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RESEARCH ARTICLE

A Randomized Double-Blind Study Comparing the Anaesthetic Efficacy of Costoclavicular and Supraclavicular Brachial Plexus Blocks in Forearm Surgery

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Abstract

Introduction: Brachial plexus blocks are well established as the primary anesthetic method in upper extremity surgeries. While the conventional supraclavicular block (SCB) is effective, it carries inherent risks of vascular puncture, ulnar nerve sparing, and Horner's syndrome. The costoclavicular brachial plexus block (CCB) is a novel modification of the infraclavicular approach where all three cords are clustered together in a compact topography lateral to the axillary artery, allowing for a single-injection technique. The study detailed in paper final documents evaluated and compared the anesthetic efficacy, onset times, and complication rates of ultrasound-guided CCB versus conventional SCB in patients undergoing forearm and hand surgeries.

Methods: This double-blind, randomized clinical study evaluated 60 patients aged 18 to 65 years (ASA grade I and II) scheduled for elective forearm and hand surgeries. Patients were randomly assigned into two equal groups of 30: Group CCB and Group SCB. Both groups received a local anesthetic mixture of 10 ml Lignocaine with adrenaline 2%, 10 ml Bupivacaine 0.5%, and 4 mg Dexamethasone. Data regarding block performance time, sensory and motor blockade onset times, block success rate, duration of postoperative analgesia, and adverse events were collected and monitored. Data analysis was conducted using SPSS version 24.0.

Results: The study findings showed that the block performance time was significantly shorter in Group CCB compared to Group SCB (7.61 $\pm$ 2.24 mins vs 9.12 $\pm$ 1.70 mins, $p = 0.0047$). Sensory onset (8.48 $\pm$ 1.29 mins vs 10.62 $\pm$ 0.68 mins, $p < 0.0001$) and motor onset (11.25 $\pm$ 1.04 mins vs 12.74 $\pm$ 0.94 mins, $p < 0.0001$) were achieved significantly earlier in the CCB group. The block success rate was 100% in Group CCB compared to 86.67% in Group SCB ($p = 0.0366$), with ulnar nerve sparing accounting for all 4 failed cases in the SCB group. Furthermore, Group CCB demonstrated a significantly longer duration of postoperative analgesia (11.11 $\pm$ 1.13 hours vs 9.79 $\pm$ 1.33 hours, $p = 0.0001$) and required fewer rescue analgesic doses. Complications in the SCB group included vascular puncture (10%) and transient Horner's syndrome (13.33%), whereas no complications were observed in the CCB group.

Conclusion: The study concluded that ultrasound-guided costoclavicular brachial plexus block provides a faster performance time, more rapid sensory and motor onset, higher procedural success, and prolonged postoperative analgesia compared to the conventional supraclavicular approach. It serves as a highly reliable and safe alternative for surgical anesthesia in forearm and hand procedures.

Key words: Costoclavicular block, Supraclavicular block, USG, Bupivacaine

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1 | INTRODUCTION

Brachial plexus block is well established and frequently used as main anaesthetic method in upper extremity surgery and even provide post-operative analgesia (1). The brachial plexus blocks offer multiple advantages over general anaesthesia including no airway manipulation, better surgical anaesthesia, decreasing the requirement of perioperative opioids, reduced post-operative stay and providing quality post-operative analgesia (2, 3).

Brachial plexus is adjacent to large vessels and vital structures extending from the inter-scalene region to the axillary region. Supra-clavicular and infra-clavicular approaches are becoming more and more popular in upper-extremity surgeries with the advent of ultrasound guidance offering real time visualization of needle tip, decreased requirement of local anaesthetics, reduced incidence of complications and increasing the overall block success rates (4, 5).

The most commonly used method for performing an infra-clavicular brachial plexus block is the lateral infra-clavicular fossa (LICF) approach, which involves a sagittal ultrasound scan. In this technique, local anaesthetic is injected around the second part of the axillary artery, located deep to the pectoral muscles (6). However, at this level, the brachial plexus cords are situated deeper and are arranged around the axillary artery, making them difficult to visualize in a single sagittal sonogram. As a result, this often requires multiple needles passes and larger volumes of local anaesthetic to achieve an effective block (7).

Costo-clavicular approach or medial infra-clavicular fossa (MILF) approach is a novel and upgraded modification of the infra-clavicular brachial plexus block. It was first described by Karnakar et al. (8) and published by Sala Blanch et al. (9) in 2016. Using ultrasound guidance, the costo-clavicular space (CCS) appears as a clearly defined intermuscular area situated deep and posterior to the midpoint of the clavicle.

This space is positioned between the clavicular head of the pectoralis major and the subclavius muscle in the front, and the upper slips of the serratus anterior muscle and the second rib at the back. In a single transverse sonogram of the costo-clavicular space, all three cords of the brachial plexus can be seen arranged together in a triangular formation, positioned immediately lateral to the first part of the axillary artery. This allows the block needle to be directed to the centre of the plexus using a single shot injection technique requiring a low volume of local anaesthetic and hence producing faster sensory-motor onset. This approach ensures an even distribution of the drug among all three cords, resulting in excellent surgical anaesthesia (10).

In the conventional supra-clavicular approach, brachial plexus around the subclavian artery is blocked with certain ramifications such as risk of pleura rupture, ulnar nerve sparing and vessel rupture. There is low risk of these complications in costo-clavicular variant of infra-clavicular brachial plexus block as the nerve cords are first approached before the vessel and pleura when compared with other approaches to infra-clavicular brachial plexus block. We hypothesize that a single injection of local anaesthetic at the center of the brachial plexus at the CCS, under sonographic guidance, will produce rapid onset of brachial plexus block producing surgical anaesthesia. We undertook this study as there are no previous studies available which compared the efficacy of costo-clavicular approach of brachial plexus block with the conventional supra-clavicular block.

