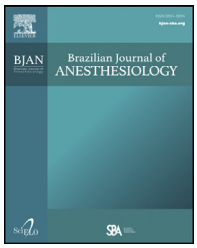
Brazilian Journal of Anesthesiology 2024;74(5):744178



Sociedade Brasileira de Anestesiologia

Brazilian Journal of ANESTHESIOLOGY

ORIGINAL INVESTIGATION

Comparison of the lateral sagittal and costoclavicular approaches for ultrasound-guided infraclavicular block in pediatric patients: a prospective randomized study

Ahmet Murat Yayik [a,b,*], **Sevim Cesur** [c], **Figen Ozturk** [d], **Erkan Cem Celik** [a,b], **Muhammet Emin Naldan** [d], **Ali Ahiskalioglu** [a,b]

[a] *Ataturk University School of Medicine, Department of Anesthesiology and Reanimation, Erzurum, Turkey*
[b] *Clinical Research, Development and Design Application and Research Center, Ataturk University School of Medicine, Erzurum, Turkey*
[c] *Kocaeli University School of Medicine, Department of Anesthesiology and Reanimation, Kocaeli, Turkey*
[d] *Erzurum Regional Training and Research Hospital, Department of Anesthesiology and Reanimation, Erzurum, Turkey*

Received 22 July 2020; accepted 8 May 2021
Available online 6 June 2021

KEYWORDS
Lateral sagittal brachial plexus block;
Costoclavicular brachial plexus block;
Pediatric ultrasound-guided regional anesthesia;
Postoperative analgesia;
Upper extremity surgery

Abstract
Background: The lateral sagittal brachial plexus block is the most used method for pediatric upper extremity surgery, whereas the applications of costoclavicular brachial plexus block are limited. This study aimed to compare the lateral sagittal and costoclavicular approaches for the ultrasound-guided infraclavicular block in pediatric patients.
Methods: Sixty pediatric patients aged 5–15 years undergoing hand or forearm surgery were randomly assigned to two groups. Group LS (n = 30) received ultrasound-guided lateral sagittal block, and Group CC (n = 30) received ultrasound-guided costoclavicular block. The block performing time, needling time, imaging time, needle visibility, number of passes, sensorial/motor block time, and postoperative pain scores were evaluated.
Results: The needling time (82.90 ± 28.17 seconds vs. 64.77 ± 28.11 seconds respectively, $p = 0.004$) and total block performance time (109.53 ± 29.75 seconds vs. 89.70 ± 29.98 seconds respectively, $p = 0.005$) were significantly longer in Group LS than in Group CC. However, there was no significant difference between the groups in imaging time, needle visibility, number of passes, sensorial/motor block time, and postoperative pain scores ($p > 0.05$).
Conclusions: Costoclavicular and lateral sagittal brachial plexus blocks resulted in similar anesthetics effects. Moreover, the costoclavicular method can be a better alternative to lateral sagittal as it has a shorter block performance time.

* Corresponding author.
E-mails: m_yayik@hotmail.com, murat.yayik@atauni.edu.tr (A.M. Yayik).

https://doi.org/10.1016/j.bjane.2021.05.005

Introduction

Brachial plexus block is frequently used as postoperative analgesia, or as the main anesthetic method in upper extremity surgery.[1,2] Brachial plexus is adjacent to large vessels and vital structures such as the pleura extending from the interscalene region to the axillary region. Since this adjacency is narrower in pediatric patients, ultrasonography becomes much more critical in pediatric regional anesthesia interventions.[3,4] Additionally, ultrasound (US) allows the practitioners to avoid potential complications such as vascular puncture and pneumothorax since it reveals the anatomic structures, needle, and local anesthetic spreading in real time.

Lateral sagittal technique for infraclavicular brachial plexus block is often preferred for hand and forearm surgeries in adults and children. The local anesthetic agent is administered around the axillary artery, which is located deep in the pectoral muscles. However, at this level, the brachial plexus cords are located deeply and are separated from each other.[5] In the costoclavicular fossa, the cords are located more on the surface and are clustered with each other in the immediate lateral side of the axillary artery.[6] This positioning offers many advantages, including short onset time of blockade in single-injection technique and effective distribution of the drug to all the cords in block catheter applications.[7,8] Although studies comparing both methods in adult patients are present in the literature, none are available for pediatric patients.

