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Original Article

Anaesthesia Section

Comparison between Ultrasound-guided Supraclavicular and Infraclavicular Approach to Brachial Plexus Block for Upper Limb Surgery: A Randomised Controlled Study

M ANIS FATHIMA[1], NAGALAKSHMI PALANISAMY[2], RV RANJAN[3], RAJALAKSHMI MAHENDRAN[4]

ABSTRACT

Introduction: Brachial plexus block is a widely used regional anaesthesia technique for upper limb surgeries, providing effective perioperative analgesia and reduced opioid requirements. Among the various approaches, supraclavicular and infraclavicular blocks are commonly performed under ultrasound guidance to improve accuracy and safety. However, differences in onset time, duration of blockade, and complication rates between these two techniques remain areas of clinical interest.

Aim: To compare the efficacy of ultrasound-guided supraclavicular and infraclavicular approaches to brachial plexus block in patients undergoing forearm and hand surgeries.

Materials and Methods: The present randomised controlled study was conducted at a tertiary care teaching hospital, Pondicherry Institute of Medical Science (PIMS) in Puducherry, India, from November 2018 to April 2020 on 64 American Society of Anaesthesiologists (ASA) grade I and II patients above 18 years undergoing upper limb surgeries. Patients were randomly assigned into two groups. Group A received ultrasound-guided infraclavicular block and Group B received ultrasound-guided supraclavicular block. The primary outcome was comparison of sensory and motor block onset, while secondary outcomes included duration of blocks and associated complications. The data were analysed using Student's t-test, Fisher's-exact test, Chi-square test, and Mann-Whitney U test.

Results: Both groups were comparable with respect to demographic characteristics including age, weight, gender distribution, ASA physical status, type and site of surgery ($p>0.05$). The onset of sensory blockade was quicker in infraclavicular group (5.59±2.53 min) than supraclavicular group (7.59±3.49 min). The timing of motor block onset showed no statistically significant differences between the groups. (11.81±6.17 vs 11.22±5.96 mins). Mean duration of sensory blockade (12.06±3.18 vs 13.25±3.34 hours) and motor blockade (9.97±2.68 vs 11.09±2.44 hours) were same in both groups.

Conclusion: Ultrasound-guided infraclavicular block provides a significantly faster onset of sensory analgesia compared to the supraclavicular approach, while both techniques offer comparable duration of sensory and motor blockade. Given the similar safety profile and effectiveness, either approach may be chosen based on clinician expertise and surgical requirements. The infraclavicular approach may be preferred when rapid onset of analgesia is desired.

Keywords: Analgesia, Dexamethasone, Nerve block, Peripheral nerves, Regional anaesthesia

INTRODUCTION

Brachial plexus block is a well-known regional anaesthetic technique for upper limb surgeries and has been used in procedures ranging from orthopaedic operations to arteriovenous fistula creation [1]. The introduction of ultrasound guidance has significantly improved the safety and accuracy of these blocks by allowing real-time visualisation of neural structures and adjacent anatomy [2]. The supraclavicular and infraclavicular techniques are commonly preferred for surgeries involving the forearm and hand among the various approaches. Although both techniques provide reliable anaesthesia, probable differences may exist in terms of onset, block quality, duration, and complication profile [3].

Comparing these two methods has been the subject of numerous studies. Randomised trials have assessed variables like the duration of analgesia, the success rate, adverse events, and the onset of sensory and motor block [3,4]. While some authors have stated similar efficacy between the two techniques, others have explored changes to reduce complications, particularly hemidiaphragmatic paresis associated with supraclavicular blocks [5,6]. The effect of local anaesthetic volume on diaphragmatic function has also been reviewed, suggesting that variations in volume can influence respiratory outcomes [7,8]. Additionally, both cadaveric and clinical studies have looked at the anatomical and technical differences in infraclavicular approaches [9,10]. Despite these efforts, the available evidence remains inconsistent.