2 | METHODS

After obtaining our Institutional Ethical committee approval (Reg No. ECR/ 275/Inst/MH/2013/RR-19) and clinical trial registration in India (**CTRI/2025/03/081673**), a double blinded (patient and observer) randomized clinical study was carried out on patients aged between 18 to 65 years of ASA grade I and II scheduled for forearm and hand surgeries at our institution. All procedures were conducted in accordance with the Helsinki Declaration of 1975 .The study's purpose and procedures

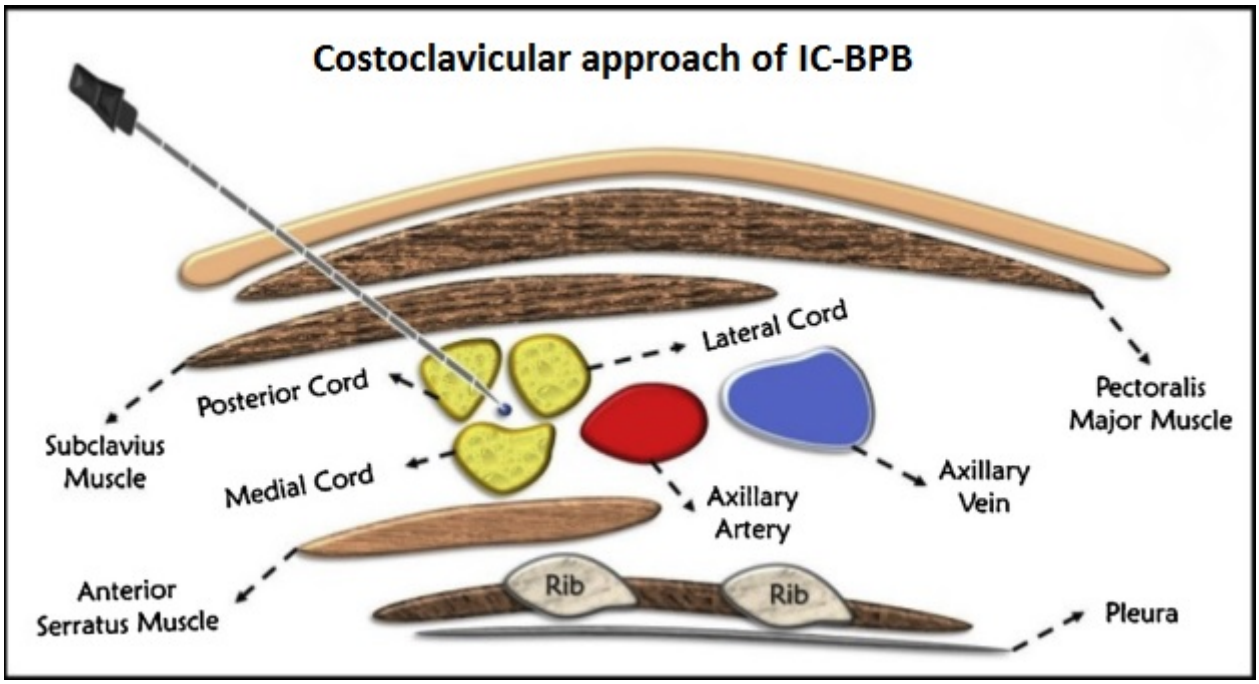

Fig. 1: Schematic diagram of costo-clavicular space

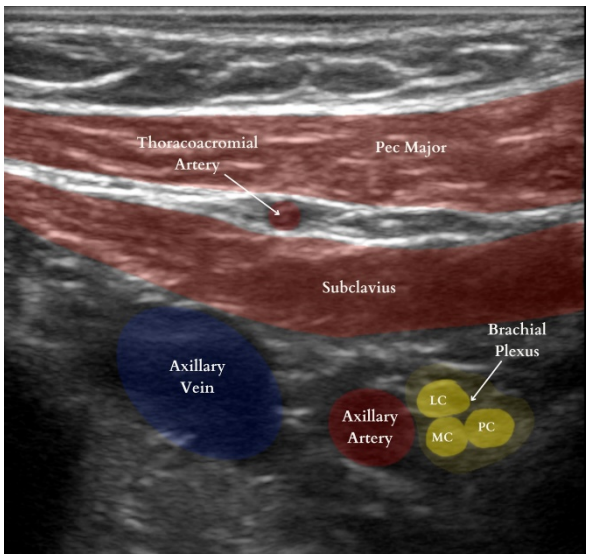

Fig. 2: Sonographic image of costo-clavicular space

were clearly explained to the patients, and written informed consent was obtained in a language they understood. Patients with local site infections, neuromuscular diseases or nerve injuries, coagulopathy, history of neck surgery, known allergies to local anaesthetics and individuals with contra-indications to peripheral nerve blocks were excluded from the study.

All the patients were subjected to detailed pre-anaesthetic evaluation. Routine and specific investigations were done according to our institutional protocol. During the preoperative visit, patients were also instructed on the use of a visual analogue scale (VAS) for postoperative analgesia and baseline vitals including HR, BP and SPO2 were evaluated and noted. All the patients were kept nil per oral 8 hours before to the surgery.

Patients were randomly divided into two groups of 30 patients each using computer random numbers using sealed envelope method into 2 groups:

Group CCB (Costo-clavicular brachial plexus

block): 10 ml Lignocaine with adrenaline 2% + 10 ml Bupivacaine 0.5% + Inj. Dexamethasone 4mg

Group SCB (Supra-clavicular brachial plexus block): 10 ml Lignocaine with adrenaline 2% + 10 ml Bupivacaine 0.5% + Inj. Dexamethasone 4mg

On arrival to the operating room, 20G peripheral intravenous cannula was secured on the non-operating hand and intravenous fluids (ringer's lactate) was started. Standard ASA monitors including electrocardiogram, non-invasive blood pressure and SpO2 were attached. The blocks were performed using a high-resolution portable ultrasound machine; FUJIFILM^{TM} Sonosite Edge II, with a 5–10 MHz linear probe with a sterile cover and 22G 50mm hypodermic needles. Block was performed by the attending anaesthesiologist who was skilled in ultrasound guided block techniques.

