound probe (Sonosite, Inc., USA). An independent investigator recorded the procedural data. The operator and the investigator took no further part in the study. An independent observer, who evaluated the sensory and motor block, was not present in the operating room during block placement and was blinded to the volume of local anesthetic injected. The same observer followed the patients postoperatively in the initial 24 h.

Technique of Block Administration

All blocks were performed after local anesthetic infiltration (2 to 3 ml of 1% lidocaine). No patient received IV sedation or analgesia during block placement. Under full aseptic precautions, the ultrasound transducer was initially placed directly on top of the middle third part of the clavicle. Subsequently, the probe was translocated off the inferior border of the clavicle and moved caudally until it slipped off the inferior border of the clavicle and was positioned in the medial infraclavicular fossa. The first part of the axillary artery and vein were visualized here, and the transducer was gently tilted cephalad toward the costoclavicular space. Here the ultrasound image was optimized to clearly view all three cords of the brachial plexus lying compactly lateral to the axillary artery, beneath the subclavius muscle. The presence of a cephalic vein or thoracoacromial artery indicated needle insertion distal to the costoclavicular space, and care was taken to avoid this. The target ultrasound window, where all the three cords were clearly seen lying lateral to the axillary artery, beneath the subclavius muscle, was considered the optimal view for needle insertion. After this, the skin was infiltrated with 2 to 3 ml of 1% lidocaine,

and a 22-gauge nerve block needle was inserted with an in-plane technique, from the lateral to medial direction, with the subclavius muscle being visualized at all times. The needle was directed toward the center of the three cords by advancing it through the gap between the lateral and posterior cords, toward the medial cord. The needle tip was considered to be correctly placed if it was visualized in the center of the nerve cluster. The technical injection endpoint was the injection of local anesthetic in the center of the three cords. The volume of local anesthetic (0.5% ropivacaine) administered through the block needle was determined using the small-sample up-and-down sequential allocation study design of binary response variables as described by Saranteas *et al.*[12] The first patient received a volume of 26 ml of 0.5% ropivacaine.[10] After a successful block (minimal sensorimotor score of 14/16), the volume of local anesthetic in the next patient was decreased by 2 ml. However, if the block was unsuccessful, then the local anesthetic volume was increased by 2 ml in the next patient. To avoid local anesthetic toxicity, we did not exceed its volume to more than 40 ml of 0.5% ropivacaine.

Block Evaluation

During the procedure, block performance time (time interval from the contact of the ultrasound probe with the patient to the end of the local anesthetic injection) as well as the level of procedure-related pain (0, no pain; 10, worst imaginable pain) were recorded. The number of times the needle required redirection or retraction of at least 10 mm was recorded as an "additional pass." Needle tip visibility at the target site was the most important factor that determined the number of needle passes in our study. The other factors were the angle between the ultrasound beam and the needle trajectory, needle direction, and presence of subcutaneous fat. After local anesthetic injection, sensory and motor blockade were evaluated by a blinded observer every 5 min, starting at 5 min after injection, until 30 min had passed. The extent of sensory block was assessed in the median, radial, ulnar, and musculocutaneous nerve distributions and graded by a 3-point scale, using a cold test, where 0 equals no block, 1 equals analgesia (patient can feel touch, not cold), and 2 equals anesthesia (patient cannot feel touch).[11] The extent of motor block was also tested in the distribution of the median (thumb opposition), radial (thumb abduction), ulnar (thumb adduction), and musculocutaneous (flexion of the elbow in supination and pronation) nerves using a 3-point scale, where 0 equals normal movement, 1 equals paresis, and 2 equals no movement.[11,13] Maximal composite sensorimotor score was 16. We considered the block a success when a minimum score of 14 was achieved. Surgical anesthesia was considered to be successful if a minimum score of 14 was achieved and the surgeon was able to proceed with surgery without needing to supplement anesthesia with IV narcotics, local infiltration of local anesthetics, or general anesthesia. Block onset time, defined as the time required to achieve a minimum sensorimotor composite score of 14/16 points, was recorded. However, if after 30 min the composite sensorimotor score was inferior to 14 points, then the block was considered a failure.

