Ultrasound-guided costoclavicular vs. axillary brachial plexus block: A randomized clinical study

Kadirehally Bheemanna Nalini, Yatish Bevinaguddaiah¹, Balaji Thiyagarajan¹, Archana Shivasankar¹, Vinayak Seenappa Pujari¹

Department of Anaesthesiology, Sathagiri Institute of Medical Sciences, ¹Department of Anaesthesiology, M S Ramaiah Medical College, Bengaluru, Karnataka, India

Introduction

The brachial plexus block (BPB) is less invasive and as equally effective as general anesthesia to anesthetize the upper limbs.[1,2] The block success rate as an important indicator for comparison of various approaches of BPB, has reached almost 95%–100% with the ultrasound (US)-guided techniques.[2,3]

US-guided axillary BPB is a reliable anesthetic method for surgical anesthesia for wrist and hand.[3,4] The onset time of BPB in the US-guided axillary approach is fast as the infiltration of the local anesthesia (LA) is done at close proximity to the nerves. In a recently described costoclavicular space (CCS), the three cords of the brachial plexus are tightly clustered together lateral to the axillary artery (25-mL LA) and the musculocutaneous nerve (5-mL LA) or at the CCS, and performance time was noted. Observer blinded to the block procedure recorded the block onset time and success rate.

Material and Methods:

Fifty patients who underwent surgeries below the level of mid-arm under ultrasound-guided BPB were randomly allocated to any one of the two study groups. Thirty milliliters of local anesthetic (LA), a mixture of 10-mL 2% lidocaine with 5-µg/mL adrenaline and 20-mL 0.5% bupivacaine, was deposited around the axillary artery (25-mL LA) and the musculocutaneous nerve (5-mL LA) or at the CCS, and performance time was noted. Observer blinded to the block procedure recorded the block onset time and success rate.

Results:

The mean (SD) onset times were comparable between the costoclavicular (CC) and axillary (AX) groups (12.0 ± 3.2 vs. 11.2 ± 2.9 min, respectively; \( P = 0.367 \)). Group CC demonstrated a reduction in performance time compared to group AX (5.3 ± 1.9 vs. 8.0 ± 3 min, respectively; \( P < 0.05 \)). All blocks were successful in both groups without any complications except for one patient in group AX who required a rescue block for radial nerve.

Conclusion:

Costoclavicular and axillary ultrasound-guided BPBs resulted in similar onset times. However, the block performance time was longer for AX group compared to CC group. There were no intergroup differences found in terms of success rates.

Keywords: Axillary block, brachial plexus, costoclavicular space, nerve block, regional anesthesia, ultrasound-guided

Abstract

Background and Aims: Brachial plexus is in a very compact state at the costoclavicular space (CCS) when compared to the axilla, where the individual nerves are separate. This study aimed to test the hypothesis that brachial plexus block (BPB) at the CCS would result in a faster onset of block as compared to the axillary approach of BPB.

Material and Methods: Fifty patients who underwent surgeries below the level of mid-arm under ultrasound-guided BPB were randomly allocated to any one of the two study groups. Thirty milliliters of local anesthetic (LA), a mixture of 10-mL 2% lidocaine with 5-µg/mL adrenaline and 20-mL 0.5% bupivacaine, was deposited around the axillary artery (25-mL LA) and the musculocutaneous nerve (5-mL LA) or at the CCS, and performance time was noted. Observer blinded to the block procedure recorded the block onset time and success rate.

Results: The mean (SD) onset times were comparable between the costoclavicular (CC) and axillary (AX) groups (12.0 ± 3.2 vs. 11.2 ± 2.9 min, respectively; \( P = 0.367 \)). Group CC demonstrated a reduction in performance time compared to group AX (5.3 ± 1.9 vs. 8.0 ± 3 min, respectively; \( P < 0.05 \)). All blocks were successful in both groups without any complications except for one patient in group AX who required a rescue block for radial nerve.

Conclusion: Costoclavicular and axillary ultrasound-guided BPBs resulted in similar onset times. However, the block performance time was longer for AX group compared to CC group. There were no intergroup differences found in terms of success rates.