Group CCB: under strict aseptic precautions block site was prepped. Patients were positioned supine, with ipsilateral arm abducted for the scan and the head was turned slightly to the contralateral side for the BPB. The following anatomic landmarks were then identified and marked on the skin: clavicle, mid-point of the clavicle, and the tip of the coracoid process. A liberal amount of ultrasound gel was applied to the skin for acoustic coupling, and a transverse scan was performed over the medial infraclavicular fossa. The transducer was placed transversely directly over the mid-point of the clavicle in the transverse orientation with its orientation marker directed laterally (outward) and it was gently moved caudally until it reached the inferior border of the clavicle to visualize axillary artery (first part) and vein. Maintaining the same transducer position, it was gently tilted cephalad to direct toward the CCS, that is, the space between the posterior surface of the clavicle and the second rib. The ultrasound image was stabilized until all 3 cords of the brachial plexus were clearly visualized lateral Care was taken to avoid needle insertion to the cephalic vein or the thoracoacromial artery. After confirmation of the placement of needle via direct visualization and saline dissection, local anaesthetic was deposited after negative aspiration of blood or air.

Group SCB: under strict aseptic precautions, the transducer was placed in the supraclavicular fossa above the tilted caudally to obtain the cross-section of the subclavian artery. The first rib was identified which appeared as a white hyperechoic line with the lung border deeper to this bony border. The cords and trunks of brachial plexus were then visualized superolateral to the artery appearing as hypoechoic small oval structures. Utilizing the in-plane approach, the block needle was targeted in the corner pocket (the intersection between the first rib and the subclavian artery). Proper needle placement was confirmed with saline dissection. A one-third volume of local anaesthetic mixture was injected into the corner pocket after negative aspiration of blood or air. The block needle was then repositioned to inject the remaining volume into the centre of the main neural cluster formed by the trunks and divisions with negative aspiration of blood or air.

Outcome measures were observed by an impartial blinded anaesthesiologist who was blinded from all the outcomes of the study. After deposition of the drugs, performance of respective blocks were assessed every 5 min until 20 min using the sensorimotor composite scale.

The sensory assessment was done in major 4 nerve distributions with a spirit-soaked cotton swab; Radial nerve - posterior part of wrist and of the three first fingers, median nerve - anterior part of wrist and of the three first fingers, ulnar nerve - medial part of wrist and hand & musculocutaneous nerve - lateral part of forearm (11, 12).

Grading was done according to a three ‑ point qualitative scale on loss of sensation to cold and touch to the cotton swab as follows: "Grade 0" – presence of cold and touch sensation, "Grade 1" – loss of cold but not touch sensation and "Grade 2" – loss of both cold and touch sensation (11, 12).

Motor blockade of each of these four nerves were assessed and graded as per their motor functions; Radial nerve - wrist extension, median nerve - wrist flexion, ulnar nerve - thumb adduction & musculocutaneous nerve - Elbow flexion (11, 12).

Motor blockade was graded using a three‑point qualitative scale: "Grade 0" – normal motor function (power 4/5, 5/5), "Grade 1" – weakness against resistance (power 3/5, 2/5) & "Grade 2" – paralysis/no motor power (power 0/5, 1/5) (11, 12).

Responses were compared with the corresponding nerves in the opposite arm.

Sensory onset time was defined as the time required to reach a minimal score of 7 points (out of 8 points).

Motor onset time was defined as the time required to reach a minimal score of 7 points (out of 8 points).

We considered the patient ready for surgery (surgical anaesthesia achieved) when a minimal composite score of 14 points was achieved, provided the sensory block score was equal or superior to 7 out of 8 points. This scale has been used in previous studies (11, 12).

However, if after 20 minutes, the composite score was inferior to 14 points, that particular block was recorded as a failure and supplemental analgesia with inj. Fentanyl in graded doses or rescue block (axillary block) was given.

Post-operatively VAS score was assessed to elicit duration of post-operative analgesia by the observer anaesthesiologist at predetermined time intervals 0, 1, 2, 4, 6, 12, 24th hour. Once the VAS score was ≥4, patients were supplemented with Inj. Tramadol 2mg/kg as a rescue analgesic and this period was recorded as duration of post-operative analgesia.

Statistical analysis:

Data was collected and entered in MS Excel using SPSS version 24.0 for analysis. A pilot study was conducted on 10 patients and mean difference of 25% was obtained between two groups for onset of sensory and motor blockade. With standard deviation of 0.8, 90% statistical power and 5% level of significance, a sample size of 42 with 21 patients in each group was adequate. To avoid errors and attrition a larger sample size in each group was considered. Descriptive statistics was used for assessing demographic variables. Hemodynamic variables were assessed by student t test. Unpaired t test was used for statistical analysis of onset of block, duration of sensory and motor block and postoperative analgesia. Fisher Exact test was used for categorical variables. P-value of <0.05 was considered statistically significant.

3 | RESULTS

As shown in CONSORT flow diagram (Figure 3), total 72 patients were assessed for eligibility; twelve patients were excluded, eight patients had not met inclusion criteria and four patients due to consent withdrawal Sixty patients (n=60) were randomized equally into two groups (n=30).

The demographic details of the study participants including age, weight, height, BMI, sex, ASA grading were comparable between both the groups (Table 1).

Table 1. Comparison of demographic variables between two groups

Variables	Group CCB	Group SCB	P- value
Age (in years)	37.23 ± 11.81	40.83 ± 12.88	0.2638
Weight (in kgs)	65.86 ± 12.01	60.86 ± 13.05	0.128
Height (in metres)	1.64 ± 0.09	1.65 ± 0.08	0.6509
BMI (kg/sq.m) Sex (M/F) ASA Grade (I/II)	24.52 ± 5.51 17/13 15/15	22.30 ± 4.47 16/14 13/17	0.0919 - -

As per our observation, duration of block performance was significantly shorter in costo-clavicular approach of brachial plexus block when compared to supra-clavicular approach (7.61 ± 2.24 mins vs 9.12 ± 1.70 mins, p-value 0.0047) **(Table 2) (Figure 4)**.