Failed Blocks

In patients having unsuccessful costoclavicular block, we administered general anesthesia following a standard technique. Analgesia was given using IV morphine 0.1 mg/kg and propofol 2 to 3 mg/kg until the loss of verbal response. IV vecuronium 0.1 mg/kg was used to facilitate intubation of the trachea. Anesthesia was maintained with isoflurane (minimum alveolar concentration, 1 to 1.3), 60% nitrous oxide in oxygen, and intermittent IV doses of vecuronium 0.02 mg/kg.

Postoperative Pain Assessment and Management

In the postoperative room, patients were monitored for heart rate, noninvasive blood pressure, and oxygen saturation for 24 h after surgery. All the patients were connected to the PCA device, programmed to deliver a bolus of 1 mg morphine with a lockout time interval of 10 min, with a set maximum limit of 6 mg morphine that could be delivered in an hour. The hemodynamic parameters and pain scores of patients who had a successful block were recorded at 0, 1, 2, 4, 6, 8, 12, and 24 h postoperatively. Time to first PCA bolus and the total number of PCA boluses received by these patients in 24 h were also recorded. The presence of any side effects or adverse events like nausea, vomiting, local anesthetic systemic toxicity, vascular puncture, pleural puncture, residual block, and persistent neurologic deficit was noted.

Statistical Analysis

Sample size was calculated using the formula by Dixon and Massey, $n = 2(SD/SEM)^2$.[14] Assuming a 5-ml SD and 1.2-ml SEM, 35 patients were needed to be included in the study. Considering an attrition rate of 10%, we included 40 patients in our study. ED50 was calculated by using the Dixon and Massey up-and-down method. The midpoint concentration of all the independent pairs of patients involving a crossover (*i.e.*, successful to not successful block) was used to calculate ED50. The technique of isotonic regression was used to confirm the ED50 to minimize reliance on unverifiable assumptions. We calculated ED50 and ED95 using centered isotonic regression with a bias-corrected Morris 95% CI derived by bootstrapping using "dosefind" and "quickinverse" commands in the Centered Isotonic Regression package. Further, an adjusted response probability was obtained by the pooled adjacent violators algorithm using the Centered Isotonic Regression–pooled adjacent violators algorithm in R software (https://rdrr.io/cran/cir/man/cirPAVA.html; accessed November 11, 2020). We also calculated Pearson's correlation coefficient (r) to find the association between the time to first analgesic request and administered local anesthetic volume.

For the continuous variables, data were presented as mean ± SD or median (interquartile range) depending on the distribution of the data. For all categorical variables, frequency/percentage was calculated. The Mann–Whitney U test was used for statistical analysis of skewed continuous variables or ordered categorical data. Chi-square or Fisher exact test was applied to find out the association between subgroup and categorical variables. Bootstrapping was performed using the Centered Isotonic Regression cran package of R software). For all other analysis, Microsoft Excel and STATA version 13.1 were used (Stata Corp., USA). $P \leq 0.05$ was considered statistically significant.

Results

A total of 50 patients were screened for inclusion in the study. Forty patients fulfilled the inclusion criteria and were enrolled. Of these, two patients had to be excluded, as the ultrasound-guided block could not be performed due to equipment failure (technical fault with the ultrasound machine). The recruitment pathway is presented in figure 1. Table 1 shows the demographic profile of all the patients and their surgical characteristics.

