Original Research

A COMPARATIVE STUDY OF INFRACLAVICULAR AND RETROCLAVICULAR BRACHIAL PLEXUS BLOCK FOR BELOW ELBOW SURGERIES

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ABSTRACT

Background: Ultrasound-guided brachial plexus block is an effective regional anaesthetic technique for below elbow surgeries, providing excellent surgical anaesthesia and prolonged postoperative analgesia. The infraclavicular approach is widely practiced, whereas the retroclavicular approach has gained popularity because of improved needle visualization during ultrasound-guided block placement. This study compared the efficacy and safety of these two approaches.

Methods: A prospective randomized comparative study was conducted in 80 adult patients (ASA physical status I–II) undergoing elective below elbow surgeries. Patients were randomly allocated into two equal groups. Group I received an ultrasound-guided infraclavicular brachial plexus block, whereas Group R received an ultrasound-guided retroclavicular brachial plexus block. Both groups received 30 mL of 0.5% ropivacaine with fentanyl 50 µg. The primary outcomes were onset and duration of sensory and motor block. Secondary outcomes included duration of postoperative analgesia, block performance time, haemodynamic changes, and procedure-related complications.

Results: Both techniques achieved successful surgical anaesthesia with a high success rate. The retroclavicular approach demonstrated significantly better needle visualization and shorter block performance time ($p<0.05$). The onset of sensory and motor block was comparable between groups. However, the retroclavicular group showed slightly prolonged sensory block, motor block, and postoperative analgesia compared with the infraclavicular group. Haemodynamic parameters remained stable throughout the perioperative period, and no major complications were observed in either group.

Conclusion: Both infraclavicular and retroclavicular brachial plexus blocks are safe and effective techniques for below elbow surgeries. The retroclavicular approach provides superior needle visualization and marginally longer postoperative analgesia while maintaining a comparable success rate and favourable safety profile, making it a valuable alternative to the conventional infraclavicular approach.

Keywords: Brachial Plexus Block, Infraclavicular; Retroclavicular, Ropivacaine, Fentanyl, Below Elbow Surgery.

INTRODUCTION

Brachial plexus block is a well-established regional anaesthetic technique for upper limb surgeries, offering excellent surgical anaesthesia, prolonged postoperative analgesia, reduced opioid consumption, early mobilisation, and improved patient satisfaction.

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Because of its favorable safety profile, quick start, and high success rate, ultrasound-guided brachial plexus block is the most popular regional method for below-elbow procedures. The accuracy of needle insertion has been greatly improved by the use of ultrasound, which minimizes block-related difficulties while enabling direct view of brain structures, surrounding arteries, and local anesthetic dissemination. [1,2]

The cords of the brachial plexus encircling the axillary artery are the focus of the well-known infraclavicular approach. For treatments affecting the elbow, forearm, wrist, and hand, it offers dense

anesthesia with a comparatively low risk of complications. However, the steep insertion angle may occasionally make needle visibility problematic, especially in patients with complex anatomy. [3,4]

The infraclavicular technique has been modified to create the retroclavicular approach. This method improves sonographic visibility and offers a more favorable in-plane needle trajectory without changing the target location by inserting the needle posterior to the clavicle. While maintaining same block efficacy and safety, improved needle visibility may make block execution easier and boost procedural confidence. [5,6]

Ropivacaine is a long-acting amide local anesthetic that is appropriate for peripheral nerve blocks since it has less neurotoxicity and cardiotoxicity than bupivacaine. Fentanyl has been shown to improve patient comfort and surgical analgesia without significantly increasing side effects when added as an adjuvant. [7]

Despite the growing use of both infraclavicular and retroclavicular techniques, there is still little data comparing their clinical efficacy in below-elbow procedures. With a focus on block features, postoperative analgesia, procedural efficiency, hemodynamic stability, and safety, the current study was conducted to compare ultrasound-guided infraclavicular and retroclavicular brachial plexus blocks using 0.5% ropivacaine with fentanyl 50 µg. [8, 9]

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology of a tertiary care teaching hospital over a period of 18 months after obtaining approval from the Institutional Ethics Committee.

Ethical Considerations

The study was approved by the Institutional Ethics Committee before commencement. Written informed consent was obtained from all participants after explaining the study objectives and procedures. Patient confidentiality was maintained throughout the study, and participation was entirely voluntary. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Study Population

A total of 80 adult patients scheduled for elective below elbow surgeries under ultrasound-guided brachial plexus block were included in the study. Patients were randomly allocated into two equal groups comprising 40 patients each.