Onset of sensory blockade (8.48 ± 1.29 mins vs 10.62 ± 0.68 mins) and onset of motor blockade (11.25 ± 1.04 mins vs 12.74 ± 0.94 mins) were achieved significantly earlier in group CCB when compared to group SCB (p- value <0.0001 and p-value <0.0001 respectively) **(Table 2) (Figure 5)**.

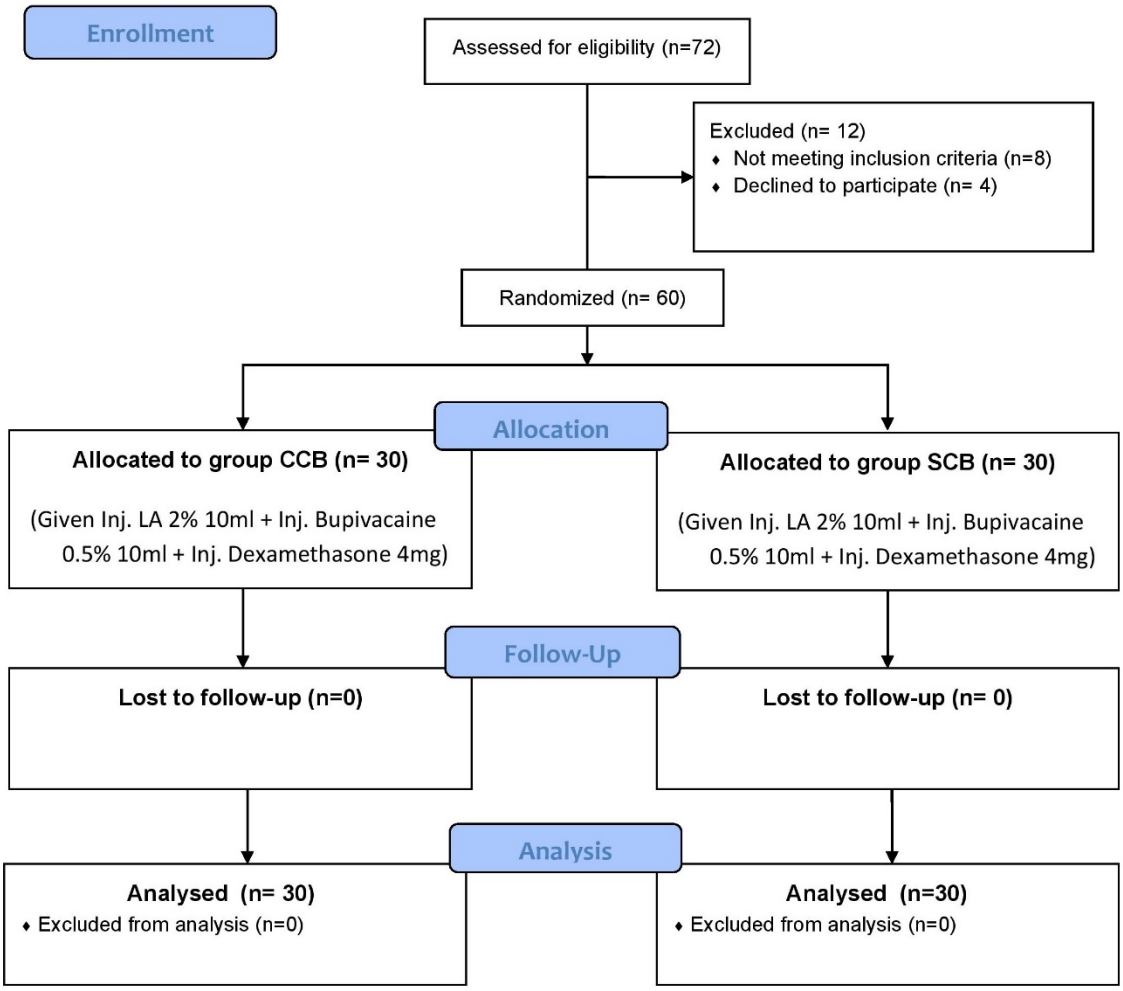

Fig. 3: Consort chart

Table 2. Comparison of study parametersbetween the two groups

Variables	Group CCB (Mean ± SD)	Group SCB(Mean ± SD)	P- value
Duration of performance of block (mins)	7.61 ± 2.24	9.12 ± 1.70	0.0047
Onset of sensory nerve block (mins)	8.48 ± 1.29	10.62 ± 0.68	< 0.0001
Onset of motor nerve block (mins)	11.25 ± 1.04	12.74 ± 0.94	< 0.0001
Number of patients having adequate block	30/30 (100%)	26/30 (86.67%)	0.0366
Number of patients having inadequate block	0/30 (0%)	4/30 (13.33%)	0.0366
Duration of analgesia (hours) Doses of rescue analgesia given	11.11 ± 1.13 1.13 ± 0.34	9.79 ± 1.33 1.46 ± 0.50	0.0001 0.0041

The block success rate was 100% (30/30) in the CCB group as compared to 86.67% (26/30) in SCB group and this difference was statistically significant (P-value = 0.03) **(Table 2) .**

In the SCB group, ulnar nerve territory was spared in all the failed cases, 4/30 (13.33%) **(Table 3)**.

