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Efficacy of Single-Site versus Two-Site Ultrasound-Guided Costoclavicular Block for Below-Elbow Surgery: A Prospective Randomized Study

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Abstract:

Background

The ultrasound-guided costoclavicular block provides surgical anaesthesia for procedures involving the elbow, forearm and hand by targeting the closely clustered cords of the brachial plexus. However, it remains uncertain whether depositing local anaesthetic at two sites improves block characteristics compared with a single central injection. This study compared the efficacy and safety of single-site and two-site ultrasound-guided costoclavicular blocks for below-elbow surgery.

Methods

This prospective, randomized, assessor-blinded study included 72 adults undergoing elective below-elbow surgery. Participants were allocated equally to single-site (n=36) or two-site (n=36) costoclavicular block. Both groups received 30 mL of 0.5% ropivacaine. In the single-site group, the entire volume was deposited centrally among the three cords. In the two-site group, 15 mL was injected centrally and 15 mL at the medial cord–arterial interface. The primary outcome was composite sensorimotor block-onset time. Secondary outcomes included performance time, readiness for surgery, block success, analgesic duration, postoperative pain, patient satisfaction and adverse events.

Results

Two-site injection required longer performance time (6.5±1.2 versus 5.7±1.0 minutes; p=0.003) and more needle passes (median 2 versus 1; p<0.001). Nevertheless, it significantly shortened sensory onset (14.4±4.8 versus 18.9±5.7 minutes; p=0.001), motor onset (16.5±5.2 versus 21.7±6.1 minutes; p<0.001) and composite onset (16.8±5.5 versus 22.3±6.4 minutes; p<0.001). Total anaesthesia-related time was shorter with two-site injection (23.3±5.8 versus 28.0±6.5 minutes; p=0.002). More two-site recipients were ready for surgery by 15 minutes (52.8% versus 22.2%; p=0.007) and 20 minutes (80.6% versus 55.6%; p=0.023). Final surgical success was comparable (97.2% versus 94.4%; p=1.000). Block duration, postoperative analgesia, satisfaction and adverse-event rates did not differ significantly.

Conclusion

Two-site ultrasound-guided costoclavicular block accelerated sensorimotor onset and surgical readiness compared with single-site injection, although it required slightly longer performance time and additional needle manipulation. Both techniques provided comparable final success, analgesic duration and safety.

Keywords:

Brachial plexus block; costoclavicular block; regional anaesthesia; ropivacaine; two-site injection

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Introduction

Regional anaesthesia is widely used for below-elbow surgery because it can provide reliable surgical anaesthesia, prolonged postoperative analgesia, reduced opioid consumption and avoidance of airway manipulation associated with general anaesthesia. Among the available brachial plexus approaches, infraclavicular block targets the plexus at the level of the cords and can provide consistent anaesthesia of the elbow, forearm and hand. Nevertheless, the conventional paracoracoid or lateral sagittal approach may be technically challenging because the cords are relatively deep and variably positioned around the axillary artery, potentially necessitating multiple needle redirections or larger local-anaesthetic volumes [1,2].

The ultrasound-guided costoclavicular block is a proximal infraclavicular technique in which the brachial plexus is approached within the costoclavicular space, deep to the midpoint of the clavicle [1]. At this site, the lateral, medial and posterior cords are superficially located and closely clustered lateral to the axillary artery, usually in a triangular arrangement [2,3]. This compact sonoanatomy facilitates simultaneous visualisation of the cords and controlled deposition of local anaesthetic. In an initial clinical series, costoclavicular block achieved surgical anaesthesia in 29 of 30 patients (97%), with median sensory and motor onset times of approximately five minutes [3]. Randomized studies have subsequently demonstrated block success comparable to the paracoracoid approach [4] and faster sensorimotor onset than the lateral sagittal approach [5]. The technique may also reduce phrenic nerve involvement; one randomized study reported hemidiaphragmatic paresis in 5% of costoclavicular blocks compared with 45% of supraclavicular blocks [6].

The optimal injection strategy within the costoclavicular space, however, remains uncertain. A single injection between the three cords is technically simple and requires fewer needle passes, but fascial septa or uneven spread may delay blockade of individual cords [7,8]. Two-site injection may improve circumferential distribution and accelerate onset, although it increases needle manipulation. Layera et al. reported shorter block onset with double injection than with single injection (16.6 versus 23.4 minutes; $p<0.001$), without a significant improvement in overall success [8]. Further comparative evidence is therefore required to determine whether the faster onset of two-site injection provides a meaningful clinical advantage without compromising procedural efficiency or safety [8,9]. The present prospective randomized study was designed to compare the efficacy of single-site and two-site ultrasound-guided costoclavicular blocks in patients undergoing below-elbow surgery.