Our main objective was to analyze whether block performance time is better in costoclavicular block compared to lateral sagittal for pediatric patients.

Methods

Ethical approval was obtained for this prospective randomized study from the Ethical Committee of Ataturk University. The study was registered with a clinical trial registry (ClinicalTrials.gov, identifier NCT04215614). Sixty American Society of Anesthesiologists (ASA) physical status I–II patients aged 5–15 years who underwent hand or forearm surgery were included in the study. Patients with respiratory disease, infection in the injection area, coagulopathy, allergy to any of the drugs to be used, and previously known neurological damage were excluded from the study.

A sealed envelope randomization method was used to randomize consented study participants on a 1:1 ratio to receive the study technique. Patient groups were written into 60 opaque envelopes and sealed, afterward the envelopes shuffled like a deck of cards and numbered. The patient who accepted to participate in the study was taken to the operating room. The envelope with the patient number was opened and the patient was administered the allocated treatment regimen.

Group LS was the lateral sagittal block group and Group CC was the costoclavicular block group. All patients were administered the same anesthetic protocol.

The patients were administered 0.1 $mg.kg^{-1}$ of midazolam intravenously in the premedication room. Routine electrocardiogram (ECG), noninvasive blood pressure, and SpO_2 were monitored, and O_2 (2–4 $L.min^{-1}$) was given via a nasal cannula. During the block procedure and operation, 1 $mg.kg^{-1}$ bolus and 25–50 $mcg.kg^{-1}.min^{-1}$ propofol infusion were started by spontaneous breathing.

All blocks were performed by anesthesiologists who had at least 2 years of experience in USG regional anesthesia. Furthermore, the same USG device, high frequency linear probe, and block needle (22G 50-mm block needle Stimuplex® Ultra, Braun, Germany) were used. The same block mixture (2% lidocaine and 0.5% bupivacaine with a volume of 0.3 $mL.kg^{-1}$ and a ratio of 1:1) was administered to all the patients.

Group LS: The intervention site and the US probe were sterilized. The head of the patient was rotated to the opposite direction of the side to be operated. The sterile USG probe was inserted into the lateral infraclavicular fossa, thereby monitoring the axillary artery and the brachial plexus cords located around it. After skin infiltration with local anesthetics, injection was made from the cranial to the caudal using in-plane technique. The area between the posterior cord and the axillary artery was accessed, which was followed by the administration of the entire local anesthetic solution to this area after ensuring negative aspiration of blood or air (Fig. 1A-B and Fig. 2A).

Group CC: After the sterilization procedure, the head of the patient was rotated to the opposite direction of the side to be operated, and the arm was abducted at an angle of 90°. The sterile USG probe was placed on the lower border of the clavicle in the middle line parallel to it. The axillary artery and the subclavius muscle were displayed in the costoclavicular fossa. Subsequently, three cords of the brachial plexus were displayed in the lateral side of the axillary artery. An in-plane technique at the center of the three brachial plexus cords after negative aspiration of blood or air was employed for administering the injection (Fig. 1C–D and Fig. 2B).

The blocks were checked using the pinprick test for ulnar radial and median nerves (no movement response to a cutaneous pinprick) 20 minutes after the injection of local anesthetic, and the surgery was commenced. Movement response after surgical incision, a 10% increase in heart rate, and a 20% increase in respiratory rate were defined as an insufficient block. Two $mcg.kg^{-1}$ fentanyl was administered to these patients with incremental boluses. Transition to general anesthesia protocol was planned in patients who felt pain and could not tolerate the surgery despite the bolus of fentanyl.

Imaging time was defined as the time interval from the contact of the US probe with the patient until obtaining a satisfactory image of the axillary artery and the brachial plexus cords. The needling time was defined as the time from the needle insertion until the entire administration of the local anesthetic solution. The block performance time was defined as the sum of the imaging time and needling time. The number of needle passes was also recorded. Needle visibility was evaluated using a 5-point Likert scale (1 = very poor; 2 = poor; 3 = fair; 4 = good; 5 = very good).

Motor blockade duration was defined as the interval between the brachial plexus puncture time and the movement of the forearm or one of the fingers. Sensory blockade duration was defined as the interval between the brachial plexus puncture time and the first dose of rescue analgesia.

