Section: Anesthesiology

Original Research Article

COMPARISON OF COSTOCLAVICULAR BRACHIAL PLEXUS BLOCK BY USING NERVE STIMULATOR AND USG VERSES NERVE STIMULATOR AND LANDMARK TECHNIQUE :INNOVATIVE AND ALTERNATIVE TECHNIQUE RCT STUDY FOR UPPER LIMB SURGERY

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Received *: 09/04/2026*
Received in revised form *: 23/05/2026*
Accepted *: 10/06/2026*

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DOI: 10.70034/ijmedph.2026.2.533

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (2); 3221-3226

ABSTRACT

Background: Costoclavicular brachial plexus block is an effective regional anaesthetic technique for upper limb surgeries. Ultrasound guidance improves block accuracy and safety; however, its availability may be limited in resource-constrained settings. This study compared ultrasound-guided nerve stimulator-assisted costoclavicular block with a landmark-guided nerve stimulator-assisted technique.

Materials and Methods: In this prospective, randomized, double-blind study, 60 ASA I–II patients aged 18–60 years undergoing elective upper limb surgery were allocated into two groups: Ultrasound and Nerve Stimulator group (UNS, n=30) and Landmark and Nerve Stimulator group (LNS, n=30). The primary outcome was block success rate. Secondary outcomes included number of needle attempts, onset and completion times of sensory and motor block, duration of blockade, patient satisfaction, and complications.

Results: The success rate was higher in Group UNS (96.7%) than Group LNS (86.7%). Group UNS required fewer needle attempts (1.20±0.41 vs. 1.83±0.65; $p<0.001$) and demonstrated significantly faster onset of sensory block (8.4±1.8 vs. 10.7±2.3 min) and motor block (11.2±2.1 vs. 13.8±2.7 min). Complete sensory and motor block were achieved significantly earlier in Group UNS ($p<0.001$). Patient satisfaction was higher in Group UNS (96.7% vs. 86.7%). Complications were fewer in the ultrasound group, with no major adverse events observed.

Conclusion: Ultrasound-guided costoclavicular brachial plexus block combined with nerve stimulation provides superior block characteristics, higher patient satisfaction, and fewer complications compared with the landmark-guided nerve stimulator technique. Nevertheless, the landmark-guided approach remains a useful alternative when ultrasound facilities are unavailable.

Keywords: Costoclavicular brachial plexus block, ultrasound guidance, nerve stimulator, landmark technique, upper limb surgery.

INTRODUCTION

Regional anaesthesia plays a pivotal role in contemporary anaesthetic practice for upper limb surgeries owing to its ability to provide effective intraoperative anaesthesia, prolonged postoperative analgesia, reduced opioid consumption, early mobilization, and enhanced patient satisfaction.[1] Among the various regional anaesthetic techniques available, brachial plexus block has gained widespread acceptance as an effective alternative to general anaesthesia for surgeries involving the arm, forearm, wrist, and hand. In addition to superior analgesia, brachial plexus blocks are associated with

fewer postoperative complications such as nausea and vomiting, improved recovery profiles, and shorter hospital stays.[2]

Several approaches to brachial plexus blockade have been described, including interscalene, supraclavicular, infraclavicular, and axillary approaches. The infraclavicular approach has become increasingly popular because it provides reliable anaesthesia of the upper extremity while minimizing complications associated with more proximal blocks, such as phrenic nerve palsy and recurrent laryngeal nerve involvement.[3,4] A recent modification of the infraclavicular block is the costoclavicular approach, which targets the cords of the brachial plexus within the costoclavicular space located beneath the clavicle. In this region, the lateral, posterior, and medial cords lie clustered together lateral to the axillary artery, allowing effective blockade with a single injection and resulting in rapid onset and consistent block characteristics.[5,6]

The introduction of ultrasound guidance has significantly improved the practice of regional anaesthesia. Ultrasound allows direct visualization of neural structures, adjacent vessels, needle trajectory, and spread of local anaesthetic, thereby improving block success and reducing complications. Numerous studies have demonstrated higher success rates, shorter onset times, and greater safety with ultrasound-guided brachial plexus blocks compared with conventional landmark techniques.[7,8] Owing to the compact arrangement of the brachial plexus cords within the costoclavicular space, ultrasound-guided costoclavicular block has emerged as an effective and reliable technique for upper limb surgeries.[9]