Material and Methods

Study design and setting

This prospective, randomized, assessor-blinded, parallel-group study was conducted in the Department of Anaesthesiology at a tertiary-care teaching hospital, 1 year from June 2022 to May 2023. Approval was obtained from the Institutional Ethics Committee, and the trial was prospectively registered with the Clinical Trials Registry–India. Written informed consent was obtained from every participant. The study was conducted in accordance with the Declaration of Helsinki and Consolidated Standards of Reporting Trials guidelines.

Study participants

Adult patients aged 18–70 years, of either sex, belonging to American Society of Anesthesiologists physical status I–III and scheduled for elective unilateral orthopaedic or soft-tissue surgery at or below the elbow under brachial plexus block were eligible. Exclusion criteria were refusal to participate, infection at the puncture site, coagulopathy or

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ongoing therapeutic anticoagulation, allergy to local anaesthetics, pre-existing neurological deficit involving the operative limb, previous surgery or anatomical deformity in the infraclavicular region, pregnancy, severe cardiopulmonary disease, body mass index $\geqslant$35 kg/m^2, inability to comprehend the sensory assessment, and requirement for emergency surgery.

Sample-size estimation

The sample size was calculated considering block-onset time as the primary outcome. Assuming a clinically meaningful intergroup difference of five minutes, a common standard deviation of seven minutes, two-sided α of 0.05 and 80% statistical power, 31 patients were required in each group. After allowing for approximately 10% attrition or protocol deviation, 72 patients were recruited, with 36 participants allocated to each group.

Randomization and blinding

Participants were assigned in a 1:1 ratio to the single-site injection group (Group S) or two-site injection group (Group T) using a computer-generated random sequence with variable block sizes. Allocation was concealed in sequentially numbered, opaque, sealed envelopes opened immediately before performing the block. An anaesthesiologist experienced in ultrasound-guided regional anaesthesia performed all blocks and could not be blinded. Block assessment and postoperative data collection were undertaken by another anaesthesiologist who was unaware of group allocation. Participants were not informed of the injection technique used.

Preprocedural preparation

Standard fasting guidelines were followed. On arrival in the block area, intravenous access was secured, and electrocardiography, non-invasive blood pressure and pulse oximetry monitoring were instituted. Baseline heart rate, blood pressure and oxygen saturation were recorded. Supplemental oxygen was administered through a nasal cannula. Sedative or opioid premedication was avoided until completion of block assessment. Resuscitation equipment and drugs required for managing local-anaesthetic systemic toxicity were kept immediately available.

Ultrasound-guided costoclavicular block technique

Patients were positioned supine with the head turned contralaterally. The operative arm was abducted to approximately 90°, with the elbow flexed. Under strict aseptic precautions, a high-frequency linear ultrasound transducer was placed transversely below the midpoint of the clavicle. The axillary artery and vein and the lateral, medial and posterior cords of the brachial plexus were identified within the costoclavicular space, deep to the subclavius and pectoralis major muscles. Following skin infiltration with 2–3 mL of 1% lidocaine, an 80–100-mm echogenic block needle was advanced using an in-plane lateral-to-medial approach. After negative aspiration, a total of 30 mL of 0.5% ropivacaine was injected incrementally, with repeated aspiration after every 3–5 mL.

In Group S, the entire 30-mL volume was deposited at a single site in the centre of the three cords. In Group T, 15 mL was injected centrally among the three cords, after which the needle was redirected and the remaining 15 mL deposited between the medial cord and axillary artery. Local-anaesthetic spread, needle tip and surrounding vascular structures were continuously visualized. Injection was discontinued if high resistance, severe pain, paraesthesia or suspected intraneural spread occurred.

Block assessment and outcomes

Sensory and motor blockade of the musculocutaneous, radial, median and ulnar nerves was assessed every five minutes for 30 minutes. Sensory blockade was graded as 0=normal sensation, 1=reduced sensation and 2=complete loss of cold

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sensation. Motor blockade was similarly graded as 0=normal power, 1=paresis and 2=paralysis using elbow flexion, wrist extension, thumb opposition and finger abduction. The maximum composite sensorimotor score was 16. Block onset was defined as the interval between completion of injection and achievement of a composite score ⩾ 14. Block success was defined as completion of surgery without conversion to general anaesthesia or additional nerve block.