Keywords: Axillary block, brachial plexus, costoclavicular space, nerve block, regional anesthesia, ultrasound-guided

How to cite this article: Nalini KB, Bevinaguddaiah Y, Thiyagarajan B, Shivasankar A, Pujari VS. Ultrasound-guided costoclavicular vs. axillary brachial plexus block: A randomized clinical study. J Anaesthesiol Clin Pharmacol 2021;37:655-60.

Submitted: 03-Feb-2020 Revised: 19-May-2020
Accepted: 14-Jun-2020 Published: 02-Nov-2021

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.
costoclavicular block would result in faster onset of action in comparison with US-guided axillary block. There are many studies comparing various approaches to brachial plexus under US guidance, but there are no comparative studies between the axillary and costoclavicular approaches.

**Material and Methods**

This was a randomized, clinical trial on adult patients scheduled for elective or emergency upper extremity surgery below the mid-arm under BPB. After obtaining Institutional Ethical Clearance (ECR/215/Inst/KA/2013/RR-16) and clinical trial registration in India (CTRI/2018/12/016646), the study was performed in the operation theater in Ramaiah hospitals, Bengaluru. Fifty patients aged 18–60 years, belonging to American Society of Anesthesiologists physical status I–III, who gave written informed consent, were included. Patients with coagulopathy, evidence of infection at the axillary or costoclavicular area, with preexisting neurological deficit and those allergic to local anesthetic (LA) drugs were excluded.

Randomization into one of the two groups, axillary (AX) or costoclavicular (CC) was determined using random number generator, and concealed by sealed envelope technique.

The principal investigator performed all the US-guided BPBs according to the allocation card and collected the procedural data without participating any further in outcome assessment. The anesthesiologist (outcome assessor) who performed the sensory and motor assessment after the BPB was not present in the anesthetic procedure room during the block performance and was blinded to the group allocation.

All the patients received pantoprazole 40 mg and ondansetron 4 mg orally on the morning of the day of surgery. In the operation theater, all patients were cannulated with 18-gauge venous cannula in the contralateral upper limb and standard monitors, viz., electrocardiogram, arterial oxygen saturation (SpO2), and noninvasive arterial blood pressure, were connected. A high-frequency linear transducer (HFL50, 15–6 MHz) of Sonosite M turbo ultrasound system, with multibeam (compound imaging) capability, was used. With strict aseptic precautions, block was performed with a 5-cm, 21-gauge nerve block needle (Stimuplex, B Braun). For both the groups, 30-mL LA mixture (20-mL 0.5% bupivacaine plus 10-mL 2% lignocaine with 5 µg/cc adrenaline) was given.

Patients in group AX were placed in the supine position with the surgical arm in 90° abduction and external rotation. After sterilization of axilla with Betadine solution, US probe was positioned over the axillary crease, to identify the axillary artery and the structures situated on the right, left and behind (medial, lateral, and posterior to) the artery [Figure 1]. The Stimuplex needle was inserted in the plane of the transducer and a total of 25-mL LA mixture was injected around the artery. Finally, the musculocutaneous nerve between the coracobrachialis and the biceps was blocked with 5-mL LA mixture. While performing the axillary block, the block needle was inserted twice into the skin, first during the infiltration of cords around the axillary artery and the next for blocking the musculocutaneous nerve.

In group CC, the transducer was placed below and parallel to the middle third of the clavicle with the surgical arm in 90° abduction and the hand in supination. The axillary artery was visualized. Also located cephalad and lateral to the axillary artery were three cords of brachial plexus (sandwiched between subclavius above and serratus anterior below) [Figure 2]. The nerve block needle was inserted in-plane, in the lateral-to-medial direction such that the needle tip was located in the middle of the three cords and 30-mL LA mixture was incrementally injected between the three cords of the brachial plexus.

