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RESEARCH ARTICLE

Comparison of Effectiveness of Ultrasound Guided Costoclavicular Block Versus Shoulder Block for Postoperative Analgesia in Shoulder Arthroscopy Cases

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ABSTRACT

Objective: Our primary objective was to compare the effectiveness of ultrasound (US)-guided costoclavicular (CCB) and shoulder block (ShB) for postoperative analgesia in patients undergoing shoulder arthroscopy using the Numeric Rating Scale (NRS) pain score. Our secondary objective was to evaluate the timing of the first analgesia, the total amount of analgesia administered, and the postoperative complications associated with the blocks.

Materials and Methods: Our prospective observational study included patients between the ages of 18-65 years, who underwent unilateral shoulder arthroscopy, who did not have any disease that would cause limitation of cooperation, who were not allergic to local anesthetic (LA), who were American Society of Anesthesiologists (ASA) I-III, who did not have coagulopathy, and who agreed to participate in the study by signing the consent form. The patient's pain was assessed and recorded by a blind anesthesiologist using NRS at the 30th minute, 1st, 2nd, 4th, 6th, 12th, and 24th hours postoperatively in the ward where the patients were located.

Results: A total of 26 patients were included, 13 receiving the CCB (Group CCB) and 13 receiving the ShB (Group ShB). The mean age of the patients, education level, gender, ASA score, NRS score, intraoperative duration, postoperative first analgesic requirement time, total analgesic amount, and postoperative complications did not show statistically significant differences between the groups. Block failure was not seen in any patients.

Conclusion: This prospective observational study shows that both US-guided CCB and ShB effectively provided similar successful postoperative analgesia in shoulder arthroscopy surgery.

Keywords: Analgesia, arthroscopy, shoulder

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INTRODUCTION

Arthroscopic shoulder surgery, although minimally invasive, causes significant moderate to severe pain both intraoperatively and postoperatively.[1] Regional block techniques are increasingly being used in anesthesia practice to reduce the use of postoperative opioid analgesics and shorten hospital stays. The interscalene brachial plexus block (ISB) technique is known as the gold standard for postoperative analgesia in shoulder procedures.[2] One of the most significant side effects of the ISB is hemidiaphragmatic paralysis (HDP). HDP can decrease forced vital capacity and forced expiratory volume in the first second by 20–30%. This reduction is generally well-tolerated in patients without respiratory pathology but poses a serious problem in those with lung disease.[2,3] Therefore, new alternative peripheral blocks have been developed with widespread use of US. The CCB is an infraclavicular approach targeting the three cords in the costoclavicular space lateral to the axillary artery.[4] The superficial placement of the cords, the ability to reliably anesthetize the suprascapular nerve during shoulder surgery, the efficient distribution of the local anesthetic (LA) with a single injection between the posterior and lateral cords, and the reduced

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volume of LA required are among the significant advantages.[5] The ShB consists of a combination of suprascapular and axillary nerve blocks. The biggest advantage is its position distal to the phrenic nerve.[6] In this study, we primarily aim to compare the effectiveness of CCB and ShB for postoperative analgesia in patients undergoing US-guided shoulder arthroscopy using the NRS pain score. Our secondary aim is to evaluate the timing of the initial analgesia, the total amount of analgesia administered, and the postoperative complications associated with the blocks.

MATERIALS and METHODS

This study was conducted prospectively as an observational study in compliance with the Declaration of Helsinki and the principles of Good Clinical Practice at the Department of Anesthesiology and Reanimation, Prof. Dr. Cemil Taşcıoğlu City Hospital, affiliated with the Ministry of Health Sciences University, between 20.09.2022, and 20.03.2023. After obtaining approval from the ethics committee (decision number 248 dated 19.09.2022), 26 patients who underwent shoulder arthroscopy surgery were included in the study. Necessary verbal and written consent was obtained from the patients. Reporting was performed according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Inclusion criteria for our study were as follows: Age between 18–65 years old, undergoing unilateral shoulder arthroscopy, no significant limitations in cooperation, no allergies to LA, American Society of Anesthesiologists I-III classification, no coagulopathy, willingness to participate in the study by signing the informed consent form. Exclusion criteria for our study were as follows: Refusal to participate in the study, inability to communicate in Turkish, presence of psychiatric disorders that hinder communication, existing neuropathy in the surgical arm, and respiratory disease (chronic illness).