A deep review of the literature reveals certain limitations. Many earlier studies were performed using nerve stimulator or landmark-based techniques, which may not reflect current ultrasound-guided practice [4]. There is also significant variation in study methodology, including differences in drug type, volume, concentration, and use of adjuvants, all of which can influence block characteristics [7,8]. Moreover, most studies have focused on selected outcomes rather than providing a comprehensive comparison of onset, duration, need for intraoperative supplementation, and complications under standardised conditions [5,6]. Variability in patient populations and surgical procedures further limits generalisability [1,3]. As a result, there is still no clear consensus regarding which approach is superior when performed under uniform ultrasound guidance [3].

In view of these gaps, a randomised controlled study using standardised anaesthetic protocols and consistent outcome assessment was considered necessary. The present study was therefore designed to compare ultrasound-guided supraclavicular

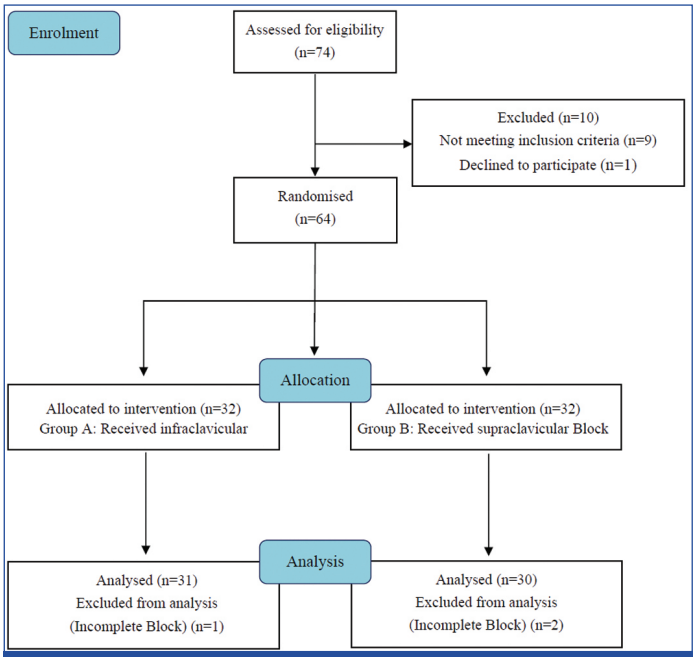
and infraclavicular brachial plexus blocks under similar clinical conditions. The primary objectives of the present study were to compare the efficacy of ultrasound-guided supraclavicular and infraclavicular approaches to brachial plexus block in patients undergoing forearm and hand surgeries. The secondary objectives were to assess the duration of sensory and motor blockade, requirement of intraoperative fentanyl supplementation, incidence of ulnar nerve sparing, haemodynamic parameters (heart rate and mean arterial pressure), and occurrence of block-related complications.

MATERIALS AND METHODS

The present single blinded randomised controlled study was conducted at a tertiary care teaching hospital, Pondicherry Institute of Medical Science (PIMS) in Puducherry, India from November 2018 to April 2020. Approval was obtained from the Institutional Ethics Committee (IEC No: RC/18/63), and written informed consent was obtained from all participants prior to enrollment. The present study was registered with the Clinical Trials Registry of India (CTRI/2019/07/020470).

Sample size calculation: The sample size was calculated based on a previous study by Abhinaya RJ et al., showing a mean difference of 2.02 minutes in sensory block onset time with a Standard Deviation (SD) of 2.61 and 2.87 minutes in the respective groups [3]. Using the formula for comparison of two independent means: $n = \{(Z\alpha/2 + Z\beta)^2 \times (SD1^2 + SD2^2)\}/d^2$ Where, $Z\alpha/2 = 1.96$ (95% confidence level), $Z\beta = 0.84$ (80% power), SD1 = 2.61, SD2 = 2.87, and d = 2.02. The calculated sample size was 29 patients per group. To account for potential dropouts, the sample size was increased to 32 patients per group, resulting in a total sample size of 64 patients.