Median Effective Dose of Local Anesthetic

The sequence of successful and failed blocks is illustrated in figure 2. The median ED50, calculated by the Dixon and Massey method, was 15.3 ± 2.6 ml. The volume of local anesthetic administered ranged from 8 to 26 ml. Isotonic regression estimator and bias-corrected bootstrapping as a part of sensitivity analysis showed an ED50 of 13.5 ml (95% CI, 11.5 to 15.4 ml), and the calculated ED95 was 18.9 ml (95% CI, 17.9 to 27.5 ml; fig. 3). Table 2 clearly indicates that more than 90% probability of the block to be effective occurred after administration of at least 18 ml of the drug.

Block Performance Characteristics

The mean block performance time was 7.3 ± 1.6 min. There was no significant difference in block performance time between patients having successful and failed blocks ($P = 0.335$). The block onset time, calculated for patients who had a successful block, was 25.0 ± 4.0 min. The majority of the patients (28/38) complained of no pain during costoclavicular block administration, with no patient experiencing more than mild pain during the procedure. The median number of needle passes was 1 (interquartile range, 1 to 4). In 63.2% (24/38) of the patients, we were able to administer the block with a single needle pass. There was no difference in the number of needle passes between successful and unsuccessful blocks ($P = 0.458$).

Postoperative Pain and Rescue Analgesia Required

Out of the total patients included in the study, 22 patients had a successful block. The postoperative numeric rating scale scores in the initial 24 h were less than 3 in all patients with a successful block (fig. 4). The mean 24-h morphine consumption was 5.3 ± 1.3 mg, with the mean time to use of first dose of rescue analgesia being 6.3 ± 1.7 h. A moderate level of positive correlation between the time to first analgesic request and administered local anesthetic volume was found, with the Pearson's correlation r being 0.487. This value of r was found to be statistically significant ($P = 0.014$). None of our patients had any complications during and after the intervention.

Discussion

In this dose-finding study, we found that the median ED50 was 13.5 ml (95% CI, 11.5 to 15.4 ml), and the ED95 was 18.9 ml (95% CI, 17.9 to 27.5 ml).

Variable types and volumes of local anesthetics, ranging from 20 to 40 ml, have been used for administering a successful infraclavicular brachial plexus block, without a significant effect on surgical anesthesia,[15] thus indicating that lower volumes of local anesthetic would also be effective. Similarly, variable volumes of ropivacaine for administering the ultrasound-guided costoclavicular block range from 20 to 25 ml of 0.5% ropivacaine.[9,10,13,16] Hence, there was a need for determining the median effective dose of ropivacaine needed to produce a successful costoclavicular block. Due to the paucity of data on median effective volume of 0.5% ropivacaine required for producing an effective costoclavicular block, we used an initial volume of 26 ml.[10] Dose step size was typically kept in equal increments of approximately half the SD. It has been suggested in simulation studies that including at least 20 to 40 patients provides stable estimates of target doses for most realistic scenarios.[17] As we had precalculated our sample size (consisting of 40 patients), using the formula by Dixon and Massey ($n = 2[SD/SEM]^2$),[14] we decided to use this parameter (fixed sample size) as the stopping rule. We found the ED50 and ED95 for producing an effective costoclavicular block using 0.5% ropivacaine to be 13.5 and 18.9 ml, respectively. Our results are consistent with the study by Li *et al.*[9] in which the authors achieved surgical anesthesia in 97% of patients with 20 ml of 0.5% ropivacaine. This previous published study was not a dose-finding study, but was mainly aimed at determining the relevant sonoanatomy, technique, and block dynamics of an ultrasound-guided costoclavicular block, wherein the authors suggested that a lower volume of local anesthetic may be required to produce an effective surgical anesthesia after costoclavicular block as compared to the classical lateral infraclavicular approach. An ED95 of 0.75% ropivacaine for producing an effective lateral sagittal infraclavicular brachial plexus block has been reported to be 31 ml (95% CI, 18 to 45 ml), with the ED50 being 19 ml (95% CI, 14 to 27 ml).[18] These volumes, as expected, are considerably more than the ED50 (ED50, 13.5 ml; 95% CI, 11.5 to 15.4 ml) and ED95 (ED95, 18.9 ml; 95% CI, 17.9 to 27.5 ml) found in our study and are in accordance with the