The total duration of postoperative analgesia was significantly longer in group CCB compared to the control SCB group. Patients who received costo-clavicular block had a mean duration of post-operative analgesia of 11.11 ±1.13 hours. In contrast, supra-clavicular block gave a much shorter

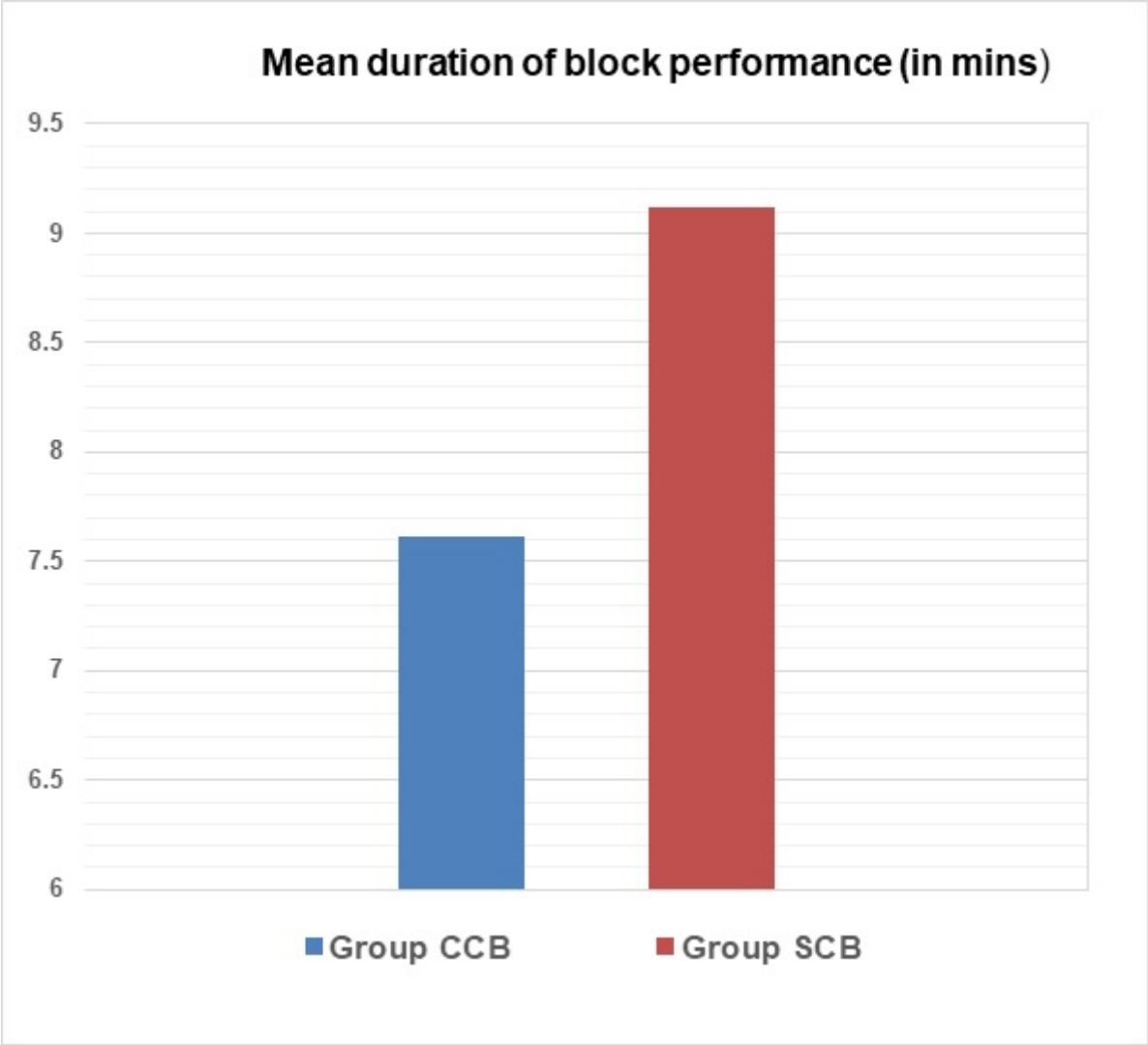

Fig. 4: Comparison of duration of block performance between two groups

Table 3. Side effects or complications

Characters	Group CCB	Group SCB	P- value
Nausea	0	0	-
Vomiting	0	0	-
Bradycardia	0	0	-
Hypotension Vascular puncture Horner syndrome Pneumothorax	0 0 0 0	0 3 (10%) 4 (13.33%) 0	- 0.0780 0.0400
Toxicity of local anaesthetic Ulnar sparing Nerve injury	0 0 0	0 4 (13.33%) 0	- - 0.0400 -

mean duration of analgesia of 9.97 ± 1.13 hours. This difference between the two groups was statistically significant (p-value 0.0001) **(Table 2) (Figure 5)**.

The number of rescue analgesic dosages required in the first 24 hours following surgery were compared between the two groups. Patients in Group CCB required significantly fewer rescue analgesic dosages (1.13 ± 0.34) compared to patients in Group SCB (1.46 ± 0.50) (p-value 0.0041) **(Table 2) (Figure 6)**.

There were few side effects or complications in the study. Vascular puncture was seen in three patients (10%) in SCB group and four patients (13.33%) were diagnosed with Horner's syndrome in SCB group. There was no significant difference in these parameters as compared to the CCB group (**Table 3)**.