Despite these advantages, the widespread use of ultrasound remains limited in many healthcare settings because of the high cost of equipment, maintenance requirements, and lack of trained personnel. This limitation is particularly relevant in resource-constrained institutions and peripheral centres where access to ultrasound technology may be inadequate.[10] In such circumstances, peripheral nerve stimulators continue to serve as a valuable tool for nerve localization. Nerve stimulation facilitates accurate needle placement through elicitation of specific motor responses, thereby improving the likelihood of successful blockade.[11]

Before the routine use of ultrasound, landmark-guided nerve stimulator techniques were extensively employed for brachial plexus blocks and demonstrated acceptable efficacy and safety. These techniques rely on surface anatomical landmarks for needle insertion and nerve stimulation for confirmation of needle proximity to neural structures.[12] Previous studies have reported satisfactory outcomes using nerve stimulator-guided infraclavicular brachial plexus blocks, suggesting that such methods remain useful where ultrasound is unavailable.[13] The anatomical characteristics of the costoclavicular space may further support the feasibility of a landmark-guided approach. The cords of the brachial plexus occupy a relatively constant position beneath the clavicle and lateral to the axillary artery, making them potentially accessible through carefully defined anatomical landmarks combined with nerve stimulation.[14] If successful, this approach could provide a practical, economical, and reproducible alternative to ultrasound-guided costoclavicular block, particularly in low-resource settings.

Although complications such as vascular puncture, hematoma, pneumothorax, nerve injury, local anaesthetic systemic toxicity, infection, and block failure may occur with brachial plexus blocks, their incidence is influenced by the technique used and operator expertise.[15] While ultrasound guidance has been shown to reduce some of these risks, the safety and efficacy of a landmark-guided costoclavicular approach assisted by nerve stimulation remain inadequately studied.[16]

Therefore, the present randomized controlled trial was designed to compare costoclavicular brachial plexus block performed using ultrasound guidance combined with nerve stimulation with an innovative landmark-guided technique combined with nerve stimulation in patients undergoing upper limb surgery. The study aims to evaluate the success rate, block characteristics, patient satisfaction, and incidence of complications associated with both techniques and to determine whether the landmark-guided approach can serve as a safe and effective alternative where ultrasound facilities are limited.

MATERIALS AND METHODS

This prospective, randomized, double-blind comparative study was conducted after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. Sixty patients of either sex, aged 18–60 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II, scheduled for elective upper limb surgeries under costoclavicular brachial plexus block were enrolled in the study.

Patient Selection: Patients undergoing surgeries involving the elbow, forearm, hand, and fingers, weighing between 50 and 65 kg, and willing to participate in the study were included. Patients who refused participation, belonged to ASA grade III or IV, had thoracic or upper limb skeletal abnormalities, clavicular fracture, local site infection, bleeding disorders, significant cardiac, respiratory, renal, hepatic, or gastrointestinal dysfunction, allergy to amide local anaesthetics, pregnancy, pre-existing sensory or motor neuropathy, or known seizure disorders were excluded from the study. Patients with failed blocks requiring conversion to general anaesthesia were also excluded from the final analysis.

Preoperative Assessment: All patients underwent a detailed pre-anaesthetic evaluation including

medical history, physical examination, and routine investigations. Laboratory investigations included haemoglobin, blood sugar, blood urea, and serum creatinine levels. Cardiovascular and respiratory assessments included electrocardiography, chest radiography, blood pressure measurement, heart rate, oxygen saturation (SpO_2), and respiratory rate recording. Patients were informed about the study in their native language and written informed consent was obtained.

Randomization and Blinding: Patients were randomly allocated into two groups of 30 each using a sealed opaque envelope technique.

Group UNS (Ultrasound and Nerve Stimulator Group): Costoclavicular brachial plexus block performed using ultrasound guidance combined with nerve stimulation.

Group LNS (Landmark and Nerve Stimulator Group): Costoclavicular brachial plexus block performed using landmark-guided technique combined with nerve stimulation.

The observer responsible for recording block characteristics and postoperative outcomes was blinded to the group allocation. Patients were also unaware of the technique used for block administration.

