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Original Research Article

COMPARISON OF ULTRASOUND-GUIDED COSTOCLAVICULAR VERSUS AXILLARY BRACHIAL PLEXUS BLOCK FOR FOREARM AND HAND SURGERIES: A PROSPECTIVE RANDOMIZED CLINICAL STUDY

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ABSTRACT

Background: Ultrasound-guided brachial plexus block has become an important regional anaesthesia technique for upper limb surgeries due to its safety, effectiveness, and prolonged postoperative analgesia. Among various approaches, costoclavicular and axillary brachial plexus blocks are commonly used for forearm and hand surgeries. However, limited comparative data are available regarding their block characteristics and clinical efficacy. **Aim:** To compare the efficacy of ultrasound-guided costoclavicular brachial plexus block versus ultrasound-guided axillary brachial plexus block in patients undergoing forearm and hand surgeries. **Materials and Methods:** This prospective randomized clinical study included 60 patients aged 18–70 years belonging to ASA grade I and II scheduled for elective forearm and hand surgeries. Patients were randomly divided into two groups of 30 each: Group G-RL received ultrasound-guided costoclavicular brachial plexus block and Group G-RH received ultrasound-guided axillary brachial plexus block. Parameters assessed included onset of sensory blockade, onset of motor blockade, time to attain surgical anaesthesia, duration of analgesia, block performance time, hemodynamic changes, requirement of rescue analgesia, and complications. Statistical analysis was performed using independent t-test and Chi-square test, with $p<0.05$ considered statistically significant. **Results:** The onset of sensory blockade was significantly faster in Group G-RL compared to Group G-RH for median nerve (3.82 ± 1.12 vs 4.67 ± 1.36 min; p=0.011), ulnar nerve (4.05 ± 1.20 vs 5.10 ± 1.49 min; p=0.004), radial nerve (4.30 ± 1.42 vs 5.36 ± 1.64 min; p=0.010), and overall sensory onset (4.18 ± 1.34 vs 5.12 ± 1.58 min; p=0.016). Motor blockade onset was also significantly faster in Group G-RL (6.52 ± 1.86 min) compared to Group G-RH (8.10 ± 2.25 min; p=0.004). Time to attain surgical anaesthesia was significantly shorter in Group G-RL (9.18 ± 2.18 min) compared to Group G-RH (11.05 ± 2.64 min; p=0.004). Duration of analgesia was significantly prolonged in Group G-RL (527.4 ± 72.5 min) compared to Group G-RH (458.6 ± 68.2 min; $p<0.001$). Block performance time was significantly shorter in Group G-RL (6.42 ± 1.21 min) than Group G-RH (8.36 ± 1.48 min; $p<0.001$). Hemodynamic parameters and complication rates were comparable between both groups. **Conclusion:** Ultrasound-guided costoclavicular brachial plexus block provided faster sensory and motor blockade, earlier surgical anaesthesia, prolonged postoperative analgesia, and shorter block performance time compared to ultrasound-guided axillary brachial plexus block. Both techniques were safe and effective; however, the costoclavicular approach demonstrated superior overall block characteristics for forearm and hand surgeries.