The duration of procedure, extending from the time the skin was punctured with the block needle to the end of LA injection was noted. The time immediately after LA injection was considered as time 0 for sensory and motor assessment. Every 5 min after block performance, a blinded observer assessed the sensory and motor block over a scale of 0-2 for 30 min, or till achievement of blockade, whichever was earlier. The sensory assessment in various nerve distributions was made with an alcohol swab. The 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): responses were compared with the corresponding nerves in the opposite arm. Grading was done according to a three-point qualitative scale on loss of sensation to cold and touch for the alcohol-soaked cotton swab:

- 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. Motor blockade of each of these four nerves in the anesthetized upper extremity was assessed and 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), and grade 2—paralysis/no motor power (power 0/5, 1/5). Elbow flexion, wrist flexion, thumb adduction, and wrist extension were used to test for motor blockade of the musculocutaneous, median, ulnar, and radial nerves, respectively.

The block was considered a success when patients achieved a minimal composite score of 14 points out of a maximal composite sensorimotor score of 16, with the minimum sensory
block score of 7 points. This scale has been adopted from previous studies.[8] Thus, the block onset time was defined as the time required to obtain 14 points or more after the end of LA injection through the block needle.

Patients were sedated for comfort and sleeping but arousable for verbal stimulus, using small doses of intravenous midazolam (1 mg) and intravenous fentanyl 1 µg/kg. The BPB was considered incomplete if the composite score was below 14 points 30 min after block. In the event of an incomplete block after 30 min, a rescue block or local infiltration was given and was recorded as block failure. In addition, cases where general anesthesia was given for pain during surgery was also recorded as a block failure. For these patients, we did not record an onset time. Any complications of the block procedure such as hematoma, pneumothorax, and LA toxicity were noted.

Using the results from the study by Song et al., that compared US-guided infraclavicular block to US-guided axillary block, for the difference in the mean onset time, the sample size necessary for a 0.8 statistical power and 0.05 confidence interval was calculated to be 17 per group.[9] Therefore, 25 patients per group were enrolled to compensate for possible dropouts.

**Statistical analysis**

Statistical analysis was performed using SPSS for Windows 18.0 (SPSS Inc., Chicago, IL, USA). The continuous variable was expressed as the mean ± standard deviation and a Student’s t-test was used for the analysis. The categorical variables were analyzed using Fisher’s exact test. Differences were considered statistically significant when the $P$ value is less than 0.05.

**Results**

The demographic data was comparable between the groups [Table 1]. Our primary outcome, the mean (SD) onset time, was similar between the CC and AX groups (12.0 ± 3.2 min vs. 11.2 ± 2.9 min, respectively; $P = 0.367$). The block was successful in all patients in the CC group, whereas in the AX group, one case needed a rescue radial nerve block. The performance time of the block procedure was shorter for group CC compared to AX group (5.3 ± 1.9 vs. 8.0 ± 3 min, respectively; $P < 0.05$). Hence, the total anesthetic time which included the performance time and the onset time was similar in the AX group as compared to the CC group (19.2 ± 2.8 vs. 17.3 ± 3.2, respectively).

The proportions of blocks achieving minimal composite scores of 14 points at the different 5-min intervals were similar between the two groups [Figure 3]. The comparison of the onset of the sensory block and motor block in patients according to each time bracket is shown in Figures 4 and 5.
Although a higher rate was consistently seen at 5 min for patients in Group CC with the sensory block except for ulnar and with the motor block except for the musculocutaneous nerve, there were no significant differences. There were no complications of hematoma, pneumothorax, and LA toxicity.

**Discussion**

In this randomized clinical trial, we compared US-guided costoclavicular and axillary BPBs. The block onset time (primary endpoint) and overall success rates (surgical anesthesia) were similar in both the groups. The

| Table 1: Demographic data |
|---------------------------|
| Group CC (n=25) | Group AX (n=25) | P |
| Age (years) | 34.9±13.2 | 32.4±6.8 | 0.29 |
| Sex (M/F) | 16/9 | 17/8 | 0.93 |
| Height (cm) | 159.3±8.7 | 158.7±7.4 | 0.92 |
| Weight (Kg) | 60.1±10.2 | 57.1±8.7 | 0.15 |
| ASA (I/II/III) | 18/3/4 | 19/3/3 | 0.91 |

Values are expressed as Mean±S.D for age, height, and weight and ratio for sex and ASA physical status. ASA indicates American Society of Anesthesiologists; M, male; F, female.
compact arrangement of medial, lateral, and posterior cords of brachial plexus under a single fascial compartment in the CCS may explain why the costoclavicular technique provides fast sensorimotor blockade. In the axilla, though the individual nerves are separate, peripheral nerves are individually identified and blocked with LA at the periphery of the nerve. Hence, the onset of block was fast with the axillary block minimizing the differences between the two methods. These findings may be partially explained by the LA volume used. There are no US-guided comparative studies between the axillary and costoclavicular approaches for BPBs.