The primary outcome was block-onset time. Secondary outcomes included block-performance time, total anaesthesia-related time, number of needle passes, procedural pain assessed using a 0–10 numerical rating scale, surgical success, duration of sensory and motor blockade, time to first rescue analgesia, postoperative pain scores and complications such as vascular puncture, haematoma, pneumothorax, neurological deficit and local-anaesthetic systemic toxicity.

Statistical analysis

Data were analysed using SPSS version 20.0. Normality was assessed using the Shapiro–Wilk test. Continuous variables were compared using the independent-samples t-test or Mann–Whitney U test, while categorical variables were analysed using the chi-square or Fisher's exact test. Repeated pain measurements were compared using repeated-measures analysis of variance or an appropriate mixed-effects model. Results were expressed as mean±standard deviation, median with interquartile range, or frequency with percentage. Analyses followed the intention-to-treat principle, and $p<0.05$ was considered statistically significant.

Results

The two groups were comparable with respect to age (38.9±12.6 vs 40.1±12.1 years; p=0.682), sex distribution, weight, height and BMI (all p>0.05). ASA physical-status distribution was also similar (p=0.969), with most patients classified as ASA I. Radius or ulna fracture fixation was the most frequent procedure in both groups, followed by wrist or hand fracture fixation; the overall distribution of surgical procedures did not differ significantly (p=0.967). Mean surgical duration (78.6±18.8 vs 80.9±19.6 minutes; p=0.613) and tourniquet duration (64.2±16.4 vs 65.8±17.1 minutes; p=0.687) were comparable (Table 1).

Table 1. Baseline demographic, clinical and operative characteristics of participants receiving single-site or two-site ultrasound-guided costoclavicular block.

Characteristic	Single-site group (n=36)	Two-site group (n=36)	p value
	Frequency (%)/Mean ± SD		
Age, years	38.9 ± 12.6	40.1 ± 12.1	0.682
Gender			
Male	24 (66.7)	23 (63.9)	0.805
Female	12 (33.3)	13 (36.1)	
Weight, kg	64.8 ± 9.9	66.2 ± 10.4	0.516
Height, cm	163.5 ± 7.6	164.1 ± 8.1	0.747
BMI, kg/m²	24.2 ± 3.1	24.6 ± 3.3	0.598
ASA physical status			
ASA I	22 (61.1)	21 (58.3)	0.969

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ASA II	**12 (33.3)**	**13 (36.1)**	
ASA III	**2 (5.6)**	**2 (5.6)**	
Type of surgery			
Radius/ulna fracture fixation	**14 (38.9)**	**13 (36.1)**	**0.967**
Wrist or hand fracture fixation	**10 (27.8)**	**11 (30.6)**	
Tendon or peripheral nerve repair	**7 (19.4)**	**8 (22.2)**	
Other soft-tissue procedure	**5 (13.9)**	**4 (11.1)**	
Duration of surgery, minutes	**78.6 ± 18.8**	**80.9 ± 19.6**	**0.613**
Tourniquet duration, minutes	**64.2 ± 16.4**	**65.8 ± 17.1**	**0.687**

BMI: body mass index; ASA: American Society of Anesthesiologists.

Ultrasound scanning time was comparable between the single-site and two-site groups (1.8±0.5 vs 1.9±0.5 minutes; p=0.399). However, two-site injection required a significantly longer block-performance time (6.5±1.2 vs 5.7±1.0 minutes; p=0.003) and a greater median number of needle passes [2 (2–3) vs 1 (1–2); p<0.001]. Procedural pain scores remained low and comparable between groups [2 (1–3) in each group; p=0.238]. Good or excellent needle visibility and complete visualization of all three cords were achieved in more than 90% of patients in both groups, without significant intergroup differences (Table 2).

Table 2. Technical characteristics of single-site and two-site ultrasound-guided costoclavicular block performance.

Technical variable	**Single-site group (n=36)**	**Two-site group (n=36)**	**p value**
	Frequency (%)/Median (IQR)		
Ultrasound scanning time, minutes	**1.8 ± 0.5**	**1.9 ± 0.5**	**0.399**
Block-performance time, minutes	**5.7 ± 1.0**	**6.5 ± 1.2**	**0.003**
Number of needle passes	**1 (1–2)**	**2 (2–3)**	**<0.001**
Procedural pain score, NRS 0–10	**2 (1–3)**	**2 (1–3)**	**0.238**
Good or excellent needle visibility	**34 (94.4)**	**35 (97.2)**	**1.000**
Complete visualization of all three cords	**33 (91.7)**	**34 (94.4)**	**1.000**

IQR: interquartile range; Block-performance time extended from needle insertion to completion of local-anaesthetic injection. NRS: numerical rating scale.