INTRODUCTION

Brachial plexus block is widely used for upper limb surgeries because it provides excellent surgical anaesthesia, prolonged postoperative analgesia, reduced opioid requirement, early mobilization, and avoidance of complications associated with general anaesthesia. With the advent of ultrasound guidance, peripheral nerve blocks have become safer and more reliable due to direct visualization of nerves, surrounding structures, needle placement, and spread of local anaesthetic solution. Among various approaches to the brachial plexus, the axillary and costoclavicular approaches are increasingly preferred for surgeries involving the forearm and hand because of their effectiveness and relatively lower complication rates. The axillary brachial plexus block is a commonly practiced technique for distal upper limb surgeries due to its superficial location and reduced risk of pneumothorax or phrenic nerve palsy. However, the musculocutaneous nerve may sometimes be spared because of its variable anatomical course, leading to incomplete block and delayed onset of anaesthesia. On the other hand, the costoclavicular approach, a relatively newer infraclavicular technique, targets the cords of the brachial plexus clustered together lateral to the axillary artery in the costoclavicular space. This compact arrangement allows uniform spread of local anaesthetic, potentially resulting in faster onset, better block quality, and reduced local anaesthetic requirement. Ultrasound-guided costoclavicular block has recently gained popularity because of consistent sonoanatomy, ease of needle visualization, and lower incidence of complications. Several studies have shown that costoclavicular block provides rapid sensory and motor blockade with improved success rates for forearm and hand surgeries. Regional anaesthesia using ultrasound guidance also minimizes systemic toxicity by reducing the required volume of local anaesthetic and improves patient satisfaction by providing prolonged postoperative analgesia. Ropivacaine is commonly used for brachial plexus block because of its long duration of action, lower cardiotoxicity, and preferential sensory blockade compared to bupivacaine. Despite increasing use of costoclavicular block, limited comparative studies are available evaluating its effectiveness against axillary brachial plexus block in forearm and hand surgeries. Hence, the present prospective randomized clinical study was undertaken to compare ultrasound-guided costoclavicular and axillary brachial plexus blocks with respect to onset of sensory and motor blockade, duration of analgesia, time to attain surgical anaesthesia, block performance time, hemodynamic stability, and complications in patients undergoing forearm and hand surgeries.

Aim

To compare the efficacy of ultrasound-guided costoclavicular brachial plexus block versus ultrasound-guided axillary brachial plexus block in patients undergoing forearm and hand surgeries.

Objectives

1. To compare the onset time of sensory blockade between costoclavicular and axillary brachial plexus block.
2. To compare the onset time of motor blockade and time to attain surgical anaesthesia between the two study groups.
3. To compare duration of analgesia, block performance time, hemodynamic changes, and complications between the two groups.

MATERIALS AND METHODS

Source of Data

The data was collected from patients undergoing elective forearm and hand surgeries under ultrasound-guided brachial plexus block in the Department of Anaesthesiology at a tertiary care teaching hospital. Patients fulfilling the inclusion criteria were enrolled after obtaining written informed consent.

Study Design

The study was designed as a prospective, randomized, comparative clinical study.

Study Location

The study was conducted in the Department of Anaesthesiology and Critical Care at a tertiary care hospital attached to a teaching institute.

Study Duration

The study was conducted over a period of 18 months from the date of approval by the Institutional Ethics Committee.

Sample Size

A total sample size of 60 patients was included in the study. Patients were randomly allocated into two groups of 30 each:

- **Group G-RL (n=30):** Patients receiving ultrasound-guided costoclavicular brachial plexus block.
- **Group G-RH (n=30):** Patients receiving ultrasound-guided axillary brachial plexus block.

Sample size was calculated based on previous studies comparing onset of sensory and motor blockade between brachial plexus block techniques, considering 95% confidence interval and 80% power of study.

Inclusion Criteria

1. Patients aged between 18 and 70 years.
2. Patients of either gender.
3. Patients belonging to ASA physical status I and II.
4. Patients scheduled for elective forearm and hand surgeries under brachial plexus block.
5. Patients willing to provide written informed consent.

Exclusion Criteria

1. Patient refusal for regional anaesthesia.
2. Known allergy to local anaesthetic drugs.

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3. Coagulopathy or patients on anticoagulant therapy.
4. Infection at the site of injection.
5. Pre-existing neurological deficit involving upper limbs.
6. Severe respiratory disease or contralateral phrenic nerve palsy.
7. Pregnancy and lactating women.
8. Psychiatric illness or inability to understand pain assessment scales.
9. BMI >35 kg/m².

Procedure and Methodology

After obtaining Institutional Ethics Committee approval and written informed consent, eligible patients were enrolled in the study. Detailed pre-anaesthetic evaluation including history, clinical examination, and relevant investigations was performed one day prior to surgery. Patients were kept nil per oral for 6 hours before surgery.

In the operation theatre, standard monitors including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and heart rate monitoring were attached. Intravenous access was secured with an 18G cannula and baseline vital parameters were recorded.

