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Original Research Article

A randomised controlled trial comparing single site versus two sites administration of costoclavicular blocks under ultrasound guidance for below-elbow procedures

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Abstract

Background: The costoclavicular block has been recently adopted for upper limb procedures. The costoclavicular space is situated within the proximal infraclavicular fossa, where the three cords of the brachial plexus are closely aggregated. This study evaluated single-site and two-site injection strategies for ultrasound-guided costoclavicular blocks.

Materials and Methods: Forty patients scheduled for below-elbow surgery with costoclavicular block were randomly allocated to Group A (single site injection, n=20) or Group B (two site injection, n=20). Both groups received 30 millilitres(mL) of a local anaesthetic solution that contained 5 microgrammes per mL of adrenaline in 15 mL of 2% lignocaine, 2 milligrams of preservative-free dexamethasone added to 14.5 millilitres of 0.5% bupivacaine. In Group A, the entire volume of anaesthetic solution was administered between the three cords of the brachial plexus. In Group B, the initial portion of 15 ml volume was given at the above-described spot, while the remaining was delivered between the axillary artery and medial cord. The principal outcome of this study was costoclavicular block onset time. Other outcomes like block performance time, imaging, needling time and total anaesthesia related time were also recorded.

Results: Group 'B' exhibited a significantly shorter onset time (18.7±2.7 min) compared to Group 'A' (25.5±1.9 min) (P=0.0005). Block performance time was significantly lower in Group 'B' (5.5±0.3 min) than in Group 'A' (5.9±0.1 min) (P=0.01). Group B patients also had lesser imaging time (50.9 sec) than Group A (62.5 sec) (P = 0.001). Needling time was more in Group B (5.3 min) than in Group A (4.7 min) (P= 0.0005). The total anaesthesia related time was lower in Group 'B' (26.6±2.9 min) than Group 'A' (31.7±3.8min) (P=0.01).

Conclusion: The two-site costoclavicular block provides shorter onset time, and shorter block performance time and reduced overall anaesthesia duration compared to its single-site injection counterpart, for upper limb procedures.

Keywords: Costoclavicular block, Ultrasound-guided nerve block, Single-injection, Double-injection, Brachial plexus, Below-elbow surgery.

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1. Introduction

The practice of upper-limb regional anaesthesia develops through increased adoption of brachial plexus block techniques for achieving sufficient anaesthesia and analgesia.[1] Recent studies indicates that the costoclavicular technique is a novel brachial plexus block method aimed at addressing the challenges associated with conventional infraclavicular approach to brachial plexus block.[2] Anaesthesiologists can achieve better block outcomes and reduce vascular puncture dangers through costoclavicular space procedures that enhance their visibility of brachial plexus cords.[3] Costoclavicular block reduces complications like Horner's syndrome, hemi diaphragmatic palsy and pneumothorax when compared to interscalene and supraclavicular blocks.[4,5] The identification for brachial plexus cords were sometimes challenging for anaesthesiologists who conduct traditional infraclavicular block procedures due to high body mass index patients, deeper location, poor visibility and those with body

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configurations that differ from the norm.[6] The compact arrangement of all 3 cords under clavicular midpoint (costoclavicular space) enables proper needle placement and more efficient distribution of local anaesthetic after administration of costoclavicular block.[7] The benefits of local anaesthetic deposition at the costoclavicular space was requirement of a lesser volume due to the dense packing of the cords, as well as a reduced risk of ipsilateral phrenic nerve palsy and pneumothorax.[4,8] Many studies have demonstrated the existence of a connective tissue barrier between the superficial lateral cord and the deeper posterior cord and medial cords.[9] Additionally, some studies observed phenomena such as dynamic cord dispersion during the block; although the initial needle target is positioned centrally among the three cords, they rapidly diverge upon local anaesthetic injection, thereby undermining the advantages of their proximity.[10] Thus, the anaesthetic solution would be explicitly confined to the compartment in which it was injected. This results in inconsistent block of the single-site injection approach. Secondary blockade failure in continuous blocks arises when the catheter is improperly positioned. Two site injection anaesthesia techniques divide local anaesthetic into specific amounts that encircle both lateral and posterior brachial plexus cords before placing the remaining portion adjacent to the medial cord and axillary artery.[10] The local anaesthetic mixture, which includes lignocaine, bupivacaine, dexamethasone, and adrenaline, was chosen for the costoclavicular block due to its ability to provide rapid onset of analgesia and prolonged duration for analgesia.[11] Lignocaine gives rapid onset of action, while bupivacaine delivers prolonged analgesic effects. Adrenaline was used as an adjuvant to local anaesthetics to prolong the duration of anaesthesia and diminish the peak plasma concentration of local anaesthetics.[12] Peripheral nerve blocks with dexamethasone in addition to the local anaesthetic solution provided pain relief for a longer duration.[13,14]