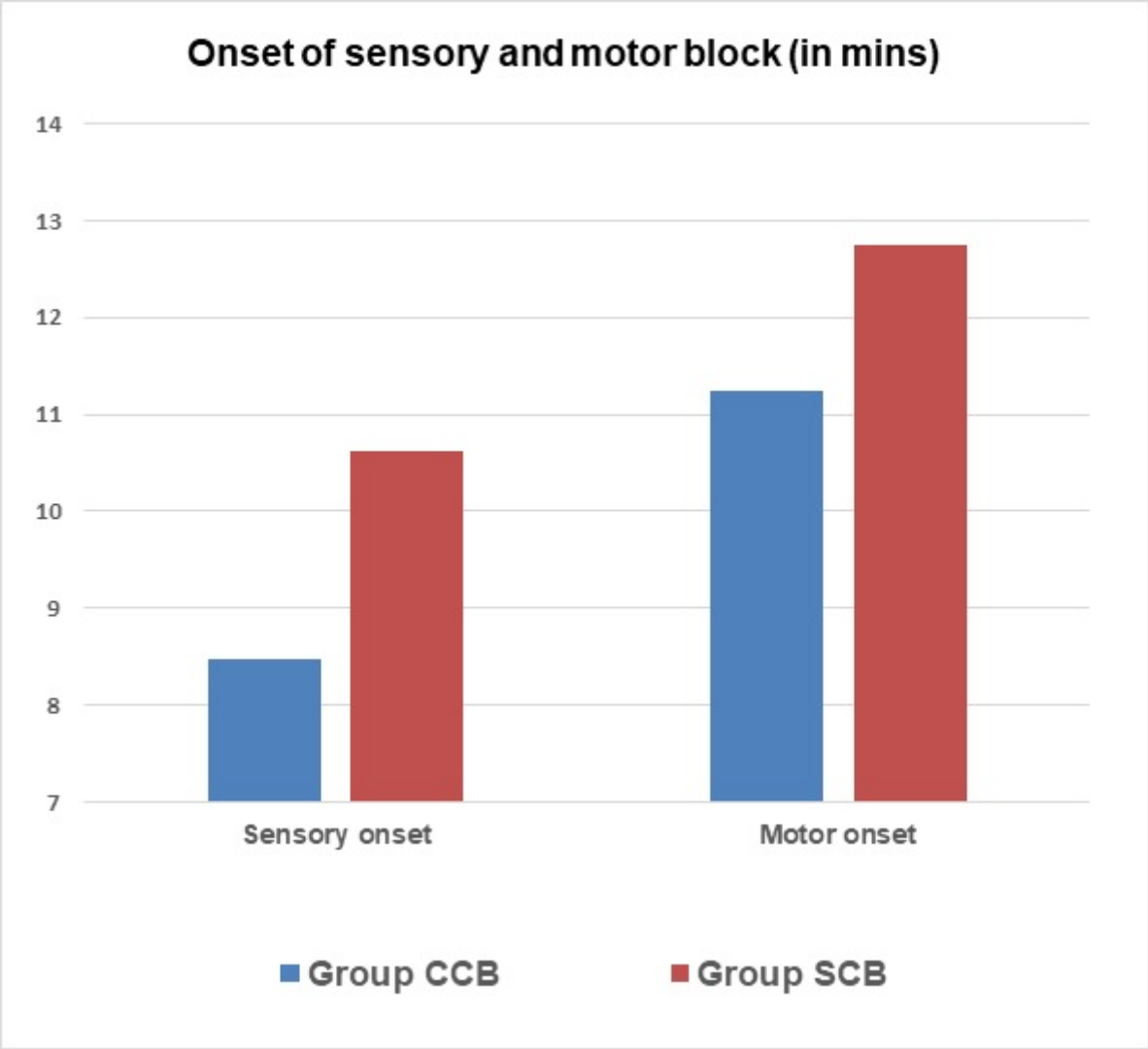

Fig. 5: Comparison of sensory and motor onset between two groups

4 | DISCUSSION

In this prospective randomized, observer blinded study, we compared costo-clavicular and supra-clavicular approach of brachial plexus block using ultrasound guidance. Our research shows that the block performance time was quicker in CCB group and the onset of sensory-motor blockade was achieved earlier when compared to group SCB. Our findings suggest that both blocks provide equivalent post-operative analgesia with comparable number of rescue analgesic doses required in the 24-hour post-operative period. None of the patients developed intra-operative or post-operative complications.

In this study we used the costo-clavicular approach of infra-clavicular block. In costo-clavicular approach all the three cords are located on the lateral aspect of the axillary artery and displays a more compact topography and thus a single site injection of local anaesthetic solution is required; whereas, in the lateral sagittal approach, the three cords are located medial, lateral and posterior to the AA, requiring multiple needle manipulations

Our results are in accordance to a similar to a study done by Ramesh et al (13) comparing costo-clavicular approach with supra-clavicular block. Results showed early onset of sensory blockade (8.20 $\pm$ 0.58 min vs 9.72 $\pm$ 0.84 min) and motor blockade (11.72 $\pm$ 0.79 min vs 12.56 $\pm$ 0.92 min) in group C (Costo-clavicular group). Duration of sensory and motor blockade was comparable between both the groups and was statistically insignificant. Duration of block performance was significantly shorter in costo-clavicular approach of brachial plexus block