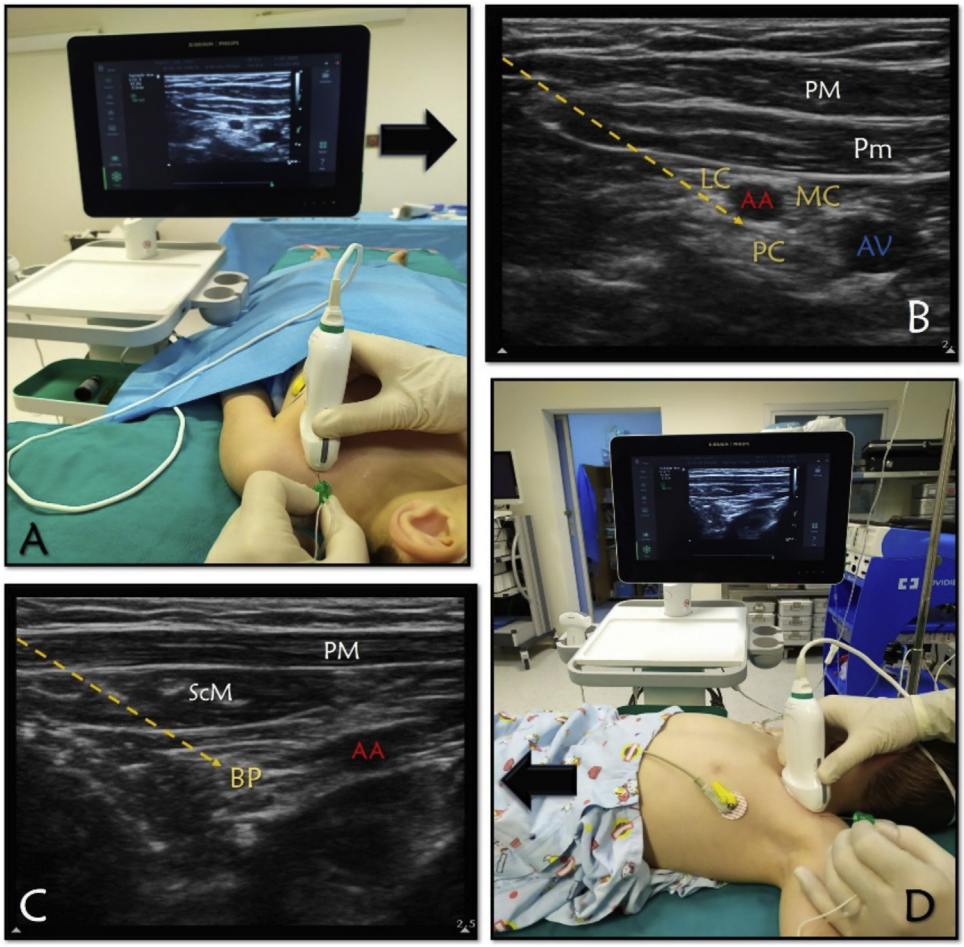


Figure 1 A, Patient, ultrasound set up and needle orientation for lateral sagittal block (LSB); B, Sonographic anatomy of LSB; C, Sonographic anatomy of costoclavicular block (CCB); D, Patient, ultrasound set up and needle orientation for CCB. PM, Pectoralis Major; Pm, Pectoralis minor; LC, Lateral cord; PC, Posterior cord; MC, Medial cord; AA, Axillary artery; AV, Axillary vein; ScM, Subclavius Muscle; BP, Brachial Plexus.

Block complications such as pneumothorax, vascular puncture, Local anesthetic systemic toxicity, hematoma, and Horner's syndrome were recorded.

The same protocol was applied for all the groups for postoperative analgesia. Patients with an Aldrete score of $\geq$ 9 were referred to the ward. Postoperative follow-up and evaluation of the cases were done by a researcher who had no knowledge of the study group. Postsurgical pain assessment was performed using the Wong–Baker FACES Pain Scale at 1, 2, 4, 8, 12, and 24 hours. In patients with a pain score of $\geq$ 4, 10 mg.kg^{-1} paracetamol was administered as a rescue analgesic, and this period was recorded as sensory blockade duration.

Sample size estimation and statistical analyses

G*Power (version 3.1.9.2) was used to estimate the sample size (a priori). The primary aim was to evaluate the block performance time. In our pilot study, we found that the block performance time for Group LS (n = 10) was 110 $\pm$ 34 seconds and that for Group CC (n = 10) was 86 $\pm$ 13 seconds. When a block performance time difference between the two groups of 24 seconds was regarded as significant, it was estimated that a sample size of 26 patients per study group (totally 52 patients) would provide 95% power with an α error of 0.05. To account for an estimated dropout, the required sample size was adjusted to 30 patients for each group.