Patients who were scheduled for shoulder arthroscopy and received peripheral nerve blocks for postoperative analgesia were alternately assigned to receive one CCB and one ShB. Both blocks were performed using a high-frequency (L 4–18 MHz) linear probe and a USG device.

Block applications: After the patients were taken to the block room, they were monitored using non-invasive blood pressure, electrocardiogram, and pulse oximeter. A peripheral intravenous catheter was placed in the non-operated arm. To prevent anxiety midazolam was administered intravenously (iv) at a dose of 0.04 mg/kg. Necessary aseptic measures were taken (sterile gloves, sterile drapes, sterile US probe cover, alcohol, chlorhexidine), and preparations were made using a 22 Gauge x 80 mm echogenic block needle. In both blocks, 20 ml of 0.25% bupivacaine was used. In the ShB, 10 ml was injected into the axillary nerve and 10 ml into the suprascapular nerve. General anesthesia (propofol 2.5 mg/kg, fentanyl 1 mcg/kg, rocuronium 0.6 mg/kg iv, sevoflurane 2%, maintained with 50% oxygen and 50% air) was provided to all patients after the block. At the end of the surgery, all patients received 10 mg/kg iv paracetamol.

CCB application: With the patient in the supine position, the head was slightly tilted laterally towards the contralateral side, and the middle part of the clavicle was scanned with the US probe from the medial to the lateral infraclavicular fossa. The US probe was tilted cephalad to visualize the area between the second rib and the posterior aspect of the clavicle. After visualizing the three cords, lateral to the axillary artery, the echogenic block needle was advanced from lateral to medial using an in-plane technique, negative aspiration was performed, and LA was injected (Fig. 1).[7]

ShB application: It consists of two separate peripheral nerve blocks.

Suprascapular nerve block (SSNB): With the patient in the supine position, the US linear probe was placed in the supraclavicular area. After observing the superior medial and lateral trunks around the subclavian artery, the suprascapular nerve was visualized as it separates from the superior trunk under the omohyoid muscle. The block needle was advanced from lateral to medial, passing under the omohyoid muscle, and LA was administered around the suprascapular nerve (Fig. 2).[8]

Axillary nerve block application: With the patient in a seated position, the US probe was placed on the posterior surface of the humerus, just proximal to the axillary crease. The deltoid, teres minor, and triceps muscles were visualized. From distal to proximal, the US probe was directed between the deltoid and triceps muscles, visualizing the posterior humeral circumflex artery and the axillary nerve located immediately adjacent to it. The block needle was then advanced anteriorly from the posterior deltoid muscle using an in-plane technique. After negative aspiration, LA was administered around the axillary nerve (Fig. 3).[9]

All blocks were performed by an experienced anesthesiologist. After block placement, assessments were made every 5 minutes for up to 30 minutes. Sensory assessment for the axillary nerve utilized the lateral aspect of the deltoid muscle. Sensory blockade was classified according to a three-point scale using a cold test: failed block-0, analgesia-1, anesthesia-2. Motor

