Comparison of Two Ultrasound-guided Infraclavicular Block Approaches with Perfusion Index for Upper Limb Surgery

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ABSTRACT

Objective: To compare block characteristics of costoclavicular and lateral sagittal infraclavicular blocks by an objective criterion such as the perfusion index (PI) for upper limb surgery.

Study Design: Observational study.

Place and duration of the study: Department of Anesthesiology and Reanimation, Izmir KCU, Ataturk Training and Research Hospital, Izmir, Turkiye, from March to July 2021.

Methodology: ASA 1-3 patients aged >18 years, who had either elbow or hand or wrist or forearm surgery, were included in the study. The patients were evaluated in two groups as costoclavicular approach (Group CC) and lateral sagittal infraclavicular approach (Group LS). Blocks were performed with 30 ml local anaesthetic containing 0.25% bupivacaine and 1% lidocaine mixture in both groups. Sensory-motor block levels and PI scores were recorded and evaluated at 5 min intervals in the first 30 minutes.

Results: The study included 46 patients in Group CC and 50 patients in Group LS. Sensory block scores at 1st, 5th, 10th, and 15th minutes (min) and motor block scores at 1st, 5th, 10th, 15th, 20th, and 25th min were significantly higher in Group CC. The PI score was significantly higher in Group CC at the 5th and 10th min in comparison with Group LS. The complete block was achieved at 11.41 ±6.38 min in Group CC, while it was 17.8 ±7.22 min in Group LS ($p<0.05$).

Conclusion: Sensory and motor block starts earlier with costoclavicular in comparison with a lateral sagittal approach for the infraclavicular block. The PI verified this result as an objective parameter.

Key Words: *Infraclavicular block, Costoclavicular approach, Lateral sagittal approach, Perfusion index, Sensory block, Motor block.*

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INTRODUCTION

Infraclavicular block is a brachial plexus block that can be used in surgical operations to be performed on the upper extremity.[1] Lateral sagittal approach is a method that is often used to block the brachial plexus in the infraclavicular region.[2]

Recently, it has been claimed that the costoclavicular brachial plexus block is easier to apply than the lateral sagittal infraclavicular block, and the success rate is higher.[3] In the costoclavicular approach, clustering of the brachial plexus cords lateral to the axillary artery compared to the lateral sagittal infraclavicular may provide an easier USG-guided block.[4]

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The effectiveness of the block is measured by the level of sensory, motor and sympathetic blockade. Sensory block is evaluated with cold or pinprick test, and motor block is evaluated with traditional methods such as the patient's response to verbal commands and can be subjective. On the other hand, sympathetic block is manifested by vasodilation and an increase in blood flow rate and can be measured with the perfusion index (PI), which is a more quantitative method.[5] The PI represents the ratio of pulsatile blood flow to static blood flow in peripheral tissue and can be measured continuously and noninvasively from a pulse oximeter.[6] In a successful peripheral nerve block, local vasodilation, increase in regional blood flow, and increase in skin temperature are observed with the blockade of sympathetic fibers. Therefore, PI can be a guide to determining block activity as it provides quick and objective evaluation without requiring patient cooperation.[7]

In this study, the aim was to compare costoclavicular and lateral sagittal infraclavicular block applications performed with ultrasound in upper extremity surgery with PI.

METHODOLOGY

This study was conducted as a prospective observational study by obtaining the approval of the Izmir Katip Celebi University Ethical Committee (2021-0165). The study was registered on clinicaltrials.gov (NCT04857216). American Society of Anesthesiology (ASA) physical status 1-3 patients over 18 years of age, who had elbow, hand, wrist, and forearm surgery, were included in the study. Patients, who did not consent to participate in the study, did not cooperate, had an infection in the area to be anaesthetised, had motor or sensory deficits, and were pregnant, were excluded from the study.