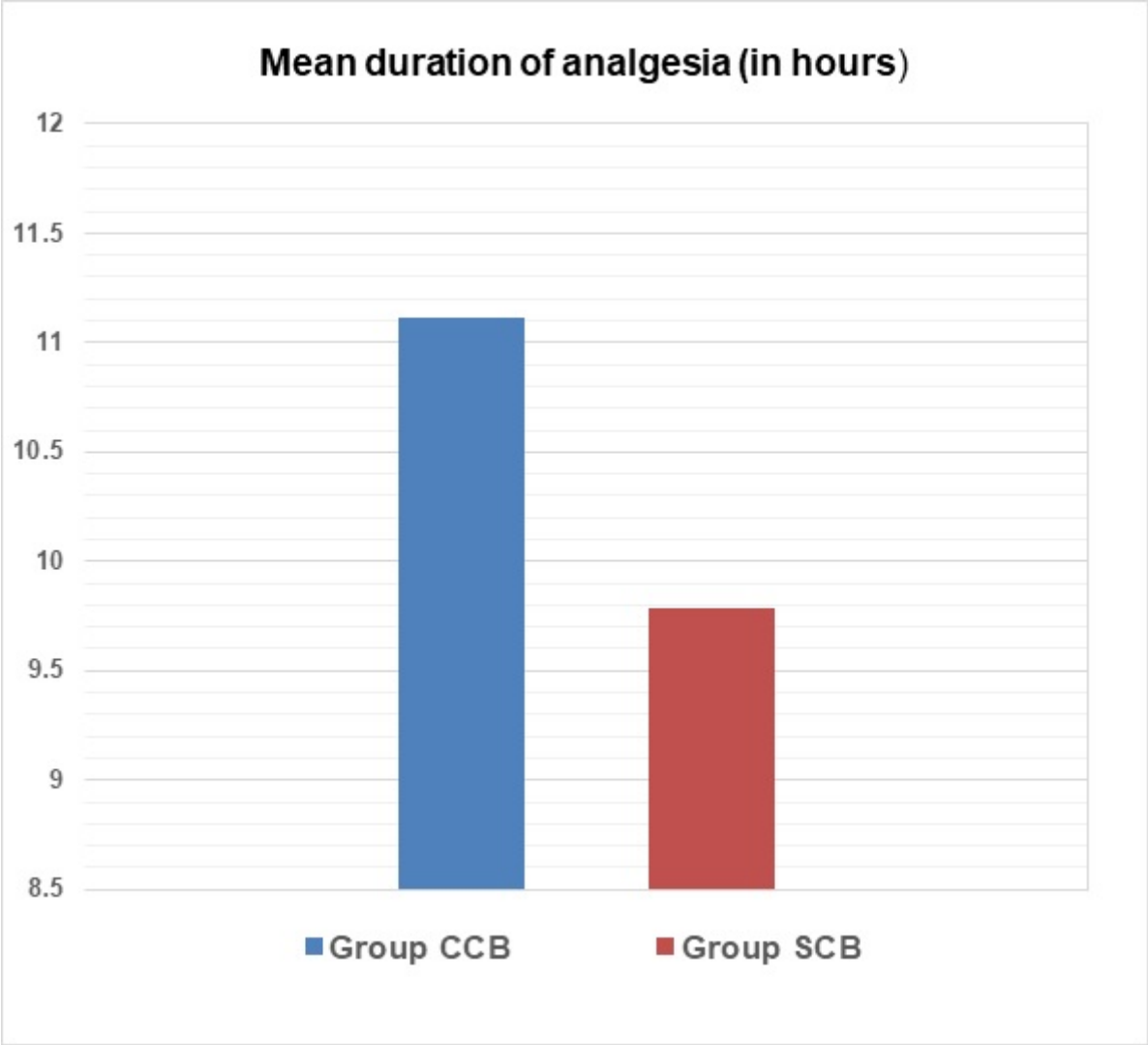

Fig. 6: Comparison of duration of analgesia between two groups

when compared to supraclavicular approach

Comparisons between CC-BPB and other techniques have also been made. Songthamwat et al. (14) compared Ultrasound-Guided conventional IC-BPB with CC-BPB in 40 patients undergoing elective upper extremity surgery. They found the overall sensory onset time was 10 min using CC-BPB, which was faster than the 20 min seen in ICBPB. Time to readiness for surgery was also faster in the CC-BPB (10 min) in]comparison to IC-BPB (20 min). Songthamwat et al. (14) found that the CC approach was faster to perform and had a higher success rate than the traditional approach. In traditional approach, the needle trajectory is steeper and the target is deeper in comparison to the costo-clavicular approach, making the procedure technically more difficult and requiring multiple needle passes to cover the lateral, medial and the posterior cords.

Furthermore, in evaluating the spread of CC-BPB, Koyyalamudi et al. demonstrated that injection in the costo-clavicular space firstly spread to the brachial plexus, reaching all its trunks and cords and sparing the phrenic nerve (15).

In our study results, 4 (13.34%) patients experienced Horner's syndrome in ultrasound-guided SCB group compared to none in ultrasound-guided CCB. In these patients, diagnosis was made within 30 minutes of onset of the surgery. The patients subjectively felt some discomfort due to the temporary nature of the phenomenon. Oxygen supplementation was provided and patients were ensured and well counselled to alleviate the anxiety. These patients were closely monitored in the post-operative period and periodic examinations were performed. The symp-