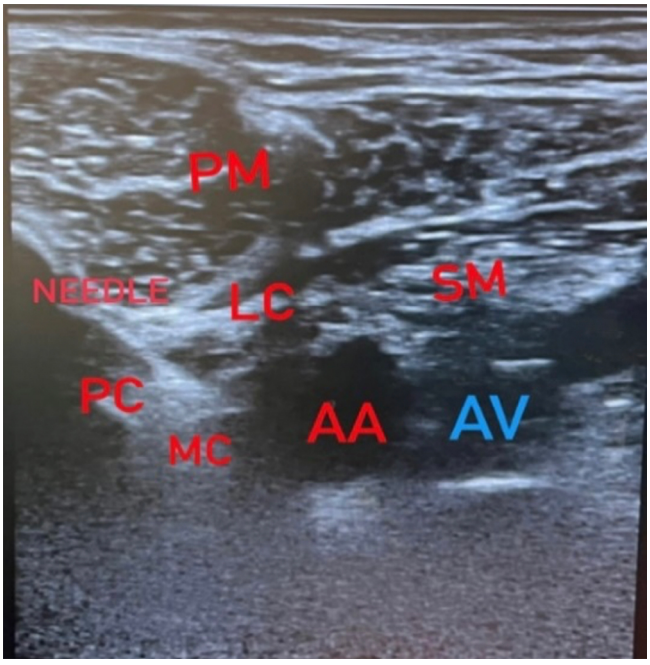

Figure 1. Costoclavicular block

AA: Axillary artery; AV: Axillary vein; LC: Lateral cord; MC: Medial cord; PC: Posterior cord; PM: Pectoral muscle; SM: Subclavius muscle

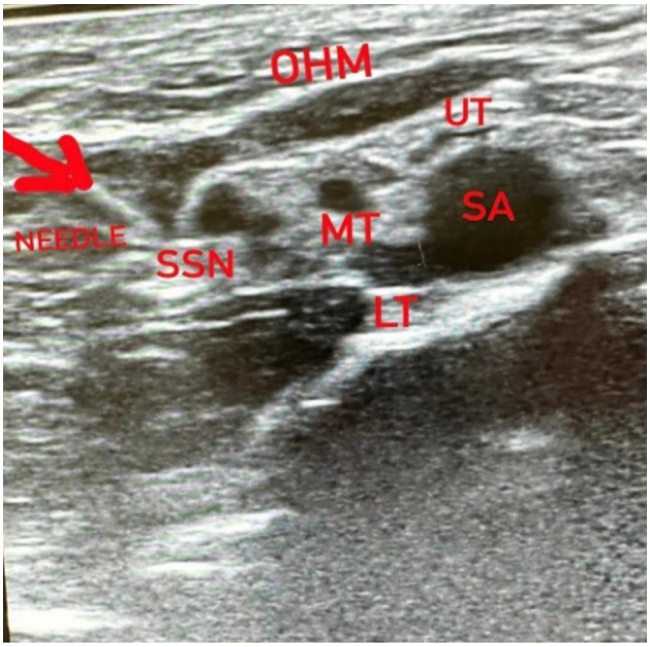

Figure 2. Suprascapular nerve block

OHM: Omohyoid muscle; UT: Upper trunk; MT: Middle trunk; LT: Lower trunk; SA: Subclavian artery; SSN: Suprascapular nerve

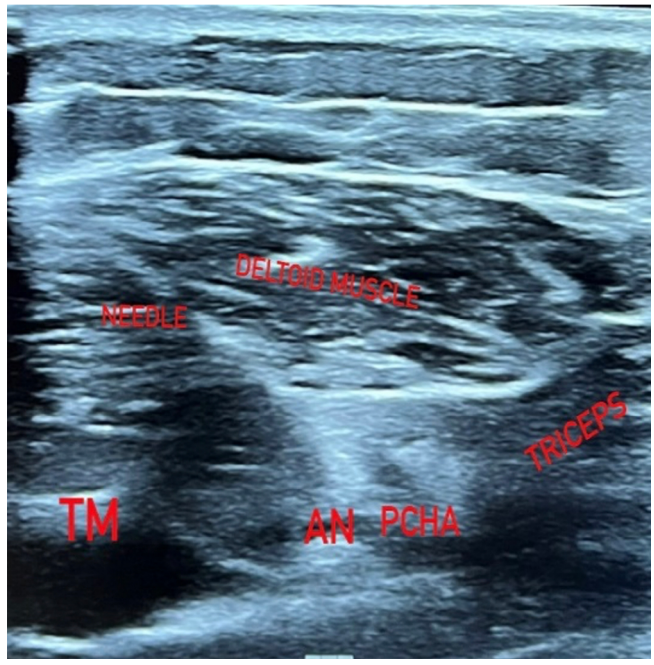

Figure 3. Axillary nerve block

TM: Teres minor; PCHA: Posterior circumflex humeral artery; AN: Axillary nerve

blockade was assessed using various shoulder movements, such as external rotation for the suprascapular nerve and abduction for the axillary nerve, on a three-point scale: failed block-0, paresis-1, paralysis-2. Thirty minutes after the block, if the combined sensory-motor score was ≥6 out of a maximum score of 8, the block was considered excellent.[10]