Inclusion and Exclusion criteria: Patients aged 18-60 years, belonging to ASA physical status I or II, and scheduled for elective upper limb surgeries (forearm and hand) under ultrasound-guided brachial plexus block were included in the study. Patients who refused to participate, had known allergy to local anaesthetics or study drugs, pre-existing neurological deficits, coagulopathy, Body Mass Index (BMI) >30 kg/m^2, pregnancy, or infection at the injection site were excluded from the study. A total of 74 patients were assessed for eligibility, of whom 10 were excluded (did not meet inclusion criteria or declined participation), and 64 patients were randomised equally into two groups [Table/Fig-1].



[Table/Fig-1]: Consolidated standards of randomised control trial flow chart.

Study Procedure

Randomisation was performed using a computer-generated random allocation sequence created by an independent anaesthesiologist not involved in patient recruitment or outcome assessment. Allocation concealment was ensured using Sequentially Numbered, Opaque, Sealed Envelopes (SNOSE technique). The envelopes were opened immediately before the block procedure by the anaesthesiologist performing the block. Participants were enrolled by a separate investigator who was unaware of the allocation sequence. The present study was single-blinded: the anaesthesiologist assessing sensory and motor block characteristics and recording intraoperative and postoperative data was blinded to group allocation. The anaesthesiologist performing the block could not be blinded due to the nature of the intervention. To reduce bias, a standardised local anaesthetic mixture, uniform drug volume (27 mL), identical monitoring protocols, and predefined objective criteria for sensory and motor block assessment were used in all patients. In addition, all blocks were performed under ultrasound guidance by experienced anaesthesiologists to minimise performance variability.

Patients were randomly allocated into two groups of 32 each. Group A received ultrasound-guided infraclavicular brachial plexus block, and Group B received ultrasound-guided supraclavicular brachial plexus block. All patients received a standardised local anaesthetic mixture comprising 18mL of 0.5% levobupivacaine, 7mL of 2% lignocaine with adrenaline, and 2mL (8 mg) dexamethasone, totaling 27mL [3,4]. Sensory blockade was assessed every three minutes using pinprick testing in the distribution of median, radial, ulnar, and musculocutaneous nerves and graded on a 3-point scale. Motor blockade was evaluated using the modified Bromage scale. The primary parameters studied were onset of sensory and motor blockade. Secondary parameters included duration of sensory and motor blockade, requirement of intraoperative fentanyl supplementation, incidence of ulnar nerve sparing, haemodynamic parameters (heart rate and mean arterial pressure), and occurrence of block-related complications such as pneumothorax, hemidiaphragmatic paresis, Horner's syndrome, and intravascular injection. Postoperatively, patients were monitored in the recovery area and ward. Pain was assessed using the Visual Analogue Scale (VAS). Intravenous paracetamol 1g every eight hours was administered as part of multimodal analgesia. Rescue analgesia with intravenous tramadol 1-2 mg/kg was given if VAS ≥4. The duration of sensory block was defined as the time from complete sensory blockade to the first complaint of pain (VAS >3), and duration of motor block was defined as the time from complete motor blockade to full motor recovery.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20. Continuous variables were expressed as mean±SD, and categorical variables were presented as frequency and percentage. Between-group comparisons of continuous variables were analysed using student's unpaired t-test, while categorical variables were compared using Chi-square test or Fisher's-exact test as appropriate. Repeated measures Analysis of Variance (ANOVA) was used to assess changes in haemodynamic parameters over time. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 64 patients were enrolled in the study, with 32 patients in each group and consolidated standards showing enrollment, allocation and analysis at every stage of randomised control trial has been provided in [Table/Fig-1].