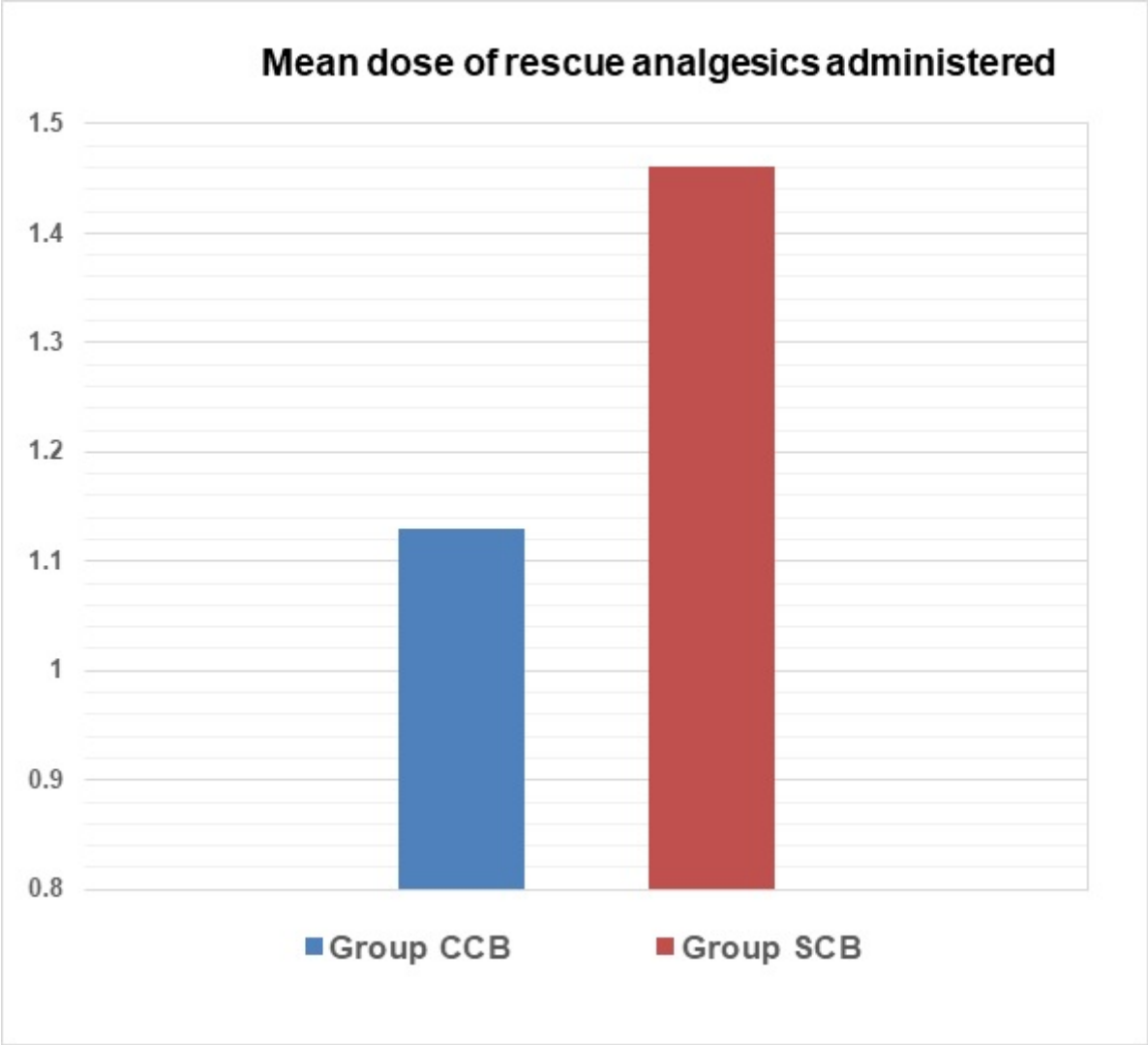

Fig. 7: Comparison of rescue analgesics administered between two groups

toms resolved with regression of the nerve block over less than 24 hours. There were no further complications and no further management was required for the same.

As cervical sympathetic chain is close to the brachial plexus in the supraclavicular region, the incidence of Horner syndrome in supra-clavicular approach is higher than in infra-clavicular approach, although it can occur in infra-clavicular approach. The cervical sympathetic chain controls sympathetic functions to the eye and the face. The sympathetic fibres traveling from the T1 (sometimes C8) root of the brachial plexus also innervate structures in the face and eye, including the muscles responsible for pupil dilation and eyelid elevation. However, no additional treatment is required considering the temporary nature of the syndrome and this syndrome has been considered to have no clinical relevance (16).

The nerves at the costo-clavicular space are further away from the trajectory of cervical sympathetic nerve and the limited diffusion capacity of a relatively small volume of LA. The incidence of Horner syndrome in supra-clavicular brachial plexus block ranges from 30-90% (17, 18). All previous studies reported higher incidence of Horner's syndrome in the supra-clavicular brachial plexus block (19–21).

Vascular puncture was observed in 3 (10%) patients in the SCB group and none in the CC group. Previous studies also demonstrated similar findings (22–24). The clustered orientation of the brachial plexus in costo-clavicular approach provides the advantage of puncture free drug delivery. Ulnar sparing was observed in 4 (13.34%) patients of SCB group and was supplemented with axillary block as a rescue

block.

Whilst no hemi-diaphragmatic paralysis was observed in the present study, several others have found a reduced incidence of hemi-diaphragmatic paralysis in CC-BPB when compared with SC-BPB in upper extremity surgery. In a recent study, Boohwi et al compared hemi-diaphragmatic paralysis following costo-clavicular and supraclavicular brachial plexus block. The incidence of HDP was (11.4%) in the group C and (47.5%) in the group and concluded that costo-clavicular block can decrease the incidence of HDP when compared to supraclavicular block and has low impact on pulmonary functions and can be considered as alternate choice for SCB (25). Aliste et al compared inter-scalene and costo-clavicular blocks for arthroscopic shoulder surgeries in a randomized trial and concluded that CCB results in equivalent postoperative analgesia while circumventing the risk of hemi-diaphragmatic paralysis (26). Based on study conducted by Charles et al. (27) the costo-clavicular approach offers better mechanical stability for catheter placement than the traditional supraclavicular approach as the catheter pierces the pectoralis major and subclavius muscles, a larger proportion of it remains tunneled and hence safe neck movements is achieved. However, we did not use any catheters in our study.

Although supra-clavicular and infra-clavicular approaches of brachial plexus blocks have been extensively compared, we rarely find any study comparing classic SCB and costo-clavicular approach. Hence, this study, may be a useful addition to the available literature.

5 | CONCLUSION:

We conclude that ultrasound guided costo-clavicular brachial plexus block is quick to perform and has a rapid onset of sensory-motor blockade with comparable duration of postoperative analgesia compared to conventional ultrasound guided supra-clavicular block. CCB can be safely used as an alternative technique for providing surgical anaesthesia for forearm and hand surgeries in routine clinical practice

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Smt. Kashibai Navale Medical College and General Hospital [Institutional Ethics Committee] with approval number, registration No. ECR/275/Inst/MH/2013/RR-19. Written consent from all enrolled patients was obtained.

Consent for publication

Consent for publication was obtained from all the patients on the institutional consent form.

Availability of data and material

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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6 | LIST OF ABBREVIATIONS:

LICF- Lateral infra-clavicular fossa

MILF- Medial infra-clavicular fossa

CCS- Costo-clavicular space

USG- Ultrasound sonography

BPB- Brachial plexus block

VAS- Visual analogue scale

HR- Heart rate

BP- Blood pressure

Sp02- Oxygen saturation in blood

ECG- Electrocardiogram

ASA- American Society of Anaesthesiologists

CCB- Costo-clavicular block

SCB- Supra-clavicular block

LA- Lignocaine with Adrenaline

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