The SPSS 22.0 (SPSS Inc, Chicago, IL) software was used for statistical analyses. The Chi-squared test was employed to compare the categorical variables between the groups. Normal distribution of numerical parameters was investigated using the Kolmogorov–Smirnov and histogram tests. Student's *t*-test was utilized to compare the normally distributed parameters, and the Mann–Whitney test was used for the non-normally distributed parameters. *p*-values < 0.05 were regarded as statistically significant.

Results

The eligible patients were analyzed for the primary outcomes and were presented in a flow diagram of Consolidated Standards of Reporting Trials (Fig. 3).

The demographic data of the patients are shown in Table 1. There was no difference between the two groups

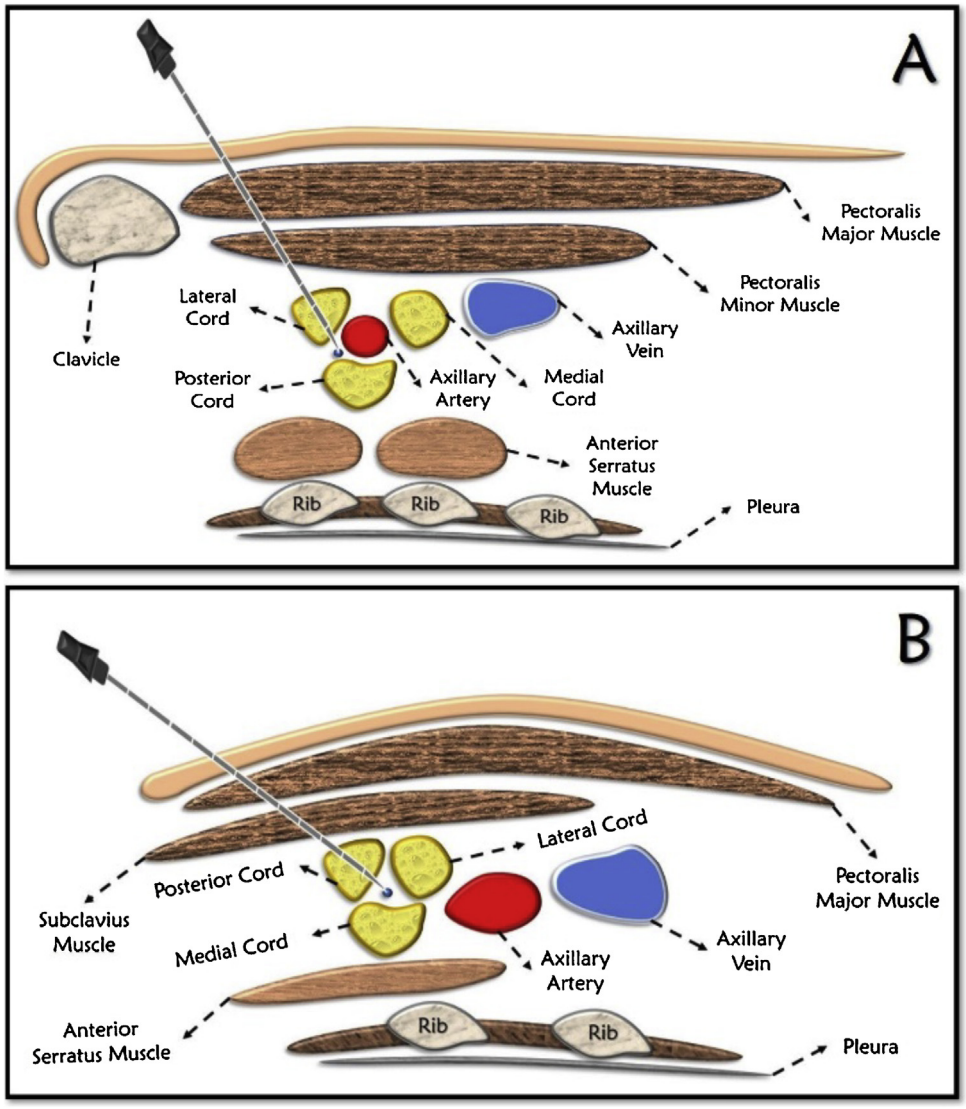


Figure 2 Basic illustration of lateral sagittal block (A) and costoclavicular block (B).