Both the groups were comparable in the demographic profile like age, weight, gender, distribution of surgery among both the groups [Table/Fig-2]. The infraclavicular approach demonstrated a faster onset of sensory blockade compared to the supraclavicular approach, while motor onset and the duration of both sensory

and motor blockade were comparable between the groups. The requirement for intraoperative analgesic supplementation and incidence of ulnar nerve sparing were similar, with no statistically significant differences observed. Postoperative pain was assessed using the VAS, and rescue analgesia was administered when VAS ≥4 [Table/Fig-3]. Intraoperative heart rate trends remained stable and comparable between the infraclavicular and supraclavicular groups, indicating similar haemodynamic responses to both

Demographic data	Group A	Group B	p
Weight (kg)	62.47±12.16	64.72±11.93	0.458*
Sex (male/female)	27/5	24/8	0.351*
ASA PS (1/2)	22/10	23/9	0.784*
Distribution of procedure (Flap/ Contracture release/ORIF+Plating)	12/7/13	11/4/17	0.497*
Site of surgery (Forearm/hand)	6/26	8/24	0.545*

[Table/Fig-2]: Comparison of patient characteristics among the two groups.
*p-value not significant. Data presented as mean±SD, except for gender,
SD: Standard deviation; Group A = ICB, Group B= SCB,
ASA PS= American Society of Anaesthesiologists physical status

Anaesthetic data	Group A	Group B	p
Onset of sensory blockade (min, mean±SD)	5.59±2.53	7.59+3.49	0.011†
Onset of motor blockade (min, mean±SD)	11.81±6.17	11.22+5.96	0.647*
Duration of sensory block (h, mean±SD)	12.06±3.18	13.25+3.34	0.150*
Duration of motor block (h, mean±SD)	9.97±2.68	11.09+2.44	0.084*
Fentanyl supplementation VAS>4 (No/yes)	26/6	30/2	0.257*
Patients requiring rescue analgesia (VAS ≥4), n (%)	6 (18.8)	2 (6.3)	0.257
Ulnar nerve sparing (No/yes)	31/1	30/2	1.000*

[Table/Fig-3]: Comparison of block characteristics and requirement of supplementation among the two groups.
*P- Not statistically significant, †p-value significant, Data presented as mean + SD. n= Number of patients, SD: Standard deviation, Group A = ICB, Group B= SCB

block techniques [Table/Fig-4]. Mean arterial pressure values were maintained within clinically acceptable limits in both groups throughout the procedure, with no significant intergroup variation, suggesting comparable haemodynamic stability [Table/Fig-5].

Time interval (minutes)	Group A (Infraclavicular) Mean±SD	Group B (Supraclavicular) Mean±SD	p-value
Baseline	86±20	85±19	0.251
5	87±06	85±16	
10	83±17	83±31	
15	82±21	84±56	
30	82±22	82±53	
45	82±09	83±31	
60	80±13	83±16	
75	81±24	82±22	

[Table/Fig-4]: Comparison of Heart Rate (beats/min) between the two groups during surgery.

DISCUSSION

The present randomised study compared ultrasound-guided infraclavicular and supraclavicular brachial plexus blocks using a standardised local anaesthetic mixture and uniform technique in patients undergoing upper limb surgeries. The authors observed a faster onset of sensory blockade with the infraclavicular approach, while motor onset and the duration of sensory and motor blockade were comparable between the two groups. The requirement for intraoperative fentanyl supplementation and the incidence of ulnar nerve sparing were

Time interval (minutes)	Group A (Infraclavicular) Mean±SD	Group B (Supraclavicular) Mean±SD	p-value
Baseline	94±4	94±03	0.401
5	95±03	93±66	
10	91±30	92±47	
15	91±19	91±19	
30	92±19	90±5	
45	93±5	90±31	
60	91±14	90±38	
75	90±13	88±53	

[Table/Fig-5]: Comparison of mean arterial pressure (mmHg) between the two groups during surgery.

also similar. Haemodynamic parameters remained stable throughout the procedure, and no major complications were encountered in either group. These findings suggest that both approaches provide effective and clinically comparable anaesthesia when performed under ultrasound guidance with standardised drug regimens.

