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Original Research Article

COMPARATIVE EFFICACY OF ULTRASOUND-GUIDED COSTOCLAVICULAR VERSUS SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK FOR ELECTIVE UPPER LIMB SURGERY: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Ultrasound-guided brachial plexus blocks are widely used for anaesthesia in upper limb surgeries. The supraclavicular approach is a well-established technique, while the costoclavicular approach is a newer infraclavicular variant with potentially improved block characteristics. This study aimed to compare the efficacy of ultrasound-guided costoclavicular brachial plexus block (CC-BPB) with supraclavicular brachial plexus block (SC-BPB).

Materials and Methods: This prospective, randomized controlled study was conducted on 50 ASA I–II patients aged 18–65 years undergoing elective upper limb surgery. Patients were randomly allocated into two groups: Group C (CC-BPB) and Group S (SC-BPB), with 25 patients in each group. Both groups received 20 mL of local anaesthetic mixture (0.5% bupivacaine and 2% lignocaine with adrenaline in equal volumes). Primary outcome was onset of motor block. Secondary outcomes included onset of sensory block, time to complete block, block performance time, duration of block, duration of analgesia, block success rate, and complications.

Results: The onset of sensory and motor blockade was significantly faster in the SC-BPB group compared to the CC-BPB group (2.12 ± 0.67 vs. 3.16 ± 0.85 min and 2.04 ± 1.21 vs. 4.40 ± 1.58 min; $P < 0.001$). However, CC-BPB achieved complete sensory and motor block earlier than SC-BPB (9.04 ± 2.30 vs. 12.60 ± 2.55 min and 11.84 ± 2.37 vs. 16.76 ± 3.44 min; $P < 0.001$). Block performance time was significantly shorter in CC-BPB (9.08 ± 2.86 vs. 11.28 ± 2.89 min; $P = 0.006$). Duration of analgesia was comparable between CC-BPB and SC-BPB groups (13.44 ± 1.42 vs. 13.60 ± 1.47 hours; $P = 0.70$). Block success rate was similar (84% vs. 80%), and no significant complications were observed in either group.

Conclusion: Both ultrasound-guided costoclavicular and supraclavicular brachial plexus blocks are safe and effective techniques for upper limb surgery. SC-BPB provides faster initial onset of blockade, whereas CC-BPB offers quicker achievement of complete surgical anaesthesia and shorter procedural time. Postoperative analgesia and safety profiles are comparable between the two techniques.

Keywords: Costoclavicular block, supraclavicular block, brachial plexus block, ultrasound-guided regional anaesthesia, upper limb surgery.

INTRODUCTION

Regional anesthesia has become an integral component of modern anesthetic practice for upper limb surgeries because it provides excellent perioperative analgesia, decreases opioid consumption, minimizes postoperative nausea and vomiting, facilitates early recovery, and avoids many

of the adverse effects associated with general anesthesia.[1] Ultrasound guidance has further improved the accuracy and safety of peripheral nerve blocks by allowing direct visualization of neural structures, adjacent vessels, and needle placement, thereby increasing block success and reducing procedure-related complications.[2]

Among the various brachial plexus block techniques, the supraclavicular approach has traditionally been regarded as one of the most reliable methods for anesthesia of the upper extremity distal to the shoulder. The compact arrangement of the brachial plexus trunks at this level contributes to rapid onset and dense anesthesia. However, because the block is performed in close proximity to the pleura and phrenic nerve, it carries potential risks such as pneumothorax, hemidiaphragmatic paralysis, Horner's syndrome, and occasional ulnar nerve sparing.[3,4]

The costoclavicular approach, first described by Karmakar and colleagues in 2015, represents a newer ultrasound-guided infraclavicular technique in which the three cords of the brachial plexus are consistently clustered lateral to the axillary artery within the costoclavicular space.[5] This anatomical arrangement facilitates uniform spread of local anesthetic around all three cords with a single injection, resulting in reliable sensory and motor blockade. Previous anatomical and clinical studies have demonstrated that the costoclavicular approach provides rapid block onset, effective surgical anesthesia with relatively low volumes of local anesthetic, and may reduce the incidence of phrenic nerve involvement compared with the supraclavicular approach.[6–8]

Although both supraclavicular and costoclavicular brachial plexus blocks are widely used for upper limb surgeries, comparative evidence regarding their clinical efficacy remains limited. Luo et al. demonstrated comparable block characteristics between the two techniques using a modified double-injection method; however, this technique differs from conventional clinical practice and may not accurately reflect the performance of standard single-injection approaches.[9] Similarly, only a few prospective randomized studies have compared conventional ultrasound-guided costoclavicular and supraclavicular blocks, and the available evidence remains insufficient to establish the superiority of either technique.[10]

Considering the limited comparative literature, the present randomized controlled trial was designed to evaluate the efficacy of ultrasound-guided costoclavicular brachial plexus block in comparison with the conventional ultrasound-guided supraclavicular brachial plexus block for elective upper limb surgeries. We hypothesized that the costoclavicular approach would provide superior block characteristics because of the close anatomical relationship and compact arrangement of the brachial plexus cords within the costoclavicular space, allowing more homogeneous distribution of local anesthetic and efficient neural blockade.[6] The primary objective of this study was to compare the onset time of sensory and motor blockade between the two techniques. Secondary objectives included comparison of block performance time, duration of sensory and motor blockade, duration of postoperative analgesia, and the incidence of block-related complications.