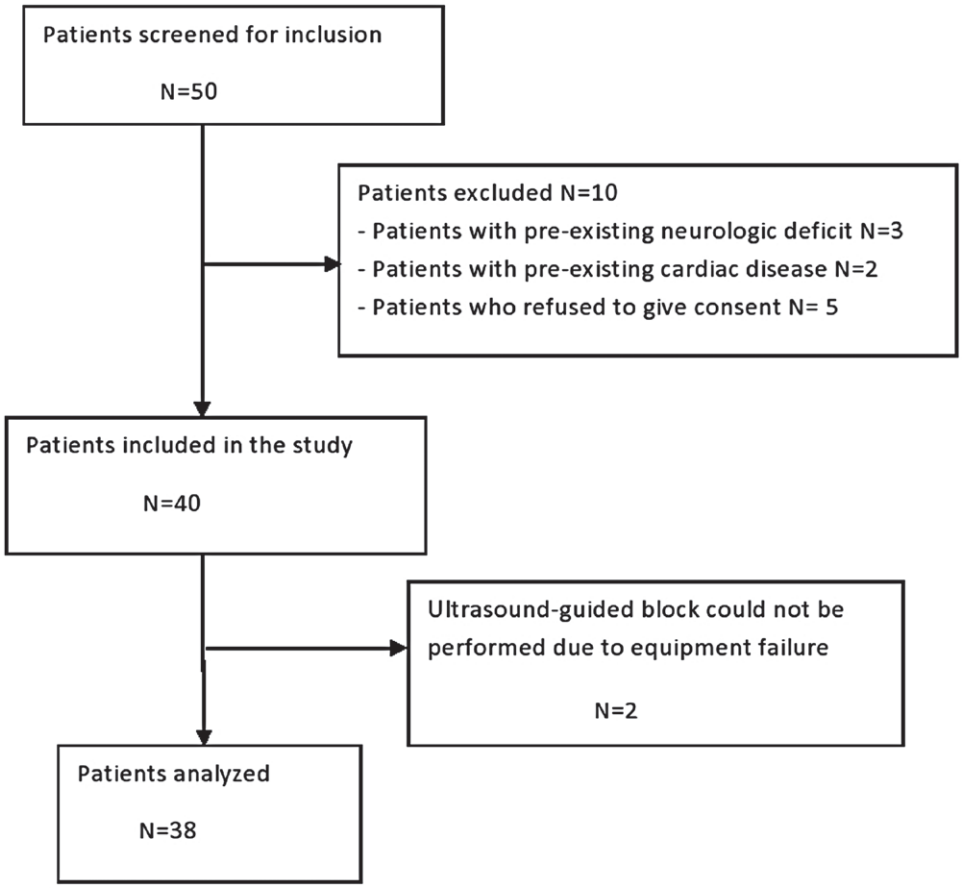

Fig. 1. Flow of participants in the study.

Table 1. Patient Characteristics

Characteristic	Mean ± SD or No. (%)
Sex (male/female)	33/5
Age (yr)	36.8 ± 13.1
Weight (kg)	64.7 ± 8.5
Height (cm)	165 ± 7
Body mass index (kg/m^2)	23.7 ± 2.6
ASA physical status (I/II)	26/12
Duration of surgery (min)	101 ± 32
Types of surgery	
Forearm	15/38 (39.5%)
Hand	14/38 (36.8%)
Wrist	9/38 (23.7%)

ASA, American Society of Anesthesiologists.

assumptions made by Li *et al.*,[9] wherein the authors felt that a lesser amount of local anesthetic may be required to produce costoclavicular block as compared to the conventional lateral sagittal infraclavicular brachial plexus block.