Anaesthetic Technique: All patients received oral alprazolam 0.5 mg on the night before surgery as anxiolytic premedication. Upon arrival in the operating room, standard monitoring including non-invasive blood pressure, electrocardiography, pulse oximetry, and respiratory rate monitoring was instituted and baseline values were recorded.

All blocks were performed under strict aseptic precautions by an experienced anaesthesiologist skilled in both ultrasound-guided and nerve stimulator-guided regional anaesthesia techniques. A peripheral nerve stimulator was used with an initial current of 1.0 mA, frequency of 2 Hz, and pulse width of 0.1 ms. In Group UNS, a high-frequency linear ultrasound probe was used to identify the costoclavicular space and visualize the axillary artery along with the lateral, posterior, and medial cords of the brachial plexus. Following confirmation of needle placement with both ultrasound visualization and appropriate motor response, the local anaesthetic solution was injected after negative aspiration.

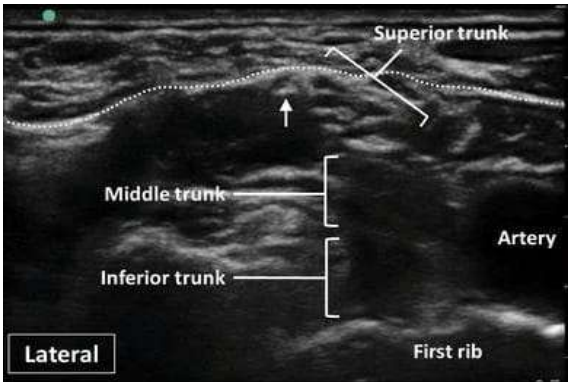

Figure 1: Costoclavicular block approach

In Group LNS, the costoclavicular block was performed using anatomical landmarks and nerve stimulator guidance. The stimulating needle was advanced until an appropriate distal motor response was elicited. After confirming correct needle placement and negative aspiration, the local anaesthetic solution was administered.

All patients received 25 mL of 0.5% bupivacaine combined with 2 mL dexamethasone, making a total injectate volume of 27 mL.

Block Assessment: Sensory and motor block characteristics were assessed at regular intervals using the modified Koscielniak-Nielsen scoring system. Sensory block was evaluated by pin-prick testing in the distribution of the musculocutaneous, radial, median, and ulnar nerves. Motor block was assessed by evaluating movements corresponding to the respective nerve distributions. The onset of sensory block was defined as the time from completion of drug injection to loss of pin-prick sensation. The onset of motor block was defined as the time from completion of injection to reduction in motor power. Complete sensory and motor block times were also recorded. Duration of blockade was defined as the time from onset of complete block until return of normal sensory and motor function.

Outcome Measures

The primary outcome of the study was the success rate of the costoclavicular brachial plexus block. Successful block was defined as adequate surgical anaesthesia without the need for supplementary analgesia or conversion to general anaesthesia.

Secondary outcomes included the number of needle attempts, onset of sensory block, onset of motor block, time to achieve complete sensory and motor block, duration of sensory and motor blockade, site of surgery, patient satisfaction, and incidence of complications. Patient satisfaction was assessed postoperatively using a two-point satisfaction scale categorized as satisfied or not satisfied. Procedure-related complications including vascular puncture, hematoma formation, pneumothorax, nerve injury, local anaesthetic systemic toxicity, infection, respiratory complications, and block failure were recorded and analyzed.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 26. Continuous variables were expressed as mean ± standard deviation and compared using the independent Student's t-test. Categorical variables were expressed as frequencies and percentages and analyzed using Chi-square test or Fisher's exact test wherever appropriate. A p-value less than 0.05 was considered statistically significant.

RESULTS

The results of 60 patients undergoing costoclavicular block using USG +Nerve stimulator

(UNS) or landmark technique+Nerve stimulator is given below (LNS).

Table 1: Comparison of Block Success Rate between Groups

Block Outcome	Group UNS (n=30)	Group LNS (n=30)	P value
Successful block	29 (96.7%)	26 (86.7%)	0.161
Failed block	1 (3.3%)	4 (13.3%)	
Total	30 (100%)	30 (100%)	

The success rate of costoclavicular brachial plexus block was higher in Group UNS (96.7%) compared to Group LNS (86.7%). Block failure occurred in 3.3% of patients in the UNS group and 13.3% in the LNS group.