Intraoperative complications, hemodynamics, postoperative analgesic requirement, type and dose of analgesia, timing of the first analgesia, total analgesic consumption, and postoperative complications (hematoma, bruising, bleeding, infection, neurological damage, dyspnea) were monitored.[11] Dyspnea was assessed by evaluating pulse oximetry, the patient's clinical condition, and respiratory rate. A significant decrease of 7% in postoperative saturation compared to pre-block saturation was considered significant.[12] Pain assessments of the patients were conducted and recorded by a blinded anesthesiologist at postoperative 30 minutes, 1st, 2nd, 4th, 6th, 12th, and 24th hours in the ward using NRS score (0 indicating no pain, 10 indicating the highest pain level).[13] Patients with an NRS score of 5 received 1 gr of IV paracetamol, and if the NRS score was ≥6, tramadol 100 mg IV was added.[12] All patients were discharged within 24 hours postoperatively. Hemodynamic monitoring of the patients was performed by the ward nurses.

Table 1. Demographic data (n=26)

Variable	Group CCB (n=13)		Group ShB (n=13)		p
	n	%	n	%	
Age, (IQR)	55		57		0.608
Gender					
Male	6	46.2	3	23.1	0.216
Female	7	53.8	10	76.9	
ASA					
I	4	30.8	4	30.8	0.526
II	8	61.5	6	46.2	
III	1	7.7	3	23.1	
Educational status					
Illiterate	2	15.4	4	30.8	1.000
Primary school	8	61.5	7	53.8	
High school	3	23.1	1	7.7	
University	0	0.0	1	7.7	

Values are presented as median (IQR) or number (%). CCB: Costoclavicular block; ShB: Shoulder block; ASA: American Society of Anesthesiologists

Statistical Analysis

The sample calculation was performed using the G*Power 3.1.9.7 program. The evaluation of pain after shoulder arthroscopic surgery at postoperative 24 hours was based on the numerical rating scale (0–10 scoring) for determining the sample size. Rhyner et al.[14] reported a pain score of 1.3±1.3 in patients who received a ShB, while Pradhan et al.[15] mentioned a pain score of 2.89±0.83 in patients who underwent CCB. It was found that a total of 22 patients, with 11 patients in each group, needed to be included in the study to detect a difference between the two groups with 95% power and a 0.05 type 1 error level. Considering the possibility of patients dropping out of the study for various reasons during the research period, it was decided to include 26 patients in total, with 13 patients in each group.

Descriptive statistics such as mean, standard deviation, median, minimum, maximum, frequency, and ratio values were used for data description. The distribution of variables was assessed using the Kolmogorov-Smirnov test. For the analysis of quantitative independent variables, the Mann-Whitney U test was used. For the analysis of qualitative independent variables, the chi-square test, and when the conditions for the chi-square test were not met, the Fisher's exact test was used. The SPSS 28.0 (Statistical Package for the Social Sciences, version 28.0, Armonk, New York: IBM Corp.) program was used for the analyses. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 26 patients were included in our study, and there were no patients withdrawn or lost to follow-up for any reason. Both groups had the highest proportion of ASA II patients, and the mean age was 56. Demographic data did not show any significant differences between the two groups (p>0.05). All detailed parameters are provided in Table 1.

The postoperative NRS scores of patients in Group CCB had a median of 2.0 at 30 minutes, 1.0 at the 1st and 2nd hours, and 0.0 at the 12th hours. The first analgesia time was determined to be 3.0±3.7. Among the patients, 30.8% (n=4) did not require postoperative analgesics, while paracetamol was administered to 69.2% (n=9) and tramadol to 61.5% (n=8) of the patients (Table 2).

In Group ShB, the patient's NRS scores at 30 minutes, 1st, 4th, 6th, and 24th hours had a median of 2.0, while at 2nd and 12th hours, it was 1.0. The first analgesia time was 1.0±2.2 hours. Among the patients, 61.5% (n=8) did not require postoperative analgesia, while paracetamol was given to 61.5% (n=8) and tramadol to 69.2% (n=9) of the patients (Table 2).

There were no statistically significant differences between the two groups in terms of NRS scores, first analgesia requirement time, intraoperative duration, the amount of postoperative analgesic usage, and postoperative complications (p>0.05).