The onset time of surgical anesthesia depends on various factors like drug, concentration, volume, site of LA deposition (intra or extra fascial), number of injections, and the definition for onset time for surgical anesthesia. To minimize the interobserver bias, we used a 14-point (out of total 16 points) minimal composite score as the study end point to a maximum of 30 min observation period instead of readiness for surgery. In our study, we selected a 30-mL LA injectate (2.0% lidocaine with 5 µg/mL adrenaline and 0.5% bupivacaine mixture). Karmakar et al. used only 20-mL LA for costoclavicular block in their original description. There is significant variation in the position of the individual nerves relative to the axillary artery in axillary approach, whereas all the cords are compact on one side in CCS. Fascial layers in the brachial plexus in the axillary region can impede LA spread affecting the onset time and efficacy of the block requiring larger volume for surgical anesthesia. The possibility that the costoclavicular technique may outperform the axillary approach with smaller LA volumes (20 mL) cannot be ruled out. Further studies are advocated with lower LA volumes.

In our study, we used the complete loss of sensation in the dermatome of the four nerves for the block onset time. This is different from previous studies which were based on hyposthesia as they used a relatively smaller amount of the local anesthesia (20 mL) to avoid complications from over-medication in the BPB, which they had relatively little experience with. But, in their study, they had difficulties when comparing the onset time due to delay in the progression of the nerve block.

Results of this randomized comparative study demonstrated that US-guided costoclavicular BPB had a shorter block performance time than the axillary approach. The difference in the performance time was because the costoclavicular approach required only one injection of LA directly into the sheath of three fascicles of cords, while the axillary approach required LA injection around each of the four nerves with two skin puncture sites. In our study, there was approximately a 3-min difference in the block performance time whose reduction may be of some comfort to the patient who needs to be under a drape for the procedure.

In our study, the performance time was from Stimuplex needle insertion to needle removal, whereas in the other studies this was defined as the sum of scanning and needling time. As there is a lot of anatomical variation in the position of the individual nerves relative to the axillary artery in axillary approach, extended scanning up and down the arm may be required to locate the nerves accurately. However in CCS, all cords are compact on one side. The time needed for extended scanning may further increase the total performance time for the axillary approach compared to the costoclavicular approach.

Multiple needle passes may increase the risk of vascular puncture in the axillary block. Patients with coagulation derangements may benefit from the costoclavicular technique as compared to the axillary approach, as the target point is in between the three cords of the brachial plexus located lateral to the artery rather than perivascular in the axillary approach.

In our study, no serious complications were encountered related to the technique (pneumothorax, accidental vascular puncture) or the LA toxicity. At the CCS, the position of the cords is lateral to the axillary artery and pleura. A lateral-to-medial directed needle insertion under US guidance similar to supraclavicular BPB may confer protection against vascular and pleural puncture. Further research is warranted to establish the safety and advantages of the costoclavicular BPB.

Our study has a number of limitations. First, scanning/imaging time was not included in the performance time. As there is significant anatomical variation in the position of the individual cords relative to the axillary artery in axillary approach, extended scanning up and down the arm is required to locate the nerves accurately, and this might increase the overall performance time (scanning and needling time) for AXB. Second, the procedural pain was not assessed. The costoclavicular approach only requires one needle puncture, whereas axillary approach requires two skin punctures. Third, the LA volume used was high. The possibility that the costoclavicular technique may outperform the axillary approach with smaller LA volumes (20 mL) cannot be ruled out. Fourth, our results are specific to the 2% lidocaine–0.5% bupivacaine mixture; further trials are required for other LA with a slower onset of action.
Conclusion

In conclusion, though the time of onset and success rate were similar in US-guided costoclavicular and axillary BPBs, block performance time was lesser in US-guided costoclavicular BPB, hence reducing its total anesthetic time. Further trials are required with lower volumes of local anesthetic.