Table 2: Comparison of Secondary Outcome Variables

Variable	Group UNS (n=30) Mean ± SD	Group LNS (n=30) Mean ± SD	P value
Number of needle attempts	1.20 ± 0.41	1.83 ± 0.65	<0.001
Onset of sensory block (min)	8.4 ± 1.8	10.7 ± 2.3	<0.001
Onset of motor block (min)	11.2 ± 2.1	13.8 ± 2.7	<0.001
Time to achieve complete sensory block (min)	14.3 ± 2.4	17.6 ± 3.1	<0.001
Time to achieve complete motor block (min)	18.5 ± 3.2	22.1 ± 3.8	<0.001
Duration of sensory blockade (hours)	11.8 ± 1.6	11.2 ± 1.7	0.164
Duration of motor blockade (hours)	9.6 ± 1.3	9.2 ± 1.4	0.252

Group UNS required significantly fewer needle attempts and demonstrated a faster onset of sensory and motor blockade compared to Group LNS ($p<0.001$). The time required to achieve complete sensory and motor block was also significantly shorter in the ultrasound-guided group. However, the duration of sensory and motor blockade was comparable between the groups, with no statistically significant difference ($p>0.05$).

Table 3: Patient satisfaction and complications

Variable	Group UNS (n=30) n (%)	Group LNS (n=30) n (%)	P value
Patient satisfied	29 (96.7%)	26 (86.7%)	0.161
Vascular puncture	0 (0.0%)	2 (6.7%)	0.150
Hematoma formation	0 (0.0%)	1 (3.3%)	0.313
Pneumothorax	0 (0.0%)	0 (0.0%)	—
Nerve injury	0 (0.0%)	0 (0.0%)	—
Local anaesthetic systemic toxicity (LAST)	0 (0.0%)	0 (0.0%)	—
Infection	0 (0.0%)	0 (0.0%)	—
Respiratory complications	0 (0.0%)	1 (3.3%)	0.313
Overall complications	1 (3.3%)	4 (13.3%)	0.161

Patient satisfaction was higher in Group UNS (96.7%) than in Group LNS (86.7%), although the difference was not statistically significant. Procedure-related complications such as vascular puncture, hematoma formation, and respiratory complications were observed only in the LNS group, while no major complications such as pneumothorax, nerve injury, infection, or local anaesthetic systemic toxicity were reported in either group.

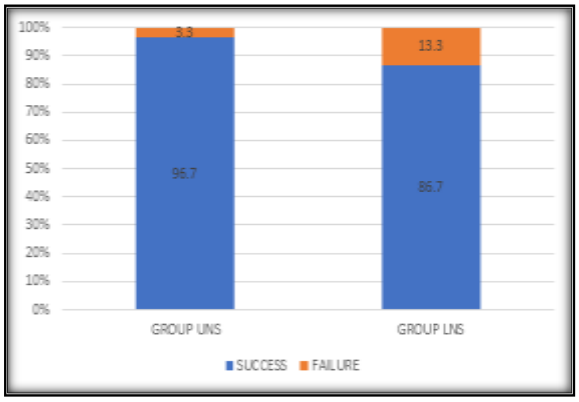

Figure 2: Successful block rate

DISCUSSION

The present randomized controlled trial compared the efficacy and safety of costoclavicular brachial plexus block performed using ultrasound guidance combined with nerve stimulation (UNS) and landmark-guided nerve stimulator technique (LNS) in patients undergoing upper limb surgeries. The results demonstrated that the ultrasound-guided technique was associated with a higher success rate, fewer needle attempts, faster onset of sensory and motor blockade, earlier achievement of complete block, higher patient satisfaction, and fewer complications compared with the landmark-guided approach.

In the present study, the success rate was 96.7% in Group UNS and 86.7% in Group LNS. Although the difference did not reach statistical significance ($p=0.161$), the findings are clinically important. These results are comparable with those reported by Leurcharusmee et al,[6] who demonstrated successful surgical anaesthesia in 95–98% of patients undergoing ultrasound-guided costoclavicular block. Similarly, Sala-Blanch et al. [9] reported a success

rate exceeding 95% with ultrasound-guided costoclavicular brachial plexus block. The slightly lower success rate observed in the landmark-guided group of our study may be attributed to the inability to directly visualize neural structures and local anaesthetic spread.