- **Group I:** Ultrasound-guided Infraclavicular brachial plexus block
- **Group R:** Ultrasound-guided Retroclavicular brachial plexus block

Inclusion Criteria

- Age between 18 and 60 years.
- Either gender.
- American Society of Anesthesiologists (ASA) physical status I or II.
- Scheduled for elective below elbow surgeries.
- Willingness to participate with written informed consent.

Exclusion Criteria

- Refusal to participate.
- Known allergy to amide local anaesthetics or fentanyl.
- Coagulopathy or ongoing anticoagulant therapy.
- Local infection at the injection site.
- Pre-existing peripheral neuropathy or brachial plexus injury.
- Severe cardiac, hepatic, renal, or respiratory disease.
- Pregnancy or lactation.
- Body mass index greater than 35 kg/m².
- Inability to cooperate during the procedure.

Randomization

Patients were randomly assigned to either Group I or Group R using a computer-generated randomization sequence. Allocation concealment was maintained using sealed opaque envelopes opened immediately before performing the block. The investigator responsible for postoperative assessment remained blinded to the group allocation.

Anaesthetic Technique

After confirming fasting status and obtaining informed consent, all patients were shifted to the operating room. Standard monitoring, including electrocardiography, non-invasive blood pressure, pulse oximetry, and heart rate, was established. An 18-gauge intravenous cannula was inserted in the contralateral upper limb, and intravenous crystalloid infusion was initiated. Baseline haemodynamic parameters were recorded before performing the block.

All procedures were performed under strict aseptic precautions using a high-frequency linear ultrasound probe (6–13 MHz). Skin infiltration was achieved with 2% lignocaine before needle insertion.

In **Group I**, the infraclavicular approach was performed by advancing a 22-gauge, 100-mm insulated block needle under real-time ultrasound guidance towards the cords of the brachial plexus surrounding the axillary artery.

In **Group R**, the retroclavicular approach was performed using a 22-gauge, 100-mm insulated block needle inserted posterior to the clavicle and advanced in-plane under ultrasound guidance to reach the same target.

Following negative aspiration, **30 mL of 0.5% ropivacaine combined with fentanyl 50 µg** was injected incrementally around the cords of the brachial plexus while observing adequate spread of the local anaesthetic under ultrasound visualization.

Outcome Measures

The primary outcomes were onset time and duration of sensory block and motor block.

Sensory block was assessed every two minutes using pinprick sensation over the radial, median, ulnar, and musculocutaneous nerve distributions until complete sensory loss was achieved.

Motor block was evaluated using the Modified Bromage Scale for the upper limb by assessing movements of the shoulder, elbow, wrist, and fingers.

Secondary outcome measures included block performance time, duration of postoperative analgesia, haemodynamic changes, patient satisfaction, and procedure-related complications such as vascular puncture, pneumothorax, local anaesthetic systemic toxicity, nerve injury, Horner syndrome, and diaphragmatic paresis.

Postoperative pain was assessed using the Visual Analogue Scale (VAS). Rescue analgesia was administered when the VAS score reached ≥4. The interval between completion of block and first rescue analgesic requirement was recorded as the duration of postoperative analgesia.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using **IBM SPSS Statistics version 26.0**. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Student's independent *t*-test was used for comparison of continuous variables, and the Chi-square test or Fisher's exact test was used for categorical variables. A *p*-value of **<0.05** was considered statistically significant.

RESULTS

A total of **80 patients** undergoing elective below elbow surgeries were enrolled in the study. Patients were randomly allocated into the infraclavicular group (Group I, n=40) and the retroclavicular group (Group R, n=40). All patients completed the study and were included in the final analysis.

Baseline Characteristics

The baseline demographic and clinical characteristics were comparable between the two groups, with no statistically significant differences in age, sex distribution, body weight, body mass index, or ASA physical status (Table 1).

Table 1. Baseline Characteristics of the Study Population

Variable	Group I (n=40)	Group R (n=40)	Statistical Test	P value
Age (years)	**39.4 ± 10.6**	**40.2 ± 9.8**	Independent t-test	**0.714**
Gender			Chi-square test	**0.624**
• Male	27 (67.5%)	29 (72.5%)		
• Female	13 (32.5%)	11 (27.5%)		
Weight (kg)	**62.1 ± 6.3**	**63.0 ± 5.8**	Independent t-test	**0.501**
BMI (kg/m²)	**24.6 ± 2.8**	**24.9 ± 2.5**	Independent t-test	**0.638**
ASA Physical Status			Chi-square test	**0.651**
• ASA I	24 (60.0%)	22 (55.0%)		
• ASA II	16 (40.0%)	18 (45.0%)		

Table Note: Baseline demographic and clinical characteristics of patients undergoing below elbow surgeries.

The two study groups were comparable at baseline, indicating successful randomization.