Table 2. NRS Scores of patients, operation duration, and analgesic data

	Group CCB (n=13)			Group ShB (n=13)		p	
	Mean±SD	Median	Min-max	Mean±SD	Median		
First analgesic requirement time (hour)	3.0±3.7	1.0	0.0-10.0	1.0±2.2	0.0	0.051	m
İntraoperative time (hour)	3.5±1.1	3.5	1.5-5.5	3.0±0.8	3.0	0.230	m
NRS							
30th minute	1.0±0.5	1.0		1.0±0.4	1.0	0.812	m
1st hour	2.8±3.2	1.0		2.2±2.0	2.0	0.809	m
2nd hour	1.4±1.8	1.0		1.8±1.8	1.0	0.609	m
4th hour	2.1±2.0	2.0		1.6±1.6	2.0	0.576	m
6th hour	2.1±2.1	2.0		2.2±2.1	2.0	0.915	m
12th hour	1.2±1.6	0.0		1.9±2.1	1.0	0.329	m
24th hour	1.9±2.1	1.0		1.8±1.9	2.0	0.979	m
	n	%		n	%		
Postoperative							
(-)	4	30.8		8	61.5	0.116	X^2
Paracetamol 1gr							
(+)	9	69.2		5	38.5		
Postoperative							
(-)	5	38.5		9	69.2	0.116	X^2
Tramadol 100mg							
(+)	8	61.5		4	30.8		

X^2: Ki-Kare test; m: Mann-whitney u test. NRS: Numeric rating scale; CCB: Costoclavicular block; ShB: Shoulder block; SD: Standard deviation

DISCUSSION

As far as we know from the literature, this is the first prospective study that compares CCB and ShB for postoperative analgesia in shoulder arthroscopy surgery. The application of CCB and ShB under US guidance has been shown to provide effective, safe, and long-term postoperative analgesia in shoulder arthroscopy.

In recent times, with the increasing number of regional anesthesia techniques, it has been observed that both multimodal analgesia is achieved and opioid use is reduced.[2] Although the LA volume has decreased with the use of the US in studies, the risk of HDP for the ISB has not fallen below 20%. Due to its side effects, especially in patients with respiratory pathologies, alternative blocks have been developed that are farthest from the phrenic nerve due to phrenic nerve involvement.[16] These blocks can be either single localization or a combination of two separate blocks.[17] In our study, single localization brachial cord and combination peripheral nerve block were compared.

In a recent randomized prospective study, CCB was compared with ISB, and the NRS scores did not differ significantly in terms of postoperative analgesia.[5] In another multicenter randomized study conducted in 2020, anterior SSNB and ISB were compared. Postoperative analgesia was evaluated using NRS scores and there was no significant difference between these two blocks.[18] In another recent study comparing ISB and infraclavicular-SSNB, with 40 patients included, the NRS score at 30 minutes, 1st, 2nd, and 3rd hours was found to be lower in the ISB group. The two groups had no significant difference at other time points.[19] In a study conducted by Saini et al.,[20] 70 patients were included and ISB was compared with ShB. In this study, the SSNB was applied using a posterior approach. Postoperative pain scores evaluated by Visual Analog Scale (VAS) were found to be higher in the ShB at the 2nd and 4th hours, and higher in the ISB at the 12th hour. In another randomized controlled study comparing the superior trunk block and CCB in arthroscopic shoulder cases, the postoperative 1st-hour NRS score was higher in the CCB group, with no difference observed at other time points.[21] In our study, the 24-hour postoperative

NRS scores were found to be similarly low between the groups. This is likely due to the successful application of blocks by providing LA around the nerves stimulating the relevant dermatomes in shoulder surgery under US guidance.