MATERIALS AND METHODS

Study Design and Participants: This prospective, randomized, comparative clinical trial was conducted in the Department of Anaesthesiology between June 2024 and December 2025 after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. Fifty patients, aged 18–65 years, of either sex, belonging to American Society of Anesthesiologists (ASA) physical status I or II and scheduled for elective upper limb surgery under brachial plexus block were enrolled. Patients with known allergy to local anaesthetics, coagulopathy, infection at the injection site, pre-existing neurological deficits, body mass index (BMI) >35 kg/m², anticipated difficult airway, chronic obstructive pulmonary disease, significant hepatic, renal or cardiovascular disease, or inability to comprehend the pain scoring system were excluded.

Sample Size: The sample size was calculated based on the study by Ramesh et al,[10] considering an expected difference in block performance time of 0.88 minutes with a standard deviation of 1.11, a superiority margin of 0.05, 80% study power, and a 5% level of significance. The minimum required sample size was 22 patients per group. To compensate for an anticipated 10% dropout rate, 25 patients were included in each group, resulting in a total sample size of 50.

Randomization and Blinding: Participants were randomly allocated into two equal groups using a computer-generated randomization sequence. Allocation concealment was ensured using sequentially numbered, sealed opaque envelopes prepared by an independent investigator who was not involved in patient management or data collection. Both the patients and the observer assessing block characteristics and postoperative outcomes were blinded to group allocation.

Preoperative Preparation: All patients underwent routine pre-anaesthetic evaluation, including detailed history, physical examination, airway assessment, and standard laboratory investigations. Oral alprazolam 0.25 mg was administered on the night before surgery. After arrival in the preoperative area, an 18-gauge intravenous cannula was secured, and intravenous ondansetron 4 mg and pantoprazole 40 mg were administered approximately 45 minutes before surgery. Standard intraoperative monitoring included electrocardiography, non-invasive blood pressure, and pulse oximetry.

Block Technique: All brachial plexus blocks were performed under ultrasound guidance (FUJIFILM Sonosite; linear high-frequency 6–13 MHz transducer) by an experienced anaesthesiologist. Patients in the Costoclavicular group (Group C) received an ultrasound-guided costoclavicular brachial plexus block, whereas those in the Supraclavicular group (Group S) received an ultrasound-guided supraclavicular brachial plexus block. In both groups, a total of 20 mL local anaesthetic solution comprising 10 mL of 0.5% bupivacaine and 10 mL of 2% lignocaine with adrenaline was administered.

For the supraclavicular approach, the brachial plexus was identified lateral and superficial to the subclavian artery, and local anaesthetic was deposited using an in-plane lateral-to-medial needle approach to achieve circumferential spread around the plexus. For the costoclavicular approach, the ultrasound probe was positioned inferior to the clavicle to visualize the three cords lateral to the axillary artery. Following skin infiltration with 1 mL of 1% lignocaine, a 20-gauge, 5-cm insulated needle was advanced using an in-plane lateral-to-medial approach until the tip was positioned centrally between the cords. Peripheral nerve stimulation (0.5 mA, 0.1 ms, 1 Hz) was used to confirm appropriate needle placement before local anaesthetic injection.

Block Assessment: An independent observer, blinded to group allocation, assessed sensory and motor blockade after completion of the block. Sensory block was evaluated over the musculocutaneous, median, radial, and ulnar nerve distributions using a three-point cold sensation scale (0 = normal sensation, 1 = analgesia, 2 = complete anaesthesia). Motor block was assessed using a three-point scale (0 = normal motor function, 1 = paresis, 2 = paralysis) by testing elbow flexion, thumb abduction, thumb opposition, and thumb adduction. A maximum composite score of 16 was possible, and patients were considered ready for surgery when a composite score of at least 14 with a sensory score of ≥7/8 was achieved.

The onset of sensory and motor blockade was defined as the interval from completion of local anaesthetic injection to complete sensory or motor block, respectively. Duration of sensory block was defined as the time from local anaesthetic injection to complete recovery of sensation, while motor block duration was defined as the time to full recovery of motor function. Duration of analgesia was recorded as the interval from completion of the block until the patient's first request for rescue analgesia.