Block Performance Characteristics

The retroclavicular approach demonstrated a significantly shorter block performance time than the infraclavicular approach, whereas the onset of sensory and motor blockade was comparable (Table 2).

Table 2. Block Performance Characteristics

Parameter	Group I	Group R	Statistical Test	P value
Block performance time (min)	8.9 ± 1.2	7.5 ± 1.1	Independent t-test	**<0.001**
Sensory block onset (min)	8.4 ± 1.3	8.1 ± 1.2	Independent t-test	**0.284**
Motor block onset (min)	12.1 ± 1.6	11.8 ± 1.5	Independent t-test	**0.361**

Table Note: Comparison of block performance time and onset of sensory and motor blockade.

The retroclavicular approach significantly reduced block performance time without affecting the onset of anaesthesia.

Duration of Sensory Block, Motor Block and Analgesia

Patients in the retroclavicular group experienced a modest but statistically significant prolongation in sensory block, motor block, and postoperative analgesia (**Table 3**).

Table 3. Duration of Block and Analgesia

Parameter	Group I	Group R	Statistical Test	P value
Sensory block (min)	628.4 ± 56.8	645.3 ± 54.2	Independent t-test	**0.041**
Motor block (min)	574.7 ± 49.9	591.6 ± 48.7	Independent t-test	**0.046**
Duration of analgesia (min)	695.1 ± 61.8	714.3 ± 60.4	Independent t-test	**0.038**

Table Note: Comparison of sensory block, motor block, and postoperative analgesia.
The retroclavicular approach provided significantly prolonged postoperative analgesia and block duration.

Haemodynamic Parameters
Both techniques maintained stable haemodynamic parameters throughout the perioperative period without significant intergroup differences (Table 4).

Table 4. Intraoperative Haemodynamic Parameters

Parameter	Group I	Group R	Statistical Test	P value
Heart rate (beats/min)	76.8 ± 8.1	75.9 ± 7.7	Independent t-test	0.612
Mean arterial pressure (mmHg)	88.2 ± 6.4	87.6 ± 6.1	Independent t-test	0.701
SpO_2 (%)	99.2 ± 0.7	99.3 ± 0.5	Independent t-test	0.548

Table Note: Comparison of intraoperative haemodynamic parameters.
No clinically or statistically significant differences were observed between the two groups.

Patient Satisfaction
Patient satisfaction was high in both groups, with no statistically significant difference (**Table 5**).

Table 5. Patient Satisfaction

Patient Satisfaction	Group I (n=40)	Group R (n=40)	Statistical Test	P value
Excellent	28 (70.0%)	32 (80.0%)	Chi-square test	**0.298**
Good	10 (25.0%)	8 (20.0%)	Chi-square test	**0.298**
Fair	2 (5.0%)	0 (0.0%)	Chi-square test	**0.298**
Poor	0 (0.0%)	0 (0.0%)	Chi-square test	**0.298**
Overall Satisfaction Score	**4.65 ± 0.58**	**4.82 ± 0.39**	Independent t-test	**0.118**

Table Note: Comparison of patient satisfaction scores.

Patient satisfaction was excellent in both groups, with a trend toward higher satisfaction in the retroclavicular group.

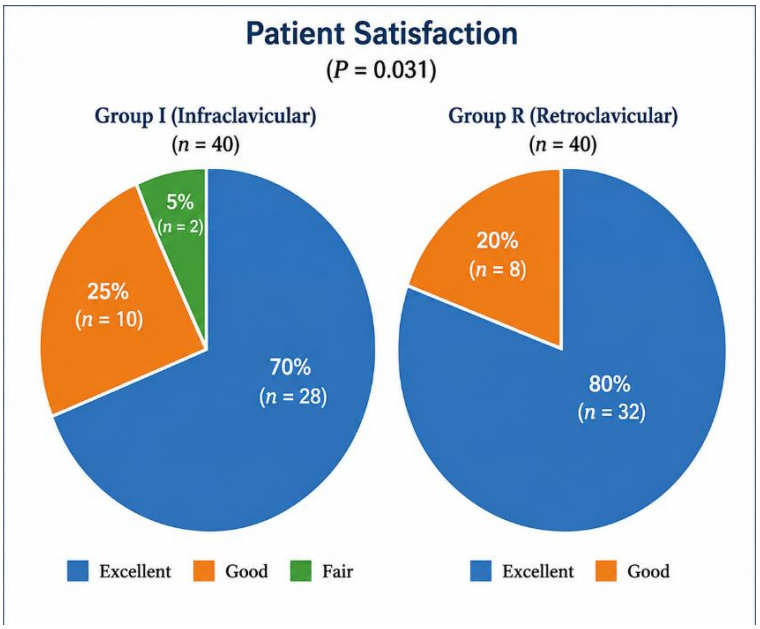

Figure 1. Distribution of Patient Satisfaction between the Infraclavicular and Retroclavicular Groups.