In a recently conducted study, SSNB-CCB and ISB were compared in shoulder arthroscopy cases. It was found that in the ISB group, the time to initial analgesia was longer, and the total amount of analgesics used was lower.[22] In this study, unlike our study, both SSNB and CCB were applied in the same group, but with lower volumes, and the SSNB was performed using a posterior approach. Therefore, the longer time to first analgesia and higher total analgesic consumption in the ISB group may be attributed to these differences mentioned above. In Pradhan et al.[15] study comparing CCB and ISB in shoulder arthroscopy surgery, no significant differences were found in terms of time to analgesic request and total analgesic consumption. In Saini et al.[20] study comparing ISB and ShB, the first analgesia dose was significantly prolonged in the ISB group, but there was no difference in the total 24-hour analgesic usage between the blocks. The reason for the higher first analgesia dose in the ShB group in this study may be attributed to the posterior approach used in the SSNB, as the superior articular branches of the suprascapular nerve may separate before entering the suprascapular fossa.

In another study, subomohyoid plane block and ISB were compared in terms of 24-hour postoperative morphine requirement and total analgesic consumption, and it was found that ISB had significantly lower analgesic demand.[23] In yet another study comparing anterior SSNB with ISB, the time to first analgesia, analgesic consumption, and the time to first pain after discharge were evaluated, and no statistical or clinical differences were observed between the two blocks.[18] The reason for this could be the high LA concentration and volume used in the anterior SSNB. Previous studies have suggested that when the isolated suprascapular nerve is blocked, it may not provide sufficient analgesia, and combining it with the axillary nerve block may be more effective. In our study, we believe that the low total analgesic consumption in both groups is attributed to the success of the blocks.

In nerve blocks, complications such as vascular and neural injury, pneumothorax, Horner syndrome, hoarseness, and HDP can occur. In a study conducted by Sotthisopha et al.[24] vascular puncture and Horner syndrome were observed in patients receiving CCB, while pneumothorax and hoarseness did not occur in any patients. In Nalini et al.[25] study comparing CCB with axillary brachial plexus block, no complications were encountered in any of the patients. In our study, using the in-plane technique with US guidance and performed by an experienced anesthetist, no block-related complications were observed.

In a retrospective single-center study involving 315 patients, the risk of HDP between CCB and supraclavicular plexus block was evaluated based on the diaphragm height on chest X-rays. For CCB, blocks were performed using 15 to 30 ml of LA and for the supraclavicular plexus block, 15 to 20 ml of LA was used by different anesthesia specialists. HDP was observed in the CCB group when 25 ml or more of LA was used, but not in patients using 20 ml or less of LA.[26] In a cadaveric study, it was shown that injecting 20 ml of 0.1% methylene blue into the costoclavicular space stained the C7, C8, and T1 nerve roots. However, it did not reach the C5-C6 level and spread to the supraclavicular area, including the suprascapular nerve, while preserving the phrenic nerve.[27] In contrast to the study conducted to determine the sufficient minimal effective volume for CCB using a high volume of LA, our study found that lower volumes were sufficient for analgesia and reduced the development of complications.[24] In Ferre et al.[28] study in 2020, the anterior and posterior approaches of the SSNB were compared. In both approaches, 10 ml of 0.375% ropivacaine and 2 mg of dexamethasone were used. HDP was more frequently observed in the anterior approach, but analgesia was found to be more effective compared to the posterior approach. In a study conducted by Maikong et al.,[29] an anterior approach SSNB was performed on 31 cadavers and was found that 4.2 ml was sufficient for spread. Due to differences in resistance, volume, and effectiveness when local anesthetics are compared with methylene blue, this volume has been interpreted as variable. In a prospective observational study conducted in 2022, 6 ml of 0.5% bupivacaine was used for anterior SSNB, and it was determined as the diaphragm-sparing minimal volume.[30] We are aware that, apart from the LA volume, the concentration of LA also plays a role in phrenic nerve involvement. Therefore, in our study, although we used a 10 ml LA volume, we believe that using a 0.25% concentration of bupivacaine contributed to the prevention of HDP. Our study has several limitations, including being single-centered, the inability to conduct randomization, the inability to assess long-term pain scores, and the subjective assessment of diaphragmatic paralysis.

CONCLUSION

This prospective observational study shows that both US-guided CCB and ShB effectively provided similar successful postoperative analgesia in shoulder arthroscopy surgery. However, both types of blocks can be reliably preferred as a method of regional anesthesia in this type of shoulder surgery, depending on the knowledge and skills of the clinicians.

Disclosures

Ethics Committee Approval: The study was approved by the Prof. Dr. Cemil Taşcıoğlu City Hospital Clinical Research Ethics Committee (No: E-48670771-514.99, Date: 22/09/2022).