The two-site group demonstrated significantly higher composite sensorimotor scores during the early assessment period. Mean scores were higher at 5 minutes (4.0±2.0 vs 3.1±1.7; p=0.044), 10 minutes (8.9±2.4 vs 6.8±2.3; p<0.001), 15 minutes (12.6±2.1 vs 10.5±2.2; p<0.001), 20 minutes (14.4±1.5 vs 13.1±1.8; p=0.001) and 25 minutes (15.2±1.0 vs 14.6±1.3; p=0.032). By 30 minutes, scores were similarly high in both groups (15.6±0.7 vs 15.3±0.9; p=0.119). The overall group-by-time interaction was significant (p<0.001) (Table 3).

Table 3. Sequential progression of composite sensorimotor blockade following single-site and two-site costoclavicular injections.

Time after injection	**Single-site group (n=36)**	**Two-site group (n=36)**	**p value**

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	Mean ± SD		
5 minutes	**3.1 ± 1.7**	**4.0 ± 2.0**	**0.044**
10 minutes	**6.8 ± 2.3**	**8.9 ± 2.4**	**<0.001**
15 minutes	**10.5 ± 2.2**	**12.6 ± 2.1**	**<0.001**
20 minutes	**13.1 ± 1.8**	**14.4 ± 1.5**	**0.001**
25 minutes	**14.6 ± 1.3**	**15.2 ± 1.0**	**0.032**
30 minutes	**15.3 ± 0.9**	**15.6 ± 0.7**	**0.119**

Composite sensorimotor scores ranged from 0 to 16 and incorporated sensory and motor blockade of the musculocutaneous, radial, median and ulnar nerves. A score ≥14 indicated readiness for surgery.

Two-site injection produced significantly shorter sensory (14.4±4.8 vs 18.9±5.7 minutes; p=0.001), motor (16.5±5.2 vs 21.7±6.1 minutes; p<0.001) and composite block-onset times (16.8±5.5 vs 22.3±6.4 minutes; p<0.001). Despite its longer performance time, the two-site technique reduced total anaesthesia-related time (23.3±5.8 vs 28.0±6.5 minutes; p=0.002). More patients in the two-site group were ready for surgery by 15 minutes (52.8% vs 22.2%; p=0.007) and 20 minutes (80.6% vs 55.6%; p=0.023). By 30 minutes, readiness (97.2% vs 94.4%; p=1.000) and successful surgical anaesthesia (97.2% vs 94.4%; p=1.000) were comparable. Supplemental block requirements, conversion to general anaesthesia and tourniquet discomfort were uncommon and did not differ significantly (Table 4).

Table 4. Block-onset characteristics, readiness for surgery and effectiveness of surgical anaesthesia.

Outcome	**Single-site group (n=36)**	**Two-site group (n=36)**	**p value**
	Frequency (%)/Mean ± SD		
Sensory block-onset time, minutes	**18.9 ± 5.7**	**14.4 ± 4.8**	**0.001**
Motor block-onset time, minutes	**21.7 ± 6.1**	**16.5 ± 5.2**	**<0.001**
Composite block-onset time, minutes	**22.3 ± 6.4**	**16.8 ± 5.5**	**<0.001**
Total anaesthesia-related time, minutes	**28.0 ± 6.5**	**23.3 ± 5.8**	**0.002**
Participants ready for surgery			
By 15 minutes	**8 (22.2)**	**19 (52.8)**	**0.007**
By 20 minutes	**20 (55.6)**	**29 (80.6)**	**0.023**
By 25 minutes	**29 (80.6)**	**33 (91.7)**	**0.307**
By 30 minutes	**34 (94.4)**	**35 (97.2)**	**1.000**
Successful surgical anaesthesia	**34 (94.4)**	**35 (97.2)**	**1.000**
Supplemental peripheral nerve block	**1 (2.8)**	**1 (2.8)**	**1.000**
Conversion to general anaesthesia	**1 (2.8)**	**0 (0.0)**	**1.000**
Tourniquet discomfort requiring fentanyl	**4 (11.1)**	**3 (8.3)**	**1.000**

Composite onset was the interval from completion of injection to attainment of a sensorimotor score ≥14/16. Total anaesthesia-related time was the sum of block-performance and composite-onset times.