Acknowledgements

We would like to thank our statistician, Dr. Radhika M at M S Ramaiah medical college, India, for statistical analysis of this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Wedel DJ, Horlocker TT. Nerve blocks. In: Ronald DM, editor. Miller's Anesthesia. 7th ed. Churchill Livingstone; Philadelphia, USA; 2010. p. 1639-75.
2. Tran DQ, Russo G, Munoz L, Zaouter C, Finlayson RJ. A prospective, randomized comparison between ultrasound-guided supraclavicular, infraclavicular, and axillary brachial plexus blocks. Reg Anesth Pain Med 2009;34:366-71.
3. Sites BD, Beach ML, Spence BC, Wiley CW, Shiffrin J, Hartman GS, et al. Ultrasound guidance improves the success rate of a perivascular axillary plexus block. Acta Anaesthesiol Scand 2006;50:678-84.
4. Ranganath A, Srinivasan KK, Inhom G. Ultrasound guided axillary brachial plexus block. Med Ultrason 2014;16:246-51.
5. Karmakar MK, Sala-Blanch X, Songthamwat B, Tsui BC. Benefits of the costoclavicular for ultrasound-guided infraclavicular brachial plexus block: Description of a costoclavicular approach. Reg Anesth Pain Med 2015;40:287-8.
6. Sala-Blanch X, Reina MA, Pangthipampai P, Karmakar MK. Anatomic basis for brachial plexus block at the costoclavicular space: A cadaver anatomic study. Reg Anesth Pain Med 2016;41:387-91.
7. Li JW, Songthamwat B, Samy W, Sala-Blanch X, Karmakar MK. Ultrasound-guided costoclavicular brachial plexus block sonoanatomy, technique, and block dynamics. Reg Anesth Pain Med 2017;42:233-40.
8. Leurcharusmee P, Elgueta MF, Tiyprasertkul W, Sothisisopa T, Samerchua A, Gordon A. A randomized comparison between costoclavicular and paracoracoid ultrasound-guided infraclavicular block for upper limb surgery. Can J Anesth 2017;64:617-25.
9. Song IA, Gil NS, Choi EY, Sim SE, Min SW, Ro YJ, et al. Axillary approach versus the infraclavicular approach in ultrasound-guided brachial plexus block: Comparison of anesthetic time. Korean J Anesthesiol 2011;61:12-8.
10. Sivashanmugam T, Ray S, Ravishankar M, Jaya V, Selvam E, Karmakar MK. Randomized comparison of extrafascial versus subfascial injection of local anesthetic during ultrasound-guided supraclavicular brachial plexus block. Reg Anesth Pain Med 2015;40:337-43.
11. Roy M, Nadeau M-J, Côté D, Levesque S, Dion N, Nicole PC, et al. Comparison of a single- or double-injection technique for ultrasound-guided supraclavicular block: A prospective, randomized, blinded controlled study. Reg Anesth Pain Med 2012;37:55-9.
12. Sothisisopa T, Elgueta MF, Samerchua A, Leurcharusmee P, Tiyprasertkul W, Gordon A. Minimum effective volume of lidocaine for ultrasound-guided costoclavicular block. Reg Anesth Pain Medicine 2017;42:571-4.
13. Barrett HD, Loughnane F, Inzucchi E, Okten F, Turhan SC. Ultrasound anatomy of the brachial plexus nerves in the neurovascular bundle at the axilla in patients undergoing upper-extremity block anesthesia. Skeletal Radiol 2013;42:707-13.
14. Christophe JL, Berthier F, Boillot A, Tatu L, Viennot A, Boichut N, et al. Assessment of topographic brachial plexus nerves variations at the axilla using ultrasonography. Br J Anaesth 2009;103:606-12.
15. Tran DQ, Pham K, Dugani S, Finlayson RJ. A prospective, randomized comparison between double-, triple-, and quadruple-injection ultrasound-guided axillary brachial plexus block. Reg Anesth Pain Med 2012;37:248-53.