Table 1 Demographic characteristic of study patients.

	Group LS (n = 30)	Group CC (n = 30)	*p*
Age (y)	8.67 ± 2.51	9.53 ± 2.93	0.224[a]
Weight (kg)	26.47 ± 5.14	28.67 ± 5.76	0.124[a]
Gender (F/M)	9/21	13/17	0.284[b]
Duration of surgery (min)	39.17 ± 27.01	40.67 ± 22.00	0.814[a]
Duration of anesthesia (min)	66.67 ± 27.99	64.33 ± 22.73	0.724[a]
Operation region (hand/forearm)	9/21	4/26	0.117[b]
Types of surgery (emergency/elective)	23/7	20/10	0.390[b]

Values are presented as number or mean ± standard deviation.
[a] Independent sample t-test.
[b] Chi-square test.

in terms of age, weight, gender, duration of anesthesia-surgery, type of surgery, and operation area ($p > 0.05$).

The imaging time was similar between Group LS and Group CC, and there was no statistically significant difference between the groups (26.53 ± 8.09 seconds vs 24.40 ± 6.74 seconds, respectively; $p = 0.272$). However, the needling time was statistically significantly longer in Group LS than in Group CC (82.90 ± 28.17 seconds vs 64.77 ± 28.11 seconds respectively; $p = 0.004$), and the block performance time was statistically significantly longer in Group LS than in