The duration of sensory blockade was comparable between the two-site and single-site groups (541±91 vs 522±87 minutes; p=0.368), as was motor-block duration (465±82 vs 448±79 minutes; p=0.373). Time to first rescue analgesia showed a modest but non-significant prolongation with two-site injection (591±106 vs 568±101 minutes; p=0.349). The proportions requiring rescue analgesia within 24 hours were 80.6% and 86.1%, respectively (p=0.527), while diclofenac consumption was

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similar. Postoperative NRS pain scores at 2, 6, 12 and 24 hours also showed no statistically significant differences between groups (all p>0.05) (Table 5).

Table 5. Duration of sensory and motor blockade and postoperative analgesic outcomes.

Outcome	Single-site group (n=36)	Two-site group (n=36)	p value
	Frequency (%)/Mean ± SD/Median (IQR)		
Duration of sensory blockade, minutes	522 ± 87	541 ± 91	0.368
Duration of motor blockade, minutes	448 ± 79	465 ± 82	0.373
Time to first rescue analgesia, minutes	568 ± 101	591 ± 106	0.349
Patients requiring rescue analgesia within 24 hours	31/36 (86.1)	29/36 (80.6)	0.527
Diclofenac consumption during 24 hours, mg	75 (75–150)	75 (75–150)	0.412
Postoperative pain score, NRS 0–10			
2 hours	0.8 ± 0.7	0.7 ± 0.6	0.517
6 hours	1.5 ± 0.9	1.4 ± 0.8	0.602
12 hours	3.2 ± 1.0	3.0 ± 0.9	0.376
24 hours	2.8 ± 1.0	2.6 ± 0.9	0.376

IQR: interquartile range; Block-duration analyses included successful blocks only. NRS: numerical rating scale.

Minor block-related adverse events occurred in 11.1% of patients in the single-site group and 16.7% in the two-site group (p=0.735). Accidental vascular puncture, transient paraesthesia, local bruising or small haematoma, and postoperative nausea or vomiting were infrequent and comparable between groups. No patient developed local-anaesthetic systemic toxicity, pneumothorax or persistent neurological deficit. High or very high satisfaction was reported by 86.1% of single-site and 88.9% of two-site recipients (p=1.000), with comparable mean satisfaction scores (4.5±0.6 vs 4.6±0.5; p=0.445) (Table 6).

Table 6. Block-related adverse events and patient satisfaction following single-site and two-site costoclavicular block.

Outcome	Single-site group (n=36)	Two-site group (n=36)	p value
	Frequency (%)/Mean ± SD		
Any minor block-related adverse event	4 (11.1)	6 (16.7)	0.735
Accidental vascular puncture	1 (2.8)	2 (5.6)	1.000
Transient paraesthesia during needle advancement	2 (5.6)	3 (8.3)	1.000
Local bruising or small haematoma	1 (2.8)	1 (2.8)	1.000
Postoperative nausea or vomiting	2 (5.6)	2 (5.6)	1.000
Local-anaesthetic systemic toxicity	0 (0.0)	0 (0.0)	—
Pneumothorax	0 (0.0)	0 (0.0)	—
Persistent neurological deficit	0 (0.0)	0 (0.0)	—
High or very high patient satisfaction	31 (86.1)	32 (88.9)	1.000

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Overall satisfaction score, 1–5	**4.5 ± 0.6**	**4.6 ± 0.5**	**0.445**

Fisher's exact test was used for comparisons involving infrequent adverse events.

Discussion

The present prospective randomized study demonstrated that two-site ultrasound-guided costoclavicular block accelerated the development of surgical anaesthesia compared with single-site injection. Although the two-site technique required a longer performance time (6.5±1.2 versus 5.7±1.0 minutes; p=0.003) and more needle passes (median 2 versus 1; p<0.001), it significantly shortened sensory onset (14.4±4.8 versus 18.9±5.7 minutes; p=0.001), motor onset (16.5±5.2 versus 21.7±6.1 minutes; p<0.001) and composite onset (16.8±5.5 versus 22.3±6.4 minutes; p<0.001). Consequently, total anaesthesia-related time was reduced by approximately five minutes. Baseline demographic and operative characteristics were comparable, supporting the likelihood that the observed differences were attributable to the injection strategy rather than patient or procedural heterogeneity.