Patients were randomly allocated into two groups using computer-generated randomization.

Group G-RL

Patients received ultrasound-guided costoclavicular brachial plexus block. Under strict aseptic precautions, a high-frequency linear ultrasound probe was placed below the clavicle in the infraclavicular region to identify the axillary artery and cords of the brachial plexus clustered in the costoclavicular space. A 22G insulated block needle was introduced using in-plane technique and the study drug was injected after negative aspiration with visualization of spread around the cords.

Group G-RH

Patients received ultrasound-guided axillary brachial plexus block. The ultrasound probe was placed in the axillary region to identify the axillary artery and surrounding nerves including median, ulnar, radial, and musculocutaneous nerves. Using an in-plane approach, local anaesthetic solution was deposited around individual nerves after negative aspiration.

The time required for block performance was recorded. Sensory blockade was assessed using pinprick method over median, ulnar, radial, and musculocutaneous nerve distributions every 2 minutes until complete sensory block was achieved. Motor blockade was assessed using modified Bromage scale for upper limb movements.

Parameters recorded included:

- Onset time of sensory blockade
- Onset time of motor blockade
- Time to attain surgical anaesthesia
- Duration of sensory and motor blockade
- Duration of postoperative analgesia
- Hemodynamic parameters (HR, SBP, DBP, MAP, SpO_2)
- Requirement of rescue analgesia or conversion to general anaesthesia
- Complications such as vascular puncture, pneumothorax, Horner's syndrome, local anaesthetic toxicity, nausea, vomiting, or nerve injury

Postoperatively, patients were monitored in recovery room and pain assessment was done using Visual Analog Scale (VAS).

Sample Processing

All collected clinical and demographic data were entered in a predesigned case record form. Data was coded and tabulated using Microsoft Excel spreadsheet before statistical analysis.

Statistical Methods

The collected data was analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Continuous variables were expressed as mean ± standard deviation and categorical variables were expressed as frequency and percentage. Independent Student's t-test was used for comparison of continuous variables between groups. Chi-square test or Fisher's exact test was used for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Data Collection

Data collection was performed prospectively using a structured case record proforma. Demographic details, intraoperative observations, block characteristics, hemodynamic variables, duration of analgesia, postoperative pain scores, and complications were recorded systematically for all patients throughout the perioperative period.

RESULTS

Table 1: Comparison of baseline characteristics and overall block efficacy between study groups

Variable	G-RL (n=30)	G-RH (n=30)	Test value	95% CI	p-value
Age (years)	39.8 ± 12.1	41.2 ± 11.6	t=0.46	-7.53 to 4.73	0.649
BMI (kg/m²)	24.1 ± 3.2	24.7 ± 3.5	t=0.69	-2.33 to 1.13	0.491
Male	18 (60.0%)	17 (56.7%)	χ^2=0.07		0.793
Female	12 (40.0%)	13 (43.3%)			
ASA I	20 (66.7%)	19 (63.3%)	χ^2=0.07		0.787
ASA II	10 (33.3%)	11 (36.7%)			
Successful surgical block	29 (96.7%)	27 (90.0%)	χ^2=1.07		0.301

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Table 1 compares the baseline demographic characteristics and overall block efficacy between Group G-RL and Group G-RH. The mean age of patients in Group G-RL was 39.8 ± 12.1 years, while in Group G-RH it was 41.2 ± 11.6 years. The difference between the groups was statistically insignificant (t=0.46, p=0.649), indicating comparable age distribution among study participants. Similarly, the mean BMI was 24.1 ± 3.2 kg/m² in Group G-RL and 24.7 ± 3.5 kg/m² in Group G-RH, with no statistically significant difference (t=0.69, p=0.491). Gender distribution was also comparable between the groups, with males constituting 60.0% in Group G-RL and 56.7% in Group G-RH, while females accounted for 40.0% and 43.3% respectively (χ^2=0.07, p=0.793). Distribution according to ASA grading showed that ASA I patients were predominant in both groups, comprising 66.7% in Group G-RL and 63.3% in Group G-RH, whereas ASA II patients accounted for 33.3% and 36.7% respectively. This difference was not statistically significant (χ^2=0.07, p=0.787). Successful surgical block was achieved in 96.7% of patients in Group G-RL compared to 90.0% in Group G-RH; however, the difference was statistically insignificant (χ^2=1.07, p=0.301).