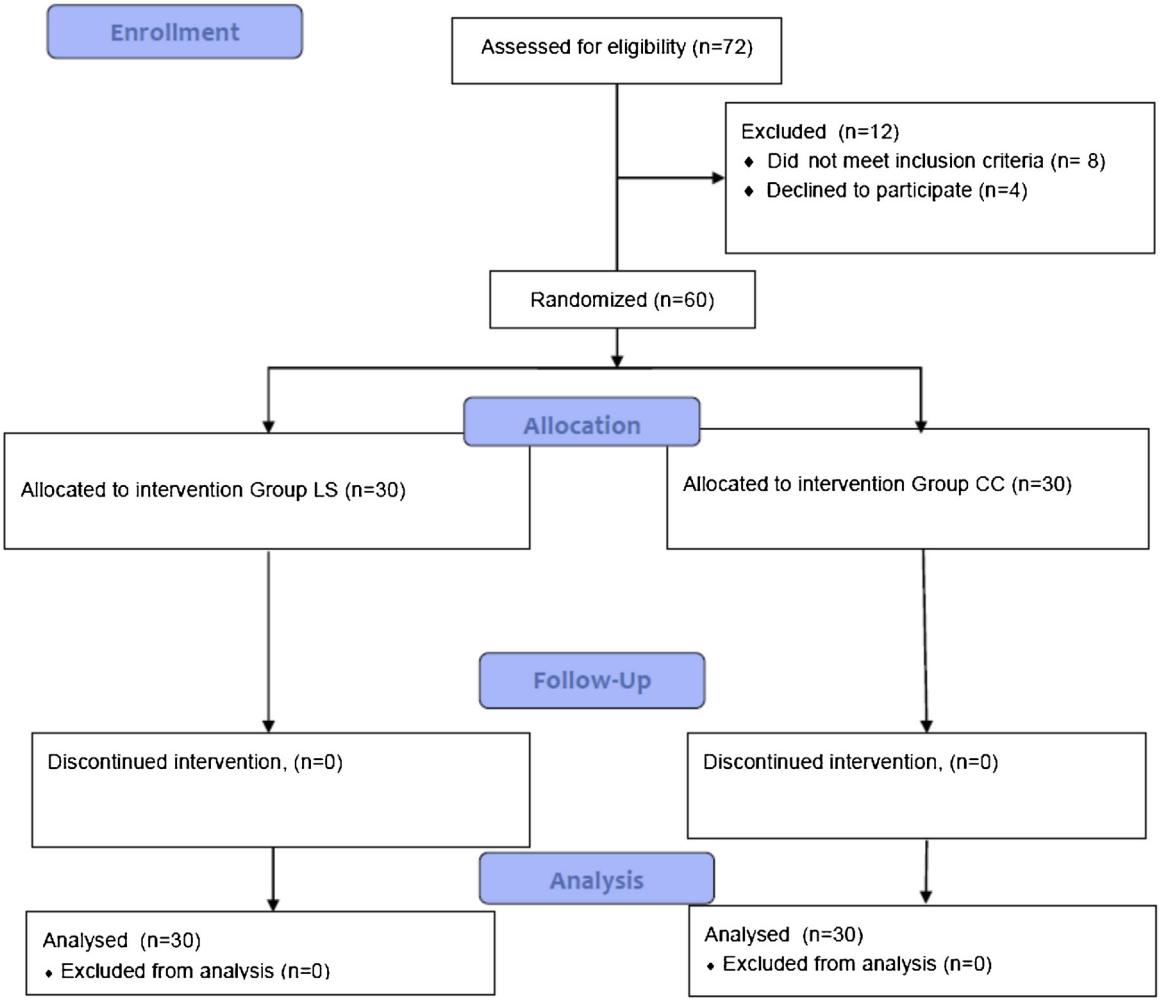


Figure 3 Consolidated standards of reporting trials.

Table 2 Block performance data.

	Group LS (n = 30)	Group CC (n = 30)	*p*
Imaging time (s)	26.53 ± 8.09	24.40 ± 6.74	0.272[a]
Needling time (s)	82.90 ± 28.17	64.77 ± 28.11	0.004[b]
Block performance time (s)	109.53 ± 29.75	89.70 ± 29.98	0.005[b]
Needle visibilty (very poor /poor /fair /good /very good)	0/0/3/10/17	0/0/0/9/21	0.176[c]
Number of passes	1.30 ± 0.53	1.20 ± 0.41	0.418[a]

Values are presented as number or mean ± standard deviation.
[a] Independent sample t-test.
[b] Mann-Whitney U test.
[c] Chi-square test.

Group CC (109.53 ± 29.75 seconds vs 89.70 ± 29.98 seconds respectively; $p = 0.005$). There was no significant difference between the groups in terms of the number of passes and needle visibility ($p > 0.05$) (Table 2).

The block was successful in all patients during the sensory examination at the 20th minute after the block performance, and no patients needed additional fentanyl or transition to general anesthesia after the onset of the surgery.

The postoperative motor blockade duration was 291.50 ± 169.98 minutes in Group LS and 261.50 ± 136.12 minutes in Group CC. The sensory blockade duration was 539.33 ± 258.34 minutes in Group LS and 487.00 ± 212.96 minutes in Group CC. These values did not reveal any statistically significant difference ($p > 0.05$).

Postoperative pain assessment was performed within the first 24-h period using the Wong–Baker FACES Scale.

Table 3 Postoperative Wong-Baker FACES scale.

	Group LS (n = 30)	Group CC (n = 30)	*p*
Postoperative 1 h	0.27 ± 0.69	0.53 ± 0.90	0.200
Postoperative 2 h	0.40 ± 1.10	0.67 ± 1.09	0.161
Postoperative 4 h	0.47 ± 1.01	0.80 ± 1.35	0.333
Postoperative 8 h	2.13 ± 2.16	2.53 ± 2.22	0.472
Postoperative 12 h	2.40 ± 2.54	2.73 ± 2.49	0.570
Postoperative 24 h	1.73 ± 1.82	1.60 ± 1.77	0.765

Values are presented as mean ± standard deviation.
Mann-Whitney U test.

There was no statistically significant difference between the groups during all the time intervals assessed ($p > 0.05$) (Table 3).

No vascular puncture, hematoma, pneumothorax, Horner's syndrome, or neurological complications occurred in any of the patients.

Discussion

The present study shows that the needling time and block performance time were shorter in the costoclavicular approach than in the LS approach of the infraclavicular brachial plexus block in pediatric patients. However, there was no difference between the two approaches in terms of the number of needle passes, needle visibility, pain scores, and sensory and motor block duration.