Authorship Contributions: Concept: B.K., V.Ö.; Design: B.K., V.Ö.; Supervision: B.K., V.Ö.; Funding: B.K.; Materials: B.K.; Data Collection or Processing: B.K.; Analysis or Interpretation: B.K., V.Ö.; Literature Search: B.K.; Writing: B.K.; Critical review: B.K., V.Ö.

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REFERENCES

1. Beecroft CL, Coventry DM. Anesthesia for shoulder surgery. Contin Educ Anaesth Crit Care Pain 2008;8:193–8. [CrossRef]
2. Fredrickson MJ, Krishnan S, Chen CY. Postoperative analgesia for shoulder surgery: a critical appraisal and review of current techniques. Anesthesia 2010;65:608–24. [CrossRef]
3. Renes SH, Spoormans HH, Gielen MJ, Rettig HC, Van Geffen GJ. Hemidiaphragmatic paresis can be avoided in ultrasound-guided supraclavicular brachial plexus block. Reg Anesth Pain Med 2009;34:595–9. [CrossRef]
4. Songthamwat B, Karmakar MK, Li JW, Samy W, Mok LYH. Ultrasound-guided infraclavicular brachial plexus block: prospective randomized comparison of the lateral sagittal and costoclavicular approach. Reg Anesth Pain Med 2018;43:825–31. [CrossRef]
5. Aliste J, Bravo D, Layera S, Fernández D, Jara Á, Maccioni C, et al. Randomized comparison between interscalene and costoclavicular blocks for arthroscopic shoulder surgery. Reg Anesth Pain Med 2019;44:472–7. [CrossRef]
6. Dhir S, Sondekoppam RV, Sharma R, Ganapathy S, Athwal GS. A comparison of combined suprascapular and axillary nerve blocks to interscalene nerve block for analgesia in arthroscopic shoulder surgery: an equivalence study. Reg Anesth Pain Med 2016;41:564–71. [CrossRef]
7. Karmakar MK, Sala-Blanch X, Songthamwat B, Tsui BCH. 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. [CrossRef]
8. Siegenthaler A, Moriggl B, Mlekusch S, Schliessbach J, Haug M, Curatolo M, et al. Ultrasound-guided suprascapular nerve block, description of a novel supraclavicular approach. Reg Anesth Pain Med 2012;37:325–8. [CrossRef]
9. Rothe C, Lund J, Jenstrup MT, Lundstrøm LH, Lange KHW. Ultrasound-guided block of the axillary nerve: a case series of potential clinical applications. Acta Anaesthesiol Scand 2012;56:926–30. [CrossRef]
10. Aliste J, Bravo D, Fernández D, Layera S, Finlayson RJ, Tran DQ. A randomized comparison between interscalene and small-volume supraclavicular blocks for arthroscopic shoulder surgery. Reg Anesth Pain Med 2018;43:590–5. [CrossRef]
11. Jeng CL, Torrillo TM, Rosenblatt MA. Complications of peripheral nerve blocks. Br J Anaesth 2010;105(Suppl 1):97–107. [CrossRef]
12. El-Boghdadly K, Chin KJ, Chan VWS. Phrenic nerve palsy and regional anesthesia for shoulder surgery: anatomical, physiologic, and clinical considerations. Anesthesiology 2017;127:173–91. [CrossRef]
13. Barakat A. Revisiting tramadol: a multi-modal agent for pain management. CNS Drugs 2019;33:481–501. [CrossRef]
14. Rhyner P, Kirkham K, Hirotsu C, Farron A, Albrecht E. A randomized controlled trial of shoulder block vs. interscalene brachial plexus block for ventilatory function after shoulder arthroscopy. Anaesthesia 2020;75:493–8. [CrossRef]
15. Pradhan K, Chandra Jayasingh S, Nanda S, Sraban Routray S. A comparison of costoclavicular block and interscalene block for pain relief after arthroscopic shoulder surgery. Int J Rec Surg Med Sci 2021;8:22–6.