The sparse randomised trial data in Indian population regarding these two costoclavicular block techniques encouraged us to conduct research in this field to evaluate the rapidity of block onset, block success rates, and other complications with different concentrations of local anaesthetics. Significant findings from the Layera et al research showing double injection costoclavicular blocks generated faster onset times than single injection costoclavicular block.[10] The current minimal availability of clinical research data remains in place due to multiple factors affecting results including local anaesthetic contents and operator skill level and block technique diversity. In this study, we hypothesised that double injection anaesthesia administration would produce anaesthesia faster than single injection, with an easy approach and few problems.

2. Methodology

This study is a prospective, randomized, double-blinded comparative study carried out in Department of Anaesthesiology, Critical Care, and Pain Medicine at a tertiary care teaching hospital. Ethical approval for this study was granted by the Institutional Ethics Committee of our hospital (IEC/21/JUN/163/31). Every participant signed written consent before study entry while the research received CTRI Number: CTRI/2022/11/047343 for registration with the Clinical Trials Registry of India. The investigation followed ethical principles according to the Declaration of Helsinki in its implementation. In this study, individuals were divided into two groups based on a random sequence that was created by a computer (Group A received single site injection versus Group B received two sites injection) **(Figure 1)**. A research assistant who did not recruit patients created sealed opaque envelopes to maintain allocation concealment. Study participant and the person who was collecting data were blinded during the study.

Patients with an American Society of Anaesthesiologists (ASA) status of I–III, a body mass index (BMI) between 18 and 35 kg/m², and aged between 18 and 65 years were enrolled in the study. Exclusion criteria included patients with sepsis, abnormal coagulation profiles, allergies to local anaesthetics, or renal or hepatic insufficiency. Individuals who had previously undergone surgery or experienced trauma around the infraclavicular fossa, as well as those who declined to provide consent, were not included. Patients with preexisting upper limb neuropathy and those weighing less than 40 kg were also excluded to avoid a toxic dose of lignocaine. Additionally, patients with a composite sensory and motor score of less than 14, thirty minutes after the block, were excluded and administered general anaesthesia.

The sample size was calculated using n master software 2.0, based on block onset time data from a prior study by Layera et al., which reported onset times of 23.4 ± 6.9 minutes for single-injection and 16.6 ± 6.4 minutes for double-injection with an effect size of 1.02.[10] With an alpha of 0.05 and a power of 90%, 20 individuals per group were required.