It is important to remember that the success of costoclavicular block depends on the accuracy of injection, and the volume (dose) of local anesthetic greatly influences the onset, success, and duration of the block. We used a standard technique of block administration, and the technical injection endpoint was clearly defined. Further, the block success, which had a direct influence on the volume of drug to be used in subsequent patients, was clearly defined using a 16-point composite sensorimotor score. Patients not achieving a minimum score of 14 points at the end of 30 min were considered to have failed blocks.

Our results appear different from a recent dose-finding study by Sotthisopha *et al.*,[11] wherein the authors achieved 90% success in ultrasound-guided costoclavicular block with 34 ml of lidocaine 1.5% with epinephrine 5 μg/ml. In comparison, we found that use of ropivacaine 0.5% was associated with a 44% reduction in the volume of local anesthetic required to produce a successful block. This could be due to the difference in the potency of local anesthetics used. An association between potency and hydrophobicity may not hold true *in vitro* and is influenced by many factors

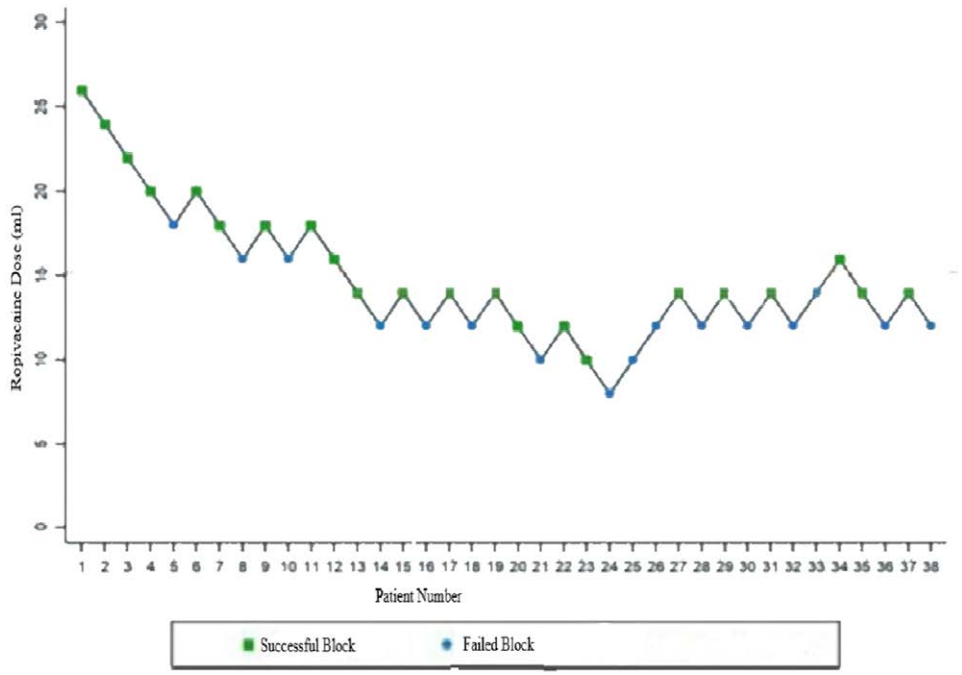

Fig. 2. Sequential block results of ultrasound-guided costoclavicular block using ropivacaine 0.5% according to the Dixon and Massey up-and-down method.