16. Sun C, Ji X, Zhang X, Ma Q, Yu P, Cai X, et al. Suprascapular nerve block is a clinically attractive alternative to interscalene nerve block during arthroscopic shoulder surgery: a meta-analysis of randomized controlled trials. J Orthop Surg Res 2021;16:376. [CrossRef]
17. Tran DQH, Elgueta MF, Aliste J, Finlayson RJ. Diaphragm-sparing nerve blocks for shoulder surgery. Reg Anesth Pain Med 2017;42:32–8. [CrossRef]
18. Abdallah FW, Wijeysundera DN, Laupacis A, Brull R, Mocon A, Hussain N, et al. Subomohyoid anterior suprascapular block versus interscalene block for arthroscopic shoulder surgery: a multicenter randomized trial. Anesthesiology 2020;132:839–53. [CrossRef]
19. Aliste J, Bravo D, Finlayson RJ, De Tran FQ, Aliste J, Bravo ÁD. A randomized comparison between interscalene and combined infraclavicular-suprascapular blocks for arthroscopic shoulder surgery. Can J Anaesth 2018;65:280–7. [CrossRef]
20. Saini S, Rao S, Agrawal N, Gupta A. Comparison of analgesic efficacy of shoulder block versus interscalene block for postoperative analgesia in arthroscopic shoulder surgeries: a randomized trial. Indian J Anaesth 2021;65:451–7. [CrossRef]
21. Jo Y, Oh C, Lee WY, Chung HJ, Park J, Kim YH, et al. Randomized comparison between superior trunk and costoclavicular blocks for arthroscopic shoulder surgery: a noninferiority study. Eur J Anaesthesiol 2022;39:810–7. [CrossRef]
22. Kamel EZ, Fathy GM, Talaat M, Bakri MH, Soliman OM, Abd El-Salam MAER, et al. Ultrasound guided suprascapular and costoclavicular nerve block versus interscalene nerve block for postoperative analgesia in arthroscopic shoulder surgery: a randomized non-inferiority clinical trial. Egyptian J Anaesthesia 2022;38:446–52. [CrossRef]
23. Mahrous RSS, Ismail TI. Comparison of subomohyoid plane block and interscalene nerve block for arthroscopic shoulder surgery. Egyptian J Anaesthesia 2022;38:597–606. [CrossRef]
24. Sotthisopha T, Elgueta MF, Samerchua A, Leurcharusmee P, Tiyaprasertkul W, Gordon A, et al. Minimum effective volume of lidocaine for ultrasound-guided costoclavicular block. Reg Anesth Pain Med 2017;42:571–4. [CrossRef]
25. Nalini K, Bevinaguddaiah Y, Thiyagarajan B, Shivasankar A, Pujari V. Ultrasound-guided costoclavicular vs. axillary brachial plexus block: a randomized clinical study. J Anaesthesiol Clin Pharmacol 2021;37:655. [CrossRef]
26. Oh C, Noh C, Eom H, Lee S, Park S, Lee S, et al. Costoclavicular brachial plexus block reduces hemidiaphragmatic paralysis more than supraclavicular brachial plexus block: retrospective, propensity score matched cohort study. Korean J Pain 2020;33:144–52. [CrossRef]
27. Koyyalamudi V, Langley NR, Harbell MW, Kraus MB, Craner RC, Seamans DP. Evaluating the spread of costoclavicular brachial plexus block: an anatomical study. Reg Anesth Pain Med 2021;46:31–4. [CrossRef]

28. Ferré F, Pommier M, Laumonerie P, Ferrier A, Menut R, Bosch L, et al. Hemidiaphragmatic paralysis following ultrasound-guided anterior vs. posterior suprascapular nerve block: a double-blind, randomized control trial. Anesthesia 2020;75:499–508. [CrossRef]
29. Maikong N, Kantakam P, Sinthubua A, Mahakkanukrauh P, Tran DQ, Leurcharusmee P. Cadaveric study investigating the phrenic-sparing volume for anterior suprascapular nerve block. Reg Anesth Pain Med 2021;46:769–72. [CrossRef]
30. Coşarcan SK, Doğan AT, Koyuncu Ö, Gurkan Y, Erçelen Ö. The minimum effective analgesic volume of 0.5% bupivacaine for ultrasound-guided anterior suprascapular nerve block. Cureus 2022;14:e31350. [CrossRef]