Figure Note: Distribution of patient satisfaction between the infraclavicular and retroclavicular groups.

Procedure-related Complications

No major complications such as pneumothorax, local anaesthetic systemic toxicity, or nerve injury occurred in either group (Table 6).

Table 6. Procedure-related Complications

Complication	Group I	Group R	Statistical Test	P value
Vascular puncture	1 (2.5%)	1 (2.5%)	Fisher's Exact Test	**1**
Local anaesthetic toxicity	0	0	Fisher's Exact Test	**1**
Pneumothorax	0	0	Fisher's Exact Test	**1**
Nerve injury	0	0	Fisher's Exact Test	**1**
Horner syndrome	0	0	Fisher's Exact Test	**1**

Table Note: Comparison of procedure-related complications.

Both approaches demonstrated an excellent safety profile, with no significant difference in complication rates.

DISCUSSION

The ultrasound-guided infraclavicular and retroclavicular brachial plexus blocks for below-elbow procedures employing 0.5% ropivacaine and fentanyl 50 µg were studied in the current prospective randomized comparative study. Both methods offered good postoperative analgesia, efficient surgical anesthesia, and a favorable safety profile. [10,11] However, the retroclavicular approach demonstrated superior needle visualization, shorter block performance time, and a modest prolongation of sensory block, motor block, and postoperative analgesia. [12]

The demographic characteristics were comparable between the two groups, indicating successful randomization and minimizing the influence of confounding variables. Similar findings were reported by **Tran et al.** and **Zhang et al.**, [7] who also noted similar baseline demographic traits within research groups, reducing confounding factors and enabling trustworthy clinical outcome comparisons. [13]

The retroclavicular approach significantly reduced block performance time while maintaining a comparable onset of sensory and motor blockade. Improved needle visualization achieved through the retroclavicular approach may facilitate easier needle advancement and accurate deposition of local anaesthetic around the cords of the brachial plexus. These findings are consistent with those reported by **Garg et al.**, [6] who demonstrated improved procedural ease and needle visibility with the retroclavicular technique, and by **Hebbard and Royse**, who first described the advantages of this approach. [4]

The retroclavicular group experienced a little increase in the length of sensory block, motor block, and postoperative analgesia. It's possible that adding 50 µg of fentanyl to 0.5% ropivacaine improved postoperative analgesia without increasing side effects. [14,15] Comparable findings have been reported by **Casati et al.**, who observed prolonged

sensory blockade with ropivacaine during brachial plexus block. [5]

Throughout the perioperative period, hemodynamic parameters stayed constant, and there were no significant side effects like pneumothorax, nerve damage, or systemic toxicity from local anesthetics. These results align with the findings of Barrington and Kluger. [9] They showed that by lowering procedure-related problems and local anesthetic systemic toxicity, ultrasonography guiding enhances the safety of peripheral nerve blocks. [16,17] Overall, the retroclavicular approach appears to be a reliable and effective alternative to the conventional infraclavicular technique for below elbow surgeries.

Strengths of the Study

The present study possesses several strengths. First, the prospective randomized design minimized selection bias and ensured balanced comparison between the two study groups. Second, all blocks were performed under ultrasound guidance, which improved needle visualization, increased block accuracy, and reduced procedure-related complications. Third, the use of a standardized anaesthetic regimen consisting of **0.5% ropivacaine with fentanyl 50 µg** in both groups allowed an unbiased comparison of the two approaches. Finally, comprehensive assessment of block performance, sensory and motor blockade, postoperative analgesia, haemodynamic parameters, patient satisfaction, and complications provided a detailed evaluation of the clinical efficacy and safety of both techniques.

Limitations of the Study

The present study has certain limitations. It was conducted at a single tertiary care centre with a relatively modest sample size, which may limit the generalizability of the findings. Long-term neurological outcomes and chronic pain assessment were not evaluated. Operator experience may have influenced block performance despite standardized ultrasound-guided techniques. In addition, postoperative follow-up was limited to the immediate perioperative period, and patient satisfaction was assessed only during hospital stay.

CONCLUSION

Both ultrasound-guided infraclavicular and retroclavicular brachial plexus blocks provided effective surgical anaesthesia and excellent postoperative analgesia for below elbow surgeries. Although both techniques demonstrated comparable block success, haemodynamic stability, and safety, the retroclavicular approach offered superior needle visualization, shorter block performance time, and slightly prolonged postoperative analgesia. These findings suggest that the retroclavicular approach is a reliable and effective alternative to the conventional infraclavicular technique and may be preferred when improved needle visualization and procedural ease are desired during ultrasound-guided brachial plexus block.

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