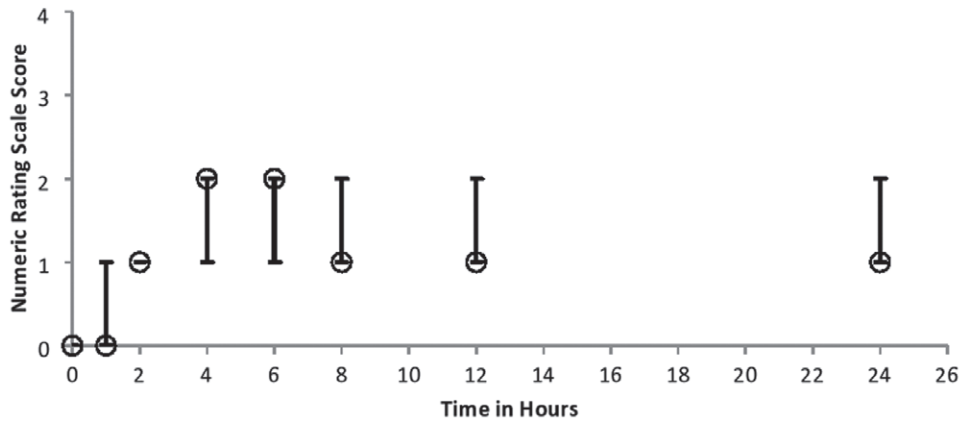

Fig. 3. Estimation of median ED95 using Centered Isotonic Regression. *X*, Different doses of ropivacaine administered to the patients. The size of X is indicative of the number of patients to whom a particular dose was administered. The larger the size of X, the greater the number of patients who were administered that particular dose. The *vertical line* is indicative of median ED95 as estimated by centered isotonic regression.

like redistribution secondary to vasodilatation; however, a potency of 3.6 has been defined for ropivacaine in the literature as compared to 1 for lidocaine.[19] Blocks of greater depth and longer duration are expected from smaller volumes of a more potent local anesthetic. Further, there was a difference in the injection technique we followed and that followed by Sotthisopha *et al*. We used a 22-gauge nerve block needle for administering the block, as opposed to Sotthisopha *et al.*, who used a Tuohy needle. This difference in needle gauges could have influenced the speed of local anesthetic injection. Use of a Tuohy needle could have led to a faster speed of local anesthetic injection (this was

Table 2. Adjusted Response Probability Obtained by Pooled Adjacent Violators Algorithm

Dose	Probability of Response	Lower 95% CI	Upper 95% CI
8	0	0	0.38
10	0.12	0.01	0.41
12	0.28	0.12	0.52
14	0.58	0.33	0.79
16	0.8	0.4	0.96
18	0.9	0.61	0.99
20	1	0.67	1
22	1	0.7	1
24	1	0.73	1
26	1	0.75	1

1 min or less, as mentioned by Sotthisopa *et al.*), resulting in the dynamic separation of the three cords, which otherwise lie compactly together. Thus, the anatomical benefit of the compact topography of the cords in costoclavicular space, allowing the use of lower volume of local anesthetic, may be lost. This could have resulted in the large ED90 found by Sotthisopha *et al.*

In our study, the mean block performance time was 7.3 ± 1.6 min, with the block onset time being 25.0 ± 4.0 min. In the majority of our patients (63.2%), we used only one needle pass to perform the block. These findings are in accordance with those of Sotthisopha *et al.*,[11] where the authors found the mean block performance time to be 6.8 ± 2.8 min and a median number of 1 (interquartile range, 1 to 5) needle passes to perform the costoclavicular block. However, the block onset time was shorter in the study by Sotthisopha *et al.* as compared to our study (18.3 ± 8 min *vs.* 25.0 ± 4.0 min). This could be due to the fact that Sotthisopha *et al.* used 1.5% lidocaine, which has a faster onset of action as compared to the 0.5% ropivacaine we used. The majority of our patients (73.6%) complained of no pain during the block administration. We noted a median numeric rating scale score of 0 (interquartile range, 0 to 3), which was comparable to the score of 0 (interquartile range, 0 to 6) noted by Sotthisopha *et al.* in their study. We compared block performance time and number of needle passes between successful and failed blocks. This comparison was done to rule out failure of the block due to a faulty technique.