The number of needle attempts was significantly lower in Group UNS (1.20 ± 0.41) compared with Group LNS (1.83 ± 0.65, $p<0.001$). Ultrasound guidance enables visualization of the needle tip throughout the procedure, facilitating accurate needle placement. These findings are consistent with those reported by Marhofer et al,[7] who demonstrated that ultrasound guidance significantly reduced needle redirections and procedural difficulty compared with traditional techniques. Similarly, Abrahams et al,[8] in a systematic review of peripheral nerve blocks, reported fewer needle passes and improved block success with ultrasound guidance compared with nerve stimulator-guided approaches.

The onset of sensory block was significantly faster in Group UNS (8.4 ± 1.8 min) than in Group LNS (10.7 ± 2.3 min). Likewise, onset of motor block occurred earlier in the ultrasound-guided group (11.2 ± 2.1 min vs. 13.8 ± 2.7 min). These findings are comparable to those reported by Leurcharusmee et al,[6] who observed a sensory block onset time of approximately 8–10 minutes and motor block onset of 10–12 minutes following ultrasound-guided costoclavicular block. The faster onset in the ultrasound group can be explained by accurate deposition of local anaesthetic around the clustered cords within the costoclavicular space, resulting in more effective neural spread.

The time required to achieve complete sensory and motor blockade was also significantly shorter in Group UNS. Complete sensory block occurred at 14.3 ± 2.4 minutes in the ultrasound group compared with 17.6 ± 3.1 minutes in the landmark group. Complete motor block was achieved at 18.5 ± 3.2 minutes and 22.1 ± 3.8 minutes, respectively. These findings support the observations of Karmakar et al,[5] who highlighted the unique anatomical arrangement of the cords in the costoclavicular space, facilitating rapid and uniform local anaesthetic distribution. Similar findings have been reported in studies evaluating ultrasound-guided infraclavicular and costoclavicular approaches.[9,14]

The duration of sensory blockade was 11.8 ± 1.6 hours in Group UNS and 11.2 ± 1.7 hours in Group LNS, while motor blockade lasted 9.6 ± 1.3 hours and 9.2 ± 1.4 hours, respectively. The differences were not statistically significant. This finding is expected because the duration of blockade is primarily influenced by the pharmacological properties of the local anaesthetic and adjuvant used rather than the guidance technique. Hadzic,[11] and Brown,[12] similarly reported that once effective deposition of local anaesthetic is achieved, block duration remains comparable regardless of the localization technique employed.

Patient satisfaction was higher in Group UNS (96.7%) than in Group LNS (86.7%). Improved satisfaction may be attributed to fewer needle attempts, faster onset of anaesthesia, and a lower incidence of complications. Similar observations have been reported by Marhofer et al,[7] and Barrington et al,[16] who noted greater patient comfort and acceptance with ultrasound-guided regional anaesthesia techniques.

With regard to safety, complications were infrequent in both groups. No cases of pneumothorax, nerve injury, infection, or local anaesthetic systemic toxicity were observed. However, vascular puncture occurred in 6.7% of patients in Group LNS and none in Group UNS. Hematoma formation and respiratory complications were also observed only in the landmark-guided group. These findings are consistent with the systematic review by Abrahams et al,[8] which demonstrated a lower incidence of vascular puncture and procedural complications with ultrasound-guided nerve blocks. Barrington et al,[16] further reported that ultrasound guidance significantly improves the safety profile of peripheral nerve blockade by enabling continuous visualization of surrounding vascular structures and needle trajectory.

The present findings support the recommendations of contemporary regional anaesthesia practice favouring ultrasound guidance whenever available.[7,8,16] Nevertheless, the landmark-guided nerve stimulator technique achieved an acceptable success rate of 86.7% and demonstrated no major adverse events. This suggests that the landmark-guided costoclavicular approach may serve as a practical alternative in resource-limited settings where ultrasound equipment is unavailable; supporting the observations of WFSA guidelines regarding the continued relevance of nerve stimulator-guided regional anaesthesia in low-resource environments.[10]

CONCLUSION

Overall, the present study demonstrates that ultrasound-guided costoclavicular brachial plexus block provides superior block characteristics, improved patient satisfaction, and a lower complication rate compared with the landmark-guided nerve stimulator technique, while both approaches offer effective anaesthesia for upper limb surgeries.

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