Outcome Measures: The primary outcome was the onset time of motor blockade. Secondary outcomes included onset of sensory blockade, block performance time, duration of sensory blockade, duration of motor blockade, duration of postoperative analgesia, patient satisfaction, and incidence of block-related complications.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 24.0. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages. Continuous variables were compared using the independent Student's t-test, while categorical variables were analysed using Fisher's exact test. A P value <0.05 was considered statistically significant.

RESULTS

A total of 50 patients were enrolled and randomized equally into two groups, with 25 patients each in the costoclavicular brachial plexus block (Group C) and supraclavicular brachial plexus block (Group S). All randomized patients completed the study and were included in the final analysis. Baseline demographic and clinical characteristics of the study participants are presented in [Table 1].

Table 1: Baseline Demographic and Clinical Characteristics of the Study Participants

Parmeter	Group C(n=25)	Group S(n=25)	P value
Age in years	37.04 ± 13.68	27.52 ± 10.10	0.01
Female(%) : Male(%)	4(16%):21(84%)	2(8%):23(92%)	0.66
Weight (kg)	65.68 ± 7.88	65.52 ± 5.78	0.93
Height (cm)	166.24 ± 4.05	169.24 ± 5.45	0.03
BMI (kg/m2)	23.88 ± 2.83	23.03 ± 2.13	0.23
ASA I(%): II(%)	24(96%):1(4%)	21(84%):4(16%)	0.34

Values are presented as mean ± standard deviation or number (percentage). A P value <0.05 was considered statistically significant.

The supraclavicular group demonstrated a significantly faster onset of both sensory and motor blockade compared with the costoclavicular group (P < 0.001). However, the costoclavicular group achieved complete sensory and motor blockade significantly earlier and required a shorter block performance time than the supraclavicular group (P < 0.01). The duration of postoperative analgesia was comparable between the two groups (P = 0.70). [Table 2]

Table 2: Comparison of Block Characteristics and Duration of Analgesia Between the Two Study Groups

Parmeter	Group C(n=25)	Group S(n=25)	P value
Onset of sensory block (min)	3.16 ± 0.85	2.12 ± 0.67	<0.001
Onset of motor block (min)	4.40 ± 1.58	2.04 ± 1.21	<0.001

Time to achieve sensory block (min)	9.04 ± 2.30	12.60 ± 2.55	<0.001
Time to achieve motor block (min)	11.84 ± 2.37	16.76 ± 3.44	<0.001
Block performance time(min)	9.08 ± 2.86	11.28 ± 2.89	0.006
Duration of analgesia in hours	13.44 ± 1.42	13.60 ± 1.47	0.70

Values are expressed as mean ± standard deviation. A P value <0.05 was considered statistically significant.

The block success rate was comparable between the two groups (84% in Group C vs. 80% in Group S). None of the patients required conversion to general anaesthesia or experienced block-related complications. The requirement for supplemental nerve block was similar between the groups, and all patients reported satisfaction with the anaesthetic technique. [Table 3]

Table 3: Comparison of Block Success, Supplemental Block Requirement, Complications, and Patient Satisfaction Between the Study Groups

Parmeter	Group C(n=25)	Group S(n=25)	P value
Block success rate No(%):Yes(%)	4(16%):21(84%)	5(20%):20(80%)	1.00*
Need for GA No(%):Yes(%)	25(100%):0(0%)	25(100%):0(0%)	-
Need of supplemental nerve block No(%):Yes(%)	21(84%):4(16%)	20(80%):5(20%)	1.00*
Complications No(%):Yes(%)	25(100%):0(0%)	25(100%):0(0%)	-
Patient satisfaction Yes(%): No(%)	25(100%):0(0%)	25(100%):0(0%)	-

Values are presented as number (percentage). Group C = Costoclavicular brachial plexus block; Group S = Supraclavicular brachial plexus block; GA = General anaesthesia. P values were calculated using Fisher's exact test where applicable. A P value <0.05 was considered statistically significant.

DISCUSSION

The present randomized controlled trial compared ultrasound-guided costoclavicular brachial plexus block (CC-BPB) with supraclavicular brachial plexus block (SC-BPB) in patients undergoing elective upper limb surgeries. The major findings of this study were that SC-BPB resulted in a significantly faster initial onset of sensory and motor blockade, whereas CC-BPB achieved complete sensory and motor blockade in a shorter time and required significantly less block performance time. However, both techniques were comparable in terms of duration of analgesia, block success rate, and incidence of complications.