The results of Abhinaya RJ et al., are in line with our observation of a quicker sensory onset with the infraclavicular approach [3], who also reported earlier sensory blockade with the infraclavicular technique compared to the supraclavicular approach. Similarly, Koscielniak-Nielsen ZJ et al., demonstrated shorter block latency with infraclavicular blocks [11]. The proposed explanation relates to deposition of local anaesthetic near the cords and lower trunk, allowing more direct neural contact and potentially overcoming septal barriers within the plexus [12]. However, not all studies are in agreement. Fredrickson MJ et al., reported comparable onset times between the two approaches, although they observed improved surgical success with infraclavicular blocks, particularly due to better ulnar nerve coverage achieved with multiple injection techniques [13]. In the present study, although isolated ulnar nerve sparing was noted in a few cases in both groups, the incidence was minimal and not significantly different.

Both sensory and motor blockade lasted longer than is typically anticipated for brachial plexus blocks in terms of block duration. This prolonged duration is likely attributable to the addition of dexamethasone as an adjuvant. Pani N et al., demonstrated that dexamethasone combined with levobupivacaine not only prolongs block duration but may also hasten onset through vasoconstrictive effects that reduce systemic absorption of local anaesthetic [14]. Several other studies have similarly confirmed the prolongation of peripheral nerve blocks with dexamethasone [15-18]. Despite the longer duration observed in both groups in our study, no statistically significant intergroup difference was found, which aligns with the findings of Yang CW et al., who also reported comparable motor block characteristics between approaches [12].

In the present study, both groups showed comparable safety profiles and intraoperative analgesic requirements. Although patients in the infraclavicular group required slightly more fentanyl supplementation, the difference was not statistically significant. This small variation could possibly be explained by the learning curve involved in performing the infraclavicular technique. Previous studies have raised concerns about complications such as hemidiaphragmatic paresis and pneumothorax, particularly with the supraclavicular approach. However, in the present experience, both techniques were similarly safe when performed with appropriate expertise and precautions [12,14]. Satani TR et al., reported a higher incidence of pneumothorax with the supraclavicular approach and suggested infraclavicular blocks as a safer option for distal upper limb surgeries [19]. However, neither group experienced any respiratory issues during our investigation, most likely as a result of careful real-time ultrasound guidance during needle advancement and local anaesthetic deposition.

The haemodynamic profile remained stable in both groups, with no clinically significant variations in heart rate or mean arterial pressure during surgery. This finding suggests that both techniques provide comparable sympathetic blockade and cardiovascular stability. Similar observations of haemodynamic stability have been reported in previous comparative studies [3,13].

Limitation(s)

The sample size may have reduced the ability to detect subtle differences in block duration. Performance time for infraclavicular blocks, though subjectively longer, was not formally analysed. Additionally, complications such as hemidiaphragmatic paresis were not assessed with imaging modalities, which could have provided more objective evaluation. Overall, the present study reinforces existing evidence that both ultrasound-guided infraclavicular and supraclavicular approaches are effective and safe for upper limb surgeries, with minor differences in onset characteristics but comparable overall block quality and safety profile.

CONCLUSION(S)

Both ultrasound-guided infraclavicular and supraclavicular brachial plexus block techniques were found to be equally effective in providing adequate surgical anaesthesia for forearm and hand surgeries. Although the infraclavicular approach demonstrated a significantly faster onset of sensory blockade, the duration of both sensory and motor block was comparable between the two groups. The overall quality of anaesthesia, need for intraoperative supplementation, and haemodynamic stability were similar with both techniques. Importantly, no major block-related complications were observed, supporting the safety of both approaches when performed under ultrasound guidance. These findings suggest that either technique can be reliably used in clinical practice, and the choice may be guided by clinician expertise, anatomical considerations, and the need for rapid onset of analgesia.

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PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Anaesthesia, Pondicherry Institute of Medical Sciences, Puducherry, India.
2. Professor, Department of Anaesthesia, Pondicherry Institute of Medical Sciences, Puducherry, India.
3. Professor, Department of Anaesthesia, Pondicherry Institute of Medical Sciences, Puducherry, India.
4. Associate Professor, Department of Community Medicine, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. M Anis Fathima,
Assistant Professor, Department of Anaesthesia, Pondicherry Institute of Medical Sciences, Puducherry, India.
E-mail: mailanisfathima@gmail.com

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