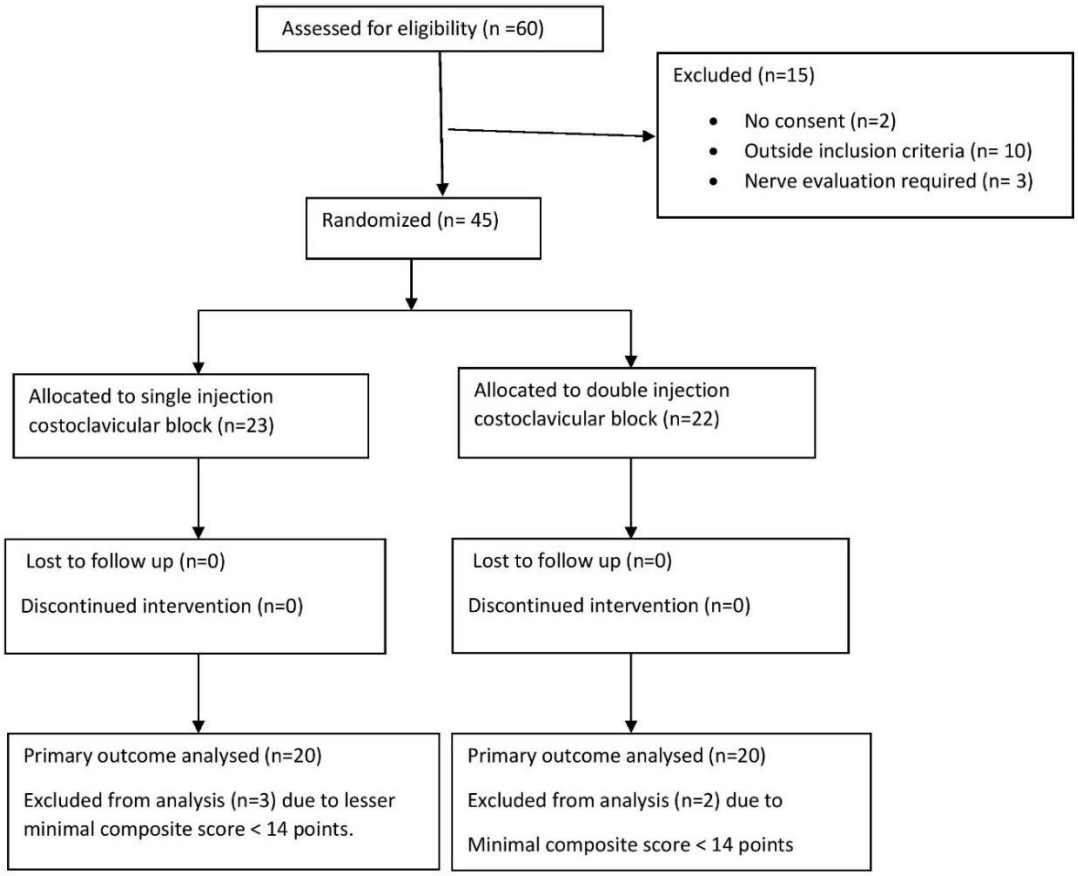

Figure 1: Depicting the flow of study participants as per consort guidelines

All patients received preoperative instructions of nil per oral for 8 hours as per institutional protocol. Patients were transported to the induction room for the application of standard ASA monitor devices, which included electrocardiography, non-invasive blood pressure, and pulse oximetry. The upper limb that was opposite the surgery area was inserted with an intravenous catheter of 18-G or 20-G. Patients were administered a dose of 1 μg/kg of intra venous fentanyl as a medication prior to the procedure, and they were simultaneously provided with oxygen at a rate of 6 L/min through a Hudson mask. A linear probe with a frequency of 3 to 16 MHz was utilized in the procedure. (HFL38, P07577, Sonosite). All blocks were completed with an in-plane technique using a 20-G, 100 mm needle from Stimuplex®. Every study participant received 30 millilitres(mL) of a local anaesthetic solution that contained 5 microgrammes per mL of adrenaline in 15 mL of 2% lignocaine, 2 milligrams of preservative-free dexamethasone added to 14.5 millilitres of 0.5% bupivacaine. Prior the ultrasonographic scan, all study subjects were lying down on a bed with their ipsilateral arm stretched **(Figure 2)**. A soft pad was positioned behind the scapular region and the head was slowly turned to contralateral side for administration of local anaesthetic solution in costoclavicular space. After positioning for block anatomical landmarks like midpoint of clavicle and the coracoid process were identified.

The ultrasonic scanning procedure consisted of various phases. In Step 1, the linear transducer was placed above the middle of the clavicle in a transverse orientation, ensuring that the probe marker was directed laterally. In Step 2, the transducer was gently repositioned caudally until it disengaged from the inferior margin of the clavicle, allowing for the visualization of the axillary artery (first part) and vein. The linear transducer was then placed below the midportion of the clavicle and adjusted to visualize the axillary artery and the costoclavicular space (**Figure 2**). A 2 ml injection of 2% lignocaine was infiltrated subcutaneously at the needle entry site.

In Group A (Single-Injection), the anaesthesiologist located the three brachial plexus cords within the costoclavicular space. All blocks were performed by three senior anaesthesiologists, each with over ten years of experience in administering regional anaesthesia with ultrasound guidance. An in-plane approach was used to administer each block, starting from the lateral direction and progressing to the medial direction. A total of 30 ml of solution containing local anaesthetics with adrenaline and dexamethasone was injected at the confluence of the three cords of the brachial plexus in Group A (**Figure 2**).