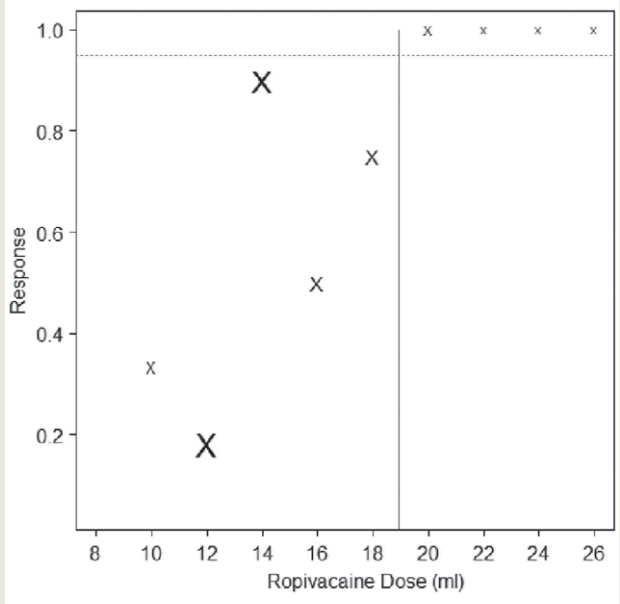

Fig. 4. Postoperative median (with 95% CI) numeric rating scale scores in patients with a successful block at different time points. *Symbols* represent median values, and the *bars* represent 95% CI.

Ropivacaine 5 mg/ml used in our study also provided good postoperative analgesia, with the mean time to use of first rescue analgesic being 6.3 ± 1.7 h and the mean 24-h analgesic consumption being 5.3 ± 1.2 mg of morphine. In our study, no complications like vascular puncture, hematoma formation, pneumothorax, and Horner's syndrome were noted in any patient.

The Dixon and Massey approach was used as a dose-finding methodology in this study. This approach has been used in a number of previous dose-finding studies.[18,20–23] To determine the median volume, an initial dose is selected that should be closer to the expected minimum value. Subsequent volumes are determined based on the previous patient's response. In case of a success or a failure, the next patient receives a lower or higher volume, respectively. All increments and decrements should be identical and predetermined.

The biased coin design up-and-down sequential method and the continued reassessment method are known to be more appropriate for determining ED95. However, the biased coin design up-and-down sequential method requires randomization for dose assignment, which can make its implementation difficult. The continued reassessment method, on the other hand, has been developed and applied in oncological drug tolerance studies and is less commonly used in anesthesia research. It also requires a steep learning curve before it can be used effectively. We thus used the Dixon and Massey up-and-down method as it has a simpler study design that requires a smaller sample size. However, the Dixon and Massey up-and-down method is associated with a broad CI that is insensitive to increasing the sample size. Further, the Dixon and Massey methodology cannot accurately determine the ED95. Therefore, we decided to analyze our data with Centered Isotonic Regression to derive ED50 and ED95 values. Additionally, we used the pooled adjacent violators algorithm for calculating response probability with its CI at point dosage.[12,24–26]

Our study is limited by the fact that, first, we did not insert a perineural catheter for intraoperative anesthesia

supplementation and postoperative pain relief because, working in a low-resource setting, we did not find the use of a perineural catheter to be cost-effective. Further, most of our surgeries were of shorter duration (less than 120 min). Therefore, intraoperative reinjection of local anesthetic was not required, and the postoperative pain management was achieved using IV opioids. Second, we did not include the duration of sensory and/or motor blockade as a secondary outcome. This was because all patients enrolled in our study were trauma patients, scheduled to undergo forearm, hand, and wrist surgeries, requiring application of slab/plaster in the postoperative period. Therefore, it was not possible to assess for the duration of sensory blockade in these patients by the standard technique. Further, we felt that the weight of a plaster of paris cast might affect assessment of motor movements.

Thus, we conclude that the median ED50 is 13.5 ml, and the calculated ED95 is 18.9 ml. Further dose-comparative studies are needed for other concentrations of ropivacaine and multiple-injection techniques as well as to strengthen the validity of the results of our study.

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Competing Interests

The authors declare no competing interests.

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