In recent years, the use of US is increasingly preferred in pediatric regional anesthetic procedures.[9] The visualization of anatomical landmarks and nerves increases block success while simultaneously avoiding possible complications related to critical structures. Since critical structures in children are located closer to the target tissues than in adults, US guidance is even more important in peripheral nerve block procedures.[4] In pediatric patients, US-guided brachial plexus block is often administered from the interscalene, supraclavicular, and infraclavicular regions for postoperative analgesia or anesthesia.[3,10–12]

The most common approach for infraclavicular brachial plexus block in adults and children is the LS method. The brachial plexus is located three cords under the pectoral major and minor muscles, apart from each other around the axillary artery. Although all three cords disperse around the axillary artery in the direction of 3-to-9 o'clock, serious anatomical differences can be present.[13] In the single-injection technique of the lateral sagittal brachial plexus block (LSB), the needle is directed between the axillary artery and the posterior cord. The local anesthetic is expected to reach all three cords with a U-shaped spreading around the axillary artery. However, block onset time may be affected by some aspects of the lateral infraclavicular fossa anatomy, such as the depth of the cords, the distance between them, and individual anatomical variations.[14]

Costoclavicular brachial plexus block (CCB) has been used in adult patients in recent years and has been successfully applied in hand, forearm, and shoulder.[14–16] In the literature, the use of CCB has been reported only in a few pediatric patients, and it was first reported by us in a case series for postoperative analgesia in 2019.[17]

The costoclavicular space is bordered by the clavicle in the superior region, subclavius, and pectoral major muscles in the anterior region, and by the anterior chest wall in the posterior region. The cords of the axillary artery, vein, and brachial plexus pass through this cavity to the lateral infraclavicular fossa. This area is more superficial than the lateral infraclavicular fossa.[18] Moreover, the cords of the brachial plexus are located adjacent to each other immediately in the lateral side of the axillary artery. This anatomical layout offers many advantages both in US imaging and in block procedures. All three cords are located in a single sonographic image in the transverse section, and local anesthetic distribution can be achieved in all three cords with a single injection. The costoclavicular space is also an area suitable for catheter applications; the block catheter applied from this area is located close to all three cords, as well as to the distal end of the catheter, and has a low risk of dislocation since it passes through an intramuscular tunnel.

Few studies have compared LSB and CCB in adults in the literature. In these studies, no difference was found between both groups in terms of block performance time.[14,19] However, there were differences between the two groups in terms of block onset time. In the study by Leurcharusmee et al. conducted using 35 mL of local anesthetics, similar block onset times were obtained in both groups.[19] However, Songthamwat et al. who used a lower volume of local anesthetics (25 mL) in their study, reported significantly shorter sensory and motor block onset times in the CCB group.[14] In the present study, while there was no difference between both groups of pediatric patients in terms of number of needle passes and needle visibility, the block performance time was shorter in Group CC. In the single-injection technique of LSB, the target point lies between the axillary artery and the posterior cord. In interventions targeting this region, vascular puncture should be avoided as the target point in CCB is further away from the axillary artery when compared with LSB. In the present study, although no patient had vascular puncture in either of the two groups, we believe that this anatomical location was advantageous for Group CC and resulted in shorter block performance time. Although the difference in the block application times between the groups was clinically negligible, it was statistically significant. It shows the ease of application of the costoclavicular block. Furthermore, in CCB, the use of USG minimized the risk although the close adjacency of the pleura was a disadvantage.

In CCB, the USG probe was placed parallel to the clavicle to display the anatomical landmarks and cords at the

lower border of the clavicle. Needle entry was performed starting at the lateral side and progressing to the medial side using in-plane technique. In pediatric patients, especially in children under 5 years of age, coracoid process can prevent needle entry and orientation at the right angle. In this case, the mediolateral approach can be considered as an alternative method.[20]

There are some limitations in this study. First, children aged 5–15 years were included in the study. The coracoid process may prevent the block procedure, especially in children under the age of five, which might also affect block performance data and complication rates. A further study is required to investigate block performance time in children under the age of five. Second, block onset time could not be evaluated because children were under sedation. Moreover, the issues such as pain and paresthesia that the patients might have experienced during the block could not be assessed because they were in a state of sedation. Finally, the sample size of the study was determined based on the block performance time, which is the primary purpose of the study. Side effects of the block procedure are not fully identifiable with a small sample size, and hence, further studies involving larger sample sizes may be needed.

In conclusion, costoclavicular and lateral sagittal brachial plexus blocks resulted in similar anesthetics effects. Moreover, the costoclavicular method can be a better alternative to lateral sagittal as it has a shorter block performance time.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

Special thanks to Dr. Muhammed Enes Aydin and Dr. Elif Oral Ahiskalioglu for support to manuscript.