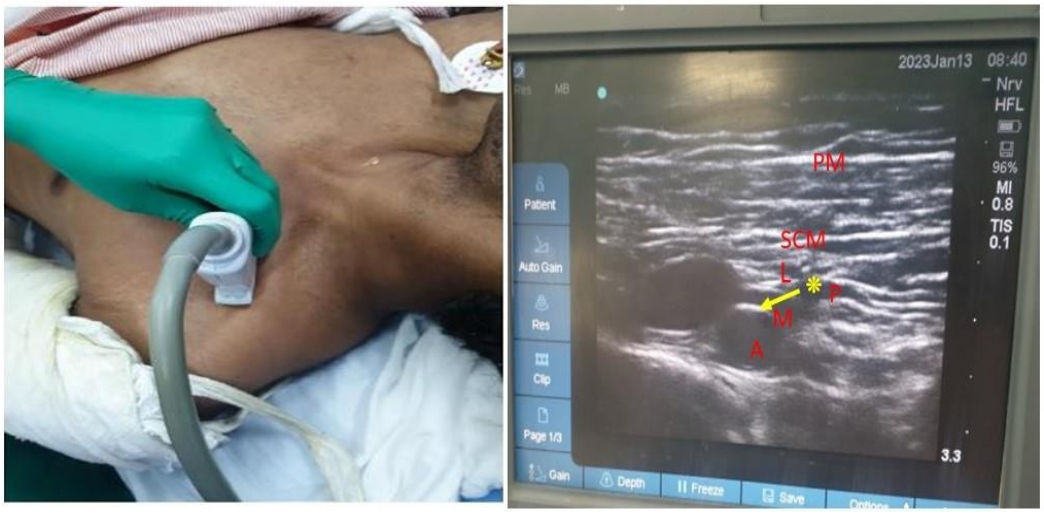

Figure 2: Costoclavicular block; The asterisk indicates where the local anaesthetic is deposited for the single-injection technique and for the first half of the double injection technique. The arrow indicates where the local anaesthetic is deposited for the second half of the double-injection technique. A: Axillary artery; L: Lateral cord; M: Medial cord; P: Posterior cord; PM: Pectoralis muscle; SCM: Subclavirus muscle

In Group B, the initial portion of 15 ml was administered at the above-described position, while the remaining portion was deposited between the axillary artery and the medial cord. After the procedure, a blinded observer documented the onset time of the block, defined as the period required to achieve a minimal sensorimotor composite score of 14 out of 16 points. Patients with a composite score of less than 14 were considered not to have adequate surgical anaesthesia. These patients were treated as block failures and excluded from the study, with general anaesthesia administered instead. A total of 45 cases were randomized, and 5 cases were excluded (3 in Group A and 2 in Group B) due to block failure, which was defined by a lower composite score. The primary outcome of the study was block onset time, and the exclusion of block failure cases ensured accurate documentation of this parameter and total anaesthesia-related time.

The blinded observer also documented any instances of paresthesia, hoarseness, and the intensity of block-related discomfort, using a scale from 0 (no pain) to 10 (worst pain). Post-procedure documentation included imaging duration, needling duration, and performance duration. Imaging time referred to the interval from the ultrasonic probe's contact with the patient to the capture of an acceptable image. Needling time was defined as the period from skin wheal to the completion of local anaesthetic administration. The performance duration was determined by adding the imaging and needling times together. Sensory and motor function of the upper limb was assessed as described in **Table 1** and **Table 2**. Motor function was evaluated using thumb abduction, thumb opposition, thumb adduction, and elbow flexion for the radial, median, ulnar, and musculocutaneous nerves, respectively. The composite sensorimotor score was assessed with a total of 16 points after the block.

The data collected were examined using IBM SPSS Statistics Software, Version 23.0. All data were analyzed according to the protocol analysis. Descriptive statistics, frequency analysis, and percentage analysis were employed for categorical variables, while the mean and standard deviation were used for continuous variables. To determine significant differences between bivariate samples in independent groups, the unpaired sample t-test was used for normally distributed data. The Mann-Whitney U test was employed for non-normally distributed continuous variables. The Fisher's exact test or Chi-Square test was used to determine the significance of associations in categorical data. In all statistical tools, a probability value of 0.05 was regarded as the significance threshold.

Table 1: Sensory block scoring system

Sensory block scoring			
Nerve	**No block**	**Analgesia**	**Sensory**
Musculocutaneous	0	1	2
Radial	0	1	2
Ulnar	0	1	2
Median	0	1	2

Sensory score – No block (score 0- response to both cold and touch), analgesia (score 1- response to touch but not to cold) sensory (score 2- no response to touch or cold)

Table 2: Motor block scoring system

Nerve	No effect	Paresis	Paralysis
Musculocutaneous	0	1	2
Radial	0	1	2
Ulnar	0	1	2
Median	0	1	2

Motor score – no effect (score 0), paresis (score 1), paralysis (score 2)

3. Results

All four demographic variables, including patient age, gender, ASA physical status classification, and body mass index, exhibited equal distribution among the groups according to statistical analysis. The BMI averages for participants in Group A and B were 24.97 ± 4.36 kg/m² and 24.64 ± 4.37 kg/m², respectively (p = 0.809) (**Table 3**).