G-Power (version 3.0.10) was used to estimate the sample size. Sample size based on the sensorimotor onset time and SD (16±3) of the previously published study.[8] Thus, a calculated sample size of 46 patients per group was required to provide a statistical power of 0.85 and a type I error of 0.05. It was planned to include 102 patients in this study, with an account for the anticipated 10% dropout rate. The study was started in March 2022, and the sample size was reached by prospectively collecting the data of the patients who were operated on within 3 months. Of the 102 patients who underwent the block during this time, 2 were excluded because they could not establish cooperation, and 4 were excluded because they were given a rescue block by the anaesthetists. It was carried out according to the decision of the enforcer anaesthesiologists, which block should be applied to patients. While the researchers did not interfere with the anaesthetists' decision to block, they observed block practices and collected data. A total of 96 patients were included in the study, 46 patients in the costoclavicular block group (Group CC) and 50 patients in the lateral sagittal infraclavicular block (Group LS) group.

Before the operation, all patients were informed about the study and their written consents were obtained. Age, gender, body mass index (BMI), and ASA physical status classification of all patients were recorded. Standard anaesthesia monitoring with electrocardiography, peripheral oxygen saturation (sPO_2), and noninvasive blood pressure was applied to all patients in the induction room. In addition to routine hemodynamic measurements, PI measurement (Mindray Beneview T5, Mindray, Shenzhen, China) was performed by placing a pulse oximeter on the third finger of the patient's both hands.[9] With an infrared thermometer (Mesilife DT-8806), distal skin temperature was measured from the inner side of both wrists without coinciding with the radial and ulnar artery traces. Basal hemodynamic data, PI and distal skin temperature were recorded before the procedure. All the patients were premedicated with 1-2 mg iv midazolam.

All blocks were performed by experienced anaesthetists with a nerve stimulator and USG device (SonoSite M-Turbo). A total of 30 cc of local anaesthetic (LA) mixture containing 0.25% bupivacaine and 1% lidocaine was used for injection in all patients.

In Group LS, while the patient was in the supine position, the head was turned to the opposite side, and the USG probe was placed approximately, 1 cm caudal to the intersection of the clavicle and the coracoid process. The needle was directed in-plane, and when no motor response was observed at 0.3 mA, LA was injected between the posterior cord and the axillary artery. A U-shaped LA spread around the artery was observed.

In Group CC, the patient's head was turned to the opposite side, and the arm to be blocked was adducted by 90°. The USG probe was placed in the costoclavicular space parallel to the clavicle and slightly bent into the space between the posterior surface of the clavicle and the second rib. All 3 cords of the brachial plexus were visualised laterally to the axillary artery. LA was injected when there was no response to the 0.3 mA stimulus, and no blood was aspirated.

Evaluation of sensory block was evaluated by the loss of cold sense with the Verbal Rating Scale (VRS, 100: Normal sensation of cold, 0:No sensation).[4] Loss of cold sensation was evaluated by comparing the sensory nerve distribution areas of the blocked extremity with the normal arm. Sensory block was assessed by applying cold to the 2nd finger palmar skin for the median nerve, 5th finger palmar skin for the ulnar nerve, 2nd finger dorsal skin for the radial nerve, and forearm anterolateral skin for the musculocutaneous nerve. Loss of cold sensation in each dermatome was scored according to VRS and recorded as the sensory block value at 1, 5, 10, 15, 20, 25, and 30 minutes by taking the average. When VRS was <30, it was recorded as the time of the complete sensory block.

Modified Bromage Scale (MBS) was used to evaluate motor block.[10] It was determined as 0:no block; 1:motor power decreased but arm movable; 2:arm motionless but fingers movable; 3: complete block arm and no movement in hand. MBS 1 point was accepted as the beginning of the motor block, and 3 points were accepted as the complete motor block. Motor block level was recorded at 0, 1, 5, 10, 15, 20, 25, and 30 minutes. When MBS was >2, it was considered as complete motor block time.

The co-occurrence times of complete sensory block and complete motor block were recorded as complete block time.

The PI value for sympathetic block and distal skin temperature were measured simultaneously from the arm with and without block, and recorded every 5 minutes from the 