The faster onset following two-site injection can be explained by more uniform local-anaesthetic distribution within the costoclavicular space. Although the three cords are closely clustered, connective-tissue septa may restrict diffusion from a single central deposit. A second injection at the medial cord–arterial interface may reduce the diffusion distance and facilitate earlier blockade of the medial cord and its terminal ulnar and median components. Tran et al. similarly found that double-injection supraclavicular block shortened onset from 21.7 to 17.5 minutes (p=0.021), although performance time increased from 6.0 to 7.2 minutes [11]. Conversely, their infraclavicular study found no significant onset advantage with double injection, suggesting that benefit depends on the anatomical level and precise location of the second deposit [12]. Desgagnés et al. also observed comparable complete sensory block at 15 minutes with single and triple infraclavicular injections (84% versus 78%; p=0.61) [13], while Roy et al. found no clear improvement in overall supraclavicular block success with double injection [14]. These differences may reflect variations in local-anaesthetic volume, concentration, endpoint definitions and fascial anatomy.

In the present study, composite block scores were significantly higher with two-site injection from 5 through 25 minutes, and more patients were ready for surgery at 15 minutes (52.8% versus 22.2%; p=0.007) and 20 minutes (80.6% versus 55.6%; p=0.023). Similar advantages of targeted multi-deposit techniques have been reported by Techasuk et al., particularly when local anaesthetic was directed towards specific neural clusters [15], and by Luo et al., who observed improved distal sensorimotor blockade when the inferior trunk was specifically targeted [16]. Choudhary et al. likewise reported faster sensory and motor onset with double-point supraclavicular injection, although the technique required additional procedural time [17]. Collectively, these findings indicate that targeted distribution primarily influences the speed and uniformity of neural exposure rather than the eventual maximum block intensity.

Despite earlier readiness, surgical success at 30 minutes was comparable between the two groups (97.2% versus 94.4%; p=1.000). This convergence suggests that a single injection usually achieves adequate spread when sufficient time is allowed. Randomized comparisons involving costoclavicular, supraclavicular, lateral sagittal and axillary approaches have similarly reported high ultimate success despite differences in early block dynamics [18–20]. Thus, two-site injection may be most advantageous when operating-room turnover and rapid readiness are priorities, whereas single-site injection remains a reasonable option when technical simplicity and minimal needle manipulation are preferred.

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Sensory-block duration, motor-block duration, time to rescue analgesia, 24-hour diclofenac consumption and postoperative pain scores were statistically similar. Because both groups received the same dose and concentration of ropivacaine, redistribution across two sites would be expected to alter onset more than duration, which is governed principally by total dose, tissue binding, vascular absorption and intrinsic pharmacology. Dose-finding studies have reported substantial variation in effective costoclavicular volumes: Sotthisopha et al. estimated an MEV90 of 34 mL for 1.5% lidocaine with epinephrine [10], whereas Kewlani et al. estimated an ED95 of approximately 18.9 mL for 0.5% ropivacaine [22]. Such differences emphasize the influence of drug selection and success definitions.

Finally, procedural discomfort and patient satisfaction were comparable despite additional needle manipulation. Minor adverse events occurred in 11.1% and 16.7% of patients (p=0.735), with no systemic local-anaesthetic toxicity, pneumothorax or persistent neurological deficit. Comparable safety has been described in randomized costoclavicular studies [18–20]. Hong et al. additionally reported less hemidiaphragmatic paralysis with costoclavicular than supraclavicular block (11.4% versus 47.5%; p=0.002) [21]. Overall, two-site costoclavicular injection appears to offer clinically useful acceleration of block onset without materially affecting final success, analgesic duration, patient satisfaction or short-term safety.

Limitations

This study has several limitations. It was conducted at a single centre with a relatively small sample, limiting generalisability. The performing anaesthesiologist could not be blinded, creating potential performance bias. Follow-up was limited to the early postoperative period, precluding assessment of delayed neurological complications. Diaphragmatic function and plasma ropivacaine concentrations were not evaluated. Furthermore, operator experience may influence procedural time, needle passes and block success.

Conclusion

Two-site ultrasound-guided costoclavicular block provided faster and more uniform sensorimotor blockade than single-site injection in patients undergoing below-elbow surgery. It significantly shortened sensory, motor and composite onset times and increased the proportion of patients ready for surgery within 15–20 minutes, despite requiring modestly longer performance time and more needle passes. Both techniques achieved similarly high final surgical success, postoperative analgesic duration, patient satisfaction and safety. These findings indicate that two-site injection may be preferable when rapid operating-room readiness is important, whereas single-site injection remains an effective and technically simpler alternative. Larger multicentre trials should evaluate lower local-anaesthetic volumes and uncommon complications.

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