The onset time for block was significantly shorter in the two-site injection (Group B) (18.7 ± 2.7 min) than in the single site injection (Group A) approach (25.55 ± 1.98 min, P=0.0005) (**Table 4**). Patients in Group B require less time for imaging procedures to identify three cords in the costoclavicular space, averaging 50.90 ± 8.35 seconds, while Group A requires 62.50 ± 11.25 seconds (p = 0.001). The time of needling was shorter in Group A (4.79 ± 0.29 min) compared to Group B (5.32 ± 0.39 min) (P= 0.0005) (**Table 4**). The performance time for block in Group A was 5.91 ± 0.19 minutes, but for Group B it was 5.54 ± 0.38 minutes (P=0.001) (**Table 4**).

Group B had a slightly higher minimal cumulative sensorimotor score at thirty minutes (15.80 ± 0.52 vs. 15.05 ± 0.83, p = 0.002) (**Table 5**). Consequently, the total anaesthesia-related duration prior to surgical procedure (performance time plus block onset time) was significantly reduced in Group B (26.69 ± 2.92 min) compared to Group A (31.71 ± 3.89 min, p < 0.0005) (**Table 5**). No significant differences were observed in number of block failure cases between two groups (P=1.00)

Adverse events were few and not statistically significant between the groups. No vascular punctures or signs of local anaesthetic systemic toxicity have been observed. Few patients reported mild paraesthesia (two in Group A, one in Group B), although none of these instances required additional intervention. Pain during the administration of block at the time of needle insertion were minimal (< 2 on a zero–10 scale) in both groups (**Table 6**).

Table 3: Demographic characteristics of study participants

Variable	Group A (n = 20)	Group B (n = 20)	p-value
Age (Years) **Mean** ± SD	31.8 ± 9.1	30.1 ±9.2	0.56
BMI (kg/m²) **Mean** ± SD	24.97 ± 4.36	24.64 ± 4.37	0.809
Gender	Female: 35.0% (7/20)	Female: 35.0% (7/20)	1.000
Percentage (number/total)	Male:65.0% (13/20)	Male: 65.0% (13/20)	
ASA Status I Percentage (number/total)	40.0% (8/20)	30.0% (6/20)	0.633
II	45.0% (9/20)	60.0% (12/20)	
III	15.0% (3/20)	10.0% (2/20)	

Unpaired t test and chi square test was used to compare the difference between both groups. SD is standard deviation.

Table 4: Comparison of imaging time, needling time, and overall performance time

Parameter	Group A (n = 20)	Group B (n = 20)	95 % confidence interval difference	p-value
Imaging Time (sec)	62.50 ± 11.25	50.90 ± 8.35	5.25 to 17.94	0.001*
Needling Time (min)	4.79 ± 0.29	5.32 ± 0.39	-0.75 to -0.31	0.0005*
Performance Time (min)	5.91 ± 0.19	5.54 ± 0.38	0.17 to 0.56	0.001*
Block onset time(min)	25.55 ± 1.98	18.73 ± 2.79	5.27 to 8.36	0.0005*

Unpaired t test was used to compare the difference between both groups. *Indicates significant difference between both groups

Table 5: Comparison of minimal composite score, and total analgesia-related time and block failure cases

Parameter	Group A (n = 20)	Group B (n = 20)	95 % confidence interval difference	p-value
Minimal Composite Score	15.05 ± 0.83	15.80 ± 0.52	-1.19 to -0.30	0.002*
Total Anaesthesia-Related Time (min)	31.71 ± 3.89	26.69 ± 2.92	2.81 to 7.22	0.0005*
Block failure cases (number of block failed cases/total randomised cases)	3/23	2/22		1.00

Unpaired t test and Fischer's exact test were used to compare the difference between both groups. *Indicates significant difference between both groups

Table 6: Adverse events and block-related pain scores

Parameter	Group A (n = 20)	Group B (n = 20)	p-value
Pain or discomfort during block administration (0–10 scale)	1.2 ± 0.6	1.0 ± 0.5	0.356
Paraesthesia, n (%)	2 (10%)	1 (5%)	0.554
Vascular Puncture, n (%)	0 (0%)	0 (0%)	–
Local Anaesthetic Toxicity, n (%)	0 (0%)	0 (0%)	–