Table 2: Comparison of onset time of sensory blockade between study groups

Sensory blockade onset	G-RL Mean ± SD	G-RH Mean ± SD	t-value	95% CI	p-value
Median nerve (min)	3.82 ± 1.12	4.67 ± 1.36	2.64	-1.49 to -0.21	0.011*
Ulnar nerve (min)	4.05 ± 1.20	5.10 ± 1.49	3.01	-1.75 to -0.35	0.004*
Radial nerve (min)	4.30 ± 1.42	5.36 ± 1.64	2.68	-1.85 to -0.27	0.010*
Musculocutaneous nerve (min)	4.55 ± 1.51	5.35 ± 1.72	1.91	-1.64 to 0.04	0.061
Overall sensory onset (min)	4.18 ± 1.34	5.12 ± 1.58	2.49	-1.70 to -0.18	0.016*

Table 2 compares the onset time of sensory blockade between Group G-RL and Group G-RH. The onset of sensory blockade for the median nerve was significantly faster in Group G-RL (3.82 ± 1.12 minutes) compared to Group G-RH (4.67 ± 1.36 minutes), with statistical significance (t=2.64, p=0.011). Similarly, the onset of sensory blockade for the ulnar nerve was significantly shorter in Group G-RL (4.05 ± 1.20 minutes) than in Group G-RH (5.10 ± 1.49 minutes), showing a highly significant difference (t=3.01, p=0.004). Radial nerve sensory blockade also occurred significantly earlier in Group G-RL (4.30 ± 1.42 minutes) compared to Group G-RH (5.36 ± 1.64 minutes) (t=2.68, p=0.010). Although the musculocutaneous nerve blockade onset was faster in Group G-RL (4.55 ± 1.51 minutes) than Group G-RH (5.35 ± 1.72 minutes), the difference did not reach statistical significance (t=1.91, p=0.061). The overall sensory onset time was significantly lower in Group G-RL (4.18 ± 1.34 minutes) compared to Group G-RH (5.12 ± 1.58 minutes), with a statistically significant p-value (t=2.49, p=0.016).

Table 3: Comparison of motor blockade and time to attain surgical anaesthesia

Variable	G-RL Mean ± SD	G-RH Mean ± SD	t-value	95% CI	p-value
Onset of motor blockade (min)	6.52 ± 1.86	8.10 ± 2.25	2.96	-2.65 to -0.51	0.004*
Time to attain surgical anaesthesia (min)	9.18 ± 2.18	11.05 ± 2.64	2.99	-3.12 to -0.62	0.004*

Table 3 compares the onset of motor blockade and time required to attain surgical anaesthesia between the two study groups. The mean onset time of motor blockade in Group G-RL was 6.52 ± 1.86 minutes, which was significantly shorter than Group G-RH, where the onset time was 8.10 ± 2.25 minutes. This difference was statistically significant (t=2.96, p=0.004). Similarly, the mean time to attain surgical anaesthesia was significantly lower in Group G-RL (9.18 ± 2.18 minutes) compared to Group G-RH (11.05 ± 2.64 minutes), with statistical significance (t=2.99, p=0.004).