References

1. Albrecht E, Mermoud J, Fournier N, et al. A systematic review of ultrasound-guided methods for brachial plexus blockade. Anaesthesia. 2016;71:213–27.
2. Chin KJ, Singh M, Velayutham V, et al. Infraclavicular brachial plexus block for regional anaesthesia of the lower arm. Anesth Analg. 2010;111:1072.
3. Yanal H, Gurkan Y, Kus A, et al. Awake hand surgery under ultrasound-guided infraclavicular block is possible for cooperative children. Agri. 2016;28:190–3.
4. Boretsky KR. Pediatric Regional Anesthesia Advances. Curr Anesthesiol Rep. 2019;9:100–9.
5. De Jose Maria B, Banus E, Navarro Egea M, et al. Ultrasound-guided supraclavicular vs infraclavicular brachial plexus blocks in children. Paediatr Anaesth. 2008;18:838–44.
6. Karmakar MK, Sala-Blanch X, Songthamwat B, et al. Benefits of the costoclavicular space for ultrasound-guided infraclavicular brachial plexus block: description of a costoclavicular approach. Reg Anesth Pain Med. 2015;40:287–8.
7. Li JW, Songthamwat B, Samy W, et al. Ultrasound-Guided Costoclavicular Brachial Plexus Block: Sonoanatomy, Technique, and Block Dynamics. Reg Anesth Pain Med. 2017;42:233–40.
8. Regufe R, Artilheiro V, Dias Mb, et al. Continuous costoclavicular brachial plexus block in a pediatric patient for post-fracture rehabilitation. Paediatr Anaesth. 2020;30:720–1.
9. Walker BJ, Long JB, Sathyamoorthy M, et al. Complications in Pediatric Regional Anesthesia: An Analysis of More than 100,000 Blocks from the Pediatric Regional Anesthesia Network. Anesthesiology. 2018;129:721–32.
10. Xu C, Wang B, Yang A, et al. The efficacy of pediatric ultrasound guided brachial plexus block anesthesia and determination of optimal anesthetic drug dosage. Minerva Pediatr. 2016. Epub ahead of print. PMID: 27827526.
11. Ergonenc T, Can H, Gokhan Beyaz S. Ultrasound-guided interscalene brachial plexus block in a child with acute upper respiratory infection: A case report. Anaesthesist. 2017;66:782–5.
12. Marhofer P, Willschke H, Kettner SC. Ultrasound-guided upper extremity blocks - tips and tricks to improve the clinical practice. Paediatr Anaesth. 2012;22:65–71.
13. Sauter AR, Smith HJ, Stubhaug A, et al. Use of magnetic resonance imaging to define the anatomical location closest to all three cords of the infraclavicular brachial plexus. Anesth Analg. 2006;103:1574–6.
14. Songthamwat B, Karmakar MK, Li JW, et al. Ultrasound-guided infraclavicular brachial plexus block: prospective randomized comparison of the lateral sagittal and costoclavicular approach. Reg Anesth Pain Med. 2018;43:825–31.
15. Aliste J, Bravo D, Layera S, et al. Randomized comparison between interscalene and costoclavicular blocks for arthroscopic shoulder surgery. Reg Anesth Pain Med. 2019, http://dx.doi.org/10.1136/rapm-2018-100055. Online ahead of print.
16. Tulgar S, Ugutmen E. A modified technique for the application of ultrasound-guided costoclavicular brachial plexus block for elbow surgery leading to differential block. J Clin Anesth. 2018;47:65–6.
17. Yayik AM, Cesur S, Ozturk F, et al. Ultrasound guided costoclavicular approach to brachial plexus: First pediatric report. J Clin Anesth. 2019;55:136–7.
18. Sala-Blanch X, Reina MA, Pangthipampai P, et al. Anatomic basis for brachial plexus block at the costoclavicular space: a cadaver anatomic study. Reg Anesth Pain Med. 2016;41:387–91.
19. Leurcharusmee P, Elgueta MF, Tiyaprasertkul W, et al. A randomized comparison between costoclavicular and paracoracoid ultrasound-guided infraclavicular block for upper limb surgery. Can J Anaesth. 2017;64:617–25.
20. Nieuwveld D, Mojica V, Herrera AE, et al. Medial approach of ultrasound-guided costoclavicular plexus block and its effects on regional perfussion. Rev Esp Anestesiol Reanim. 2017;64:198–205.