Unpaired t test and Fischer's exact test was used to compare the difference between both groups

4. Discussion

All the demographic factors, including age, gender, body mass index, and ASA physical status, were compared between the groups and found to be similar in this study. In this study onset time for costoclavicular block was shorter in Group B 18.7+/- 2.73 minutes compared to Group A 25.5± 1.98 minutes with p-value <0.01. Similarly, Leurcharusmee P et al. in their RCT compared costoclavicular and Para coracoid ultrasound-guided infraclavicular brachial plexus blocks in patients having upper limb surgery.[15] The average onset time of the costoclavicular group is 16.0 minutes, which aligns with our study. Layera S and colleagues reported that, in comparison to the single-site injection method, the two-site injection technique demonstrated a quicker onset time of 16.6 (6.4) minutes versus 23.4 (6.9) minutes ($p < 0.001$), which aligns with our findings.[10] Similarly, Cesur et al. reported block onset time in costoclavicular block was 15.9 min which was comparable to this study block onset time.[16] Songthamwat et al. reported median onset time for block was 10 minutes, in costoclavicular block group than infraclavicular block group (20 minutes).[17]

In Group B, the mean performance time of the block was 5.54 minutes, which is lower than the performance time of Group A, which was 5.91 minutes, with a p-value of less than 0.01. Leurcharusmee P et al. reported that the mean block performance time was 6.7 minutes.[15] Similarly, Songthamwat et al. in their study reported that mean performance time of 5.9 minutes which was similar to our study.[17] In contrast to this study Cesur et al. reported that mean performance time was 1.5 minutes.[16] This was due to reduced imaging time (7 sec) and needling time (90 seconds). In our study, the imaging time was lesser in Group B (50.90 seconds) compared to Group A (62.50 seconds), Shorter imaging time in Group B was due to anatomical clarity during ultrasound screening. Similarly Layera S, et al. stated in his randomised trial that double injection technique had shorter imaging time (52.4 seconds) than single injection technique (54.7 seconds).[10] Group B patients had longer needling time (5.32 min) than in Group A patients (4.79 min) due to two site administration of local anaesthetic solution. Ashwin et al also reported lower mean needling time (3.6 min) in costoclavicular block group.[18]

In the present study Group B showed greater success rates with higher mean composite score (15.80) than Group A (15.05), but there was no appreciable difference in proportion of participants with minimum composite score of 14 in both groups (P = 0.91). Layera et al. also reported no difference between the two groups in the proportion of patients obtaining a minimum composite score of 14.[10] In this study the mean total anaesthesia related time in Group B (26.69 min) was shorter than in Group A (31.71 min). Similarly, Layera et al. reported lesser total anaesthesia related time in double injection group (22.5 min) compared to single injection group (28.9 min).[10] The reduced total duration of anaesthesia, coupled with a shorter block onset time before surgical incision, minimises the delay in patient handover to surgery. The reduction of overall anaesthesia time by 5 minutes, along with effective time management by operating room personnel, decreases surgery duration, enhances operating room scheduling, and concurrently ensures adequate analgesia with fewer complications.

Regarding paraesthesia, local anaesthetic systemic toxicity, block associated pain scores, and vascular injury rate, this study did not find any significant differences between the groups. This was also reported by Layera et al, who found that there was no significant difference in the levels of paraesthesia and block-related discomfort. injury to the blood vessels.[10] Am Saranlal et al. also noted that there was incidence of procedural complications were minimal in costoclavicular block.[19]

Though our study had an adequate sample size to detect the primary outcome of the difference in block onset times, it is underpowered to detect other outcomes, such as the incidence of vascular puncture, paraesthesia, and local anaesthetic systemic toxicity (LAST). Block success rate was not determined due to the exclusion of block failure cases from the analysis. We did not collect data on the duration of postoperative analgesia, which could potentially vary between the single-injection and double-injection methods. The omission of postoperative analgesia duration is a limitation of this study. Further research could consider comparing the duration of analgesia between the single-site and two-site administration strategies. Additionally, the clinical procedures were performed by skilled anaesthesiologists specializing in ultrasound-guided regional anaesthesia, which limits the external validity for other practitioners with different levels of experience.

5. Conclusion

The two-site costoclavicular block offers a shorter onset time, reduced block performance time, and overall anaesthesia duration compared to the single-site injection method. These advantages make it a more efficient and time-saving

approach for upper limb procedures, potentially improving surgical workflow while maintaining effective anaesthesia.

6. Source of Funding

None.

7. Conflict of Interest

None.

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