In the present study, the onset of sensory block was significantly faster in the SC-BPB group compared to the CC-BPB group (2.12 ± 0.67 vs. 3.16 ± 0.85 minutes; P<0.001). Similarly, motor block onset was earlier in the SC-BPB group (2.04 ± 1.21 vs. 4.40 ± 1.58 minutes; P<0.001). This may be attributed to the dense clustering of brachial plexus elements at the supraclavicular level, where a small volume of local anaesthetic rapidly surrounds the nerve structures, producing an earlier initial block effect.

However, despite the earlier onset in SC-BPB, CC-BPB demonstrated significantly faster achievement of complete sensory and motor blockade. The time to complete sensory block was 9.04 ± 2.30 minutes in CC-BPB compared to 12.60 ± 2.55 minutes in SC-BPB (P<0.001), while complete motor block was achieved at 11.84 ± 2.37 minutes versus 16.76 ± 3.44 minutes (P<0.001), respectively. This finding suggests that although SC-BPB initiates blockade earlier, CC-BPB provides a more uniform and efficient spread of local anaesthetic, resulting in faster attainment of a dense surgical block. The anatomical arrangement in the costoclavicular space, where the three cords lie compactly lateral to the axillary artery, facilitates circumferential spread of local anaesthetic with a single injection.[6]

Block performance time was significantly shorter in the CC-BPB group compared with the SC-BPB group (9.08 ± 2.86 vs. 11.28 ± 2.89 minutes; P=0.006). The costoclavicular approach allows easier needle placement with minimal redirection due to consistent sonoanatomy and clustered cord arrangement, which contributes to reduced procedural time.[5,6] Although the absolute difference was small, even a reduction of approximately two minutes may improve operating room efficiency in high-volume surgical settings.

Our findings are consistent with those of Senapati et al,[11] who also demonstrated superior procedural efficiency with CC-BPB. They reported significantly shorter block performance time (1.53 vs. 1.98 minutes; P<0.001), earlier onset of sensory block (9 vs. 10 minutes; P=0.001), and earlier onset of motor block (12 vs. 13 minutes; P=0.001) in the CC-BPB group compared to SC-BPB. Similarly, Ramesh et al,[10] and Devi et al,[12] reported comparable findings, with shorter performance time and reliable block characteristics using the costoclavicular approach. Li et al,[6] further supported these observations by describing the anatomical advantage of the costoclavicular space, which promotes uniform local anaesthetic spread around the brachial plexus cords.

In contrast, Luo et al,[9] reported similar block dynamics between CC-BPB and SC-BPB when a modified double-injection technique was used. The discrepancy with our findings may be due to differences in injection technique, spread pattern of local anaesthetic, and study methodology. Despite minor variations across studies, the overall evidence supports that both approaches provide reliable surgical anaesthesia with subtle differences in block kinetics.

In the present study, the duration of sensory block (13.44 ± 1.42 vs. 13.60 ± 1.47 hours; P=0.70), motor block, and duration of analgesia were comparable between CC-BPB and SC-BPB groups. These findings indicate that once an effective block is

established, the pharmacological duration of local anaesthetic action is independent of the site of injection. Similar results have been reported by Ramesh et al,[10] Devi et al,[12] and Luo et al,[9] who found no significant difference in postoperative analgesia duration between the two techniques. Notably, Zhang et al,[13] reported longer block duration and prolonged postoperative analgesia with CC-BPB; however, the retrospective design of their study may limit the strength of these conclusions.

Block success rate was high and comparable in both groups (84% in CC-BPB vs. 80% in SC-BPB), with no patient requiring conversion to general anaesthesia. Supplemental nerve block was required in a small proportion of patients (16% vs. 20%), and patient satisfaction was 100% in both groups. Importantly, no block-related complications were observed, highlighting the safety of both ultrasound-guided techniques when performed by experienced operators.

Although no complications occurred in this study, the costoclavicular approach has theoretical safety advantages. The needle path is farther from the pleura, potentially reducing the risk of pneumothorax, and its more distal location may reduce the likelihood of phrenic nerve involvement and hemidiaphragmatic paralysis compared to the supraclavicular approach.[3,4] However, diaphragmatic function was not assessed in this study, and therefore these benefits remain speculative in our cohort.

The present study has certain limitations. It was conducted at a single centre with a relatively small sample size of 50 patients. All blocks were performed by an experienced anaesthesiologist, which may not reflect results during the learning phase. In addition, objective assessment of diaphragmatic excursion and pulmonary function was not performed. Future multicentric trials with larger sample sizes and respiratory outcome evaluation are warranted.

CONCLUSION

Both ultrasound-guided costoclavicular and supraclavicular brachial plexus blocks are effective and safe for upper limb surgeries. SC-BPB provides a faster initial onset of blockade, whereas CC-BPB offers faster achievement of complete surgical anaesthesia and shorter block performance time. Both techniques provide comparable postoperative analgesia and high success rates, making either approach suitable depending on clinical preference and operator expertise.

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