Table 4: Comparison of duration of analgesia, block performance time, hemodynamic changes and complications

Variable	G-RL (n=30)	G-RH (n=30)	Test value	95% CI	p-value
Duration of analgesia (min)	527.4 ± 72.5	458.6 ± 68.2	t=3.79	32.42 to 105.18	<0.001*
Block performance time (min)	6.42 ± 1.21	8.36 ± 1.48	t=5.56	-2.64 to -1.24	<0.001*
Baseline HR (bpm)	82.4 ± 8.6	83.1 ± 9.1	t=0.31	-5.28 to 3.88	0.761
Baseline MAP (mmHg)	91.5 ± 7.2	90.8 ± 7.6	t=0.37	-3.13 to 4.53	0.716
Baseline SpO_2 (%)	98.3 ± 1.1	98.1 ± 1.2	t=0.67	-0.40 to 0.80	0.504
HR at 30 min (bpm)	80.2 ± 7.9	81.7 ± 8.3	t=0.72	-5.69 to 2.69	0.476
MAP at 30 min (mmHg)	89.2 ± 6.8	90.1 ± 7.1	t=0.50	-4.49 to 2.69	0.618
SpO_2 at 30 min (%)	98.4 ± 1.0	98.2 ± 1.1	t=0.74	-0.34 to 0.74	0.464
Rescue analgesia required	2 (6.7%)	5 (16.7%)	χ^2=1.46		0.228
Complications	1 (3.3%)	3 (10.0%)	χ^2=1.07		0.301

Table 4 compares the duration of analgesia, block performance time, hemodynamic parameters, and complications between Group G-RL and Group G-RH. The duration of analgesia was significantly longer in Group G-RL (527.4 ± 72.5 minutes) compared to Group G-RH (458.6 ± 68.2 minutes), with a highly significant difference (t=3.79, p<0.001). In contrast, the block performance time

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was significantly shorter in Group G-RL (6.42 ± 1.21 minutes) than Group G-RH (8.36 ± 1.48 minutes), indicating easier and quicker administration of the block in the costoclavicular group (t=5.56, p<0.001). Hemodynamic parameters including baseline heart rate, mean arterial pressure, and oxygen saturation were comparable between both groups, with no statistically significant differences observed. Similarly, heart rate, MAP, and SpO_2 measured at 30 minutes after block administration also remained comparable and statistically insignificant between the groups, indicating stable hemodynamic profiles in both techniques. Rescue analgesia was required in 6.7% of patients in Group G-RL and 16.7% in Group G-RH; however, this difference was not statistically significant (χ^2=1.46, p=0.228). Complications were minimal in both groups, occurring in 3.3% of patients in Group G-RL and 10.0% in Group G-RH, without statistically significant difference (χ^2=1.07, p=0.301).

DISCUSSION

In the present study, baseline characteristics were comparable between G-RL and G-RH groups. The mean age was 39.8 ± 12.1 years in G-RL and 41.2 ± 11.6 years in G-RH, with no statistically significant difference (p=0.649). BMI, gender distribution, and ASA grading were also comparable between groups, indicating adequate randomization and baseline homogeneity. Successful surgical block was achieved in 96.7% of patients in G-RL and 90.0% in G-RH, though the difference was not statistically significant (p=0.301). Similar baseline comparability was reported by Nalini KB et al. (2021),[1] and Silva J et al. (2024),[2] who studied ultrasound-guided costoclavicular brachial plexus block and found comparable demographic profiles among study groups. Likewise, Nijs K et al. (2023),[3] and Baral U et al. (2025),[4] reported high success rates with ultrasound-guided axillary brachial plexus block, supporting the reliability of ultrasound guidance in upper limb regional anaesthesia.

In the present study, sensory blockade occurred significantly earlier in G-RL compared to G-RH. The onset of median nerve blockade was 3.82 ± 1.12 minutes in G-RL versus 4.67 ± 1.36 minutes in G-RH (p=0.011). Ulnar nerve, radial nerve, and overall sensory onset were also significantly faster in G-RL. This faster onset may be due to the compact arrangement of the brachial plexus cords in the costoclavicular space, allowing more uniform spread of local anaesthetic. Similar findings were observed by Guzel M et al. (2023),[5] who described the costoclavicular space as a consistent anatomical location where the cords are clustered together. Zhang L et al. (2021),[6] also found that costoclavicular block provided rapid and effective sensory blockade. In comparison, axillary block may require separate deposition around individual nerves, which can delay complete sensory onset, as also reported by Saranlal AM et al. (2024),[7] and Senapati LK et al. (2025).[8]

The onset of motor blockade was also significantly faster in G-RL than G-RH, with mean onset times of 6.52 ± 1.86 minutes and 8.10 ± 2.25 minutes respectively (p=0.004). Time to attain surgical anaesthesia was also significantly shorter in G-RL (9.18 ± 2.18 minutes) than G-RH (11.05 ± 2.64 minutes, p=0.004). These findings suggest that costoclavicular block may provide faster readiness for surgery. This observation is consistent with the findings of Chaithrashree B et al. (2025),[9] who reported that costoclavicular block provided rapid onset and reliable surgical anaesthesia for upper limb procedures. Similarly, Devi AY et al. (2024),[10] observed effective motor and sensory blockade with costoclavicular technique due to the close grouping of cords. In contrast, axillary block may require blockade of median, ulnar, radial, and musculocutaneous nerves separately, which may prolong the time to complete motor blockade.

In the present study, duration of analgesia was significantly longer in G-RL (527.4 ± 72.5 minutes) compared to G-RH (458.6 ± 68.2 minutes), with p<0.001. This indicates better postoperative analgesic efficacy with the costoclavicular approach. Similar prolonged analgesia was reported by Rao A et al. (2025),[11] in ultrasound-guided costoclavicular block. The longer duration may be attributed to more compact local anaesthetic spread around the cords of the brachial plexus. Block performance time was also significantly shorter in G-RL (6.42 ± 1.21 minutes) than G-RH (8.36 ± 1.48 minutes, p<0.001), suggesting technical ease once the costoclavicular sonoanatomy was identified. Comparable findings were noted by Ramesh SM et al. (2021),[12] who reported that ultrasound-guided infraclavicular approaches provided efficient block performance with reliable anaesthesia.

Hemodynamic parameters including heart rate, MAP, and SpO_2 at baseline and 30 minutes were comparable between both groups, with no statistically significant differences. This indicates that both techniques maintained stable intraoperative hemodynamics. Similar hemodynamic stability was reported by Cesur S et al. (2021),[13] in patients receiving brachial plexus block for upper limb surgery. Rescue analgesia was required in 6.7% of patients in G-RL compared to 16.7% in G-RH, although the difference was not statistically significant (p=0.228). Complications were also minimal in both groups, occurring in 3.3% of G-RL and 10.0% of G-RH patients (p=0.301).

CONCLUSION

The present prospective randomized clinical study demonstrated that ultrasound-guided costoclavicular brachial plexus block was superior to ultrasound-guided axillary brachial plexus block for forearm and hand surgeries in terms of faster onset of sensory

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blockade, faster onset of motor blockade, and shorter time to attain surgical anaesthesia. The costoclavicular approach also provided significantly prolonged duration of postoperative analgesia and shorter block performance time. Both techniques were associated with high success rates, stable hemodynamic parameters, and minimal complications, confirming their safety and efficacy for upper limb regional anaesthesia. However, the costoclavicular approach showed better overall block characteristics and postoperative analgesic profile compared to the axillary approach. Therefore, ultrasound-guided costoclavicular brachial plexus block can be considered an effective and reliable alternative to axillary brachial plexus block for forearm and hand surgeries.

Limitations of the study

1. The study was conducted at a single tertiary care centre, limiting the generalizability of results to other institutions and populations.
2. The sample size was relatively small, which may reduce the statistical power for detecting rare complications.
3. Only ASA grade I and II patients were included; therefore, results may not be applicable to high-risk patients with severe systemic illness.
4. Long-term neurological outcomes and delayed complications were not evaluated.
5. Operator expertise and learning curve in ultrasound-guided regional anaesthesia may have influenced block performance and success rates.
6. Patient satisfaction scores were not assessed in detail.
7. Different types and durations of forearm and hand surgeries may have affected postoperative analgesic requirements.
8. Blinding of the anaesthesiologist performing the block was not possible due to the nature of the intervention.
9. Postoperative analgesic consumption beyond the initial analgesia duration was not evaluated.
10. The study did not compare different volumes or concentrations of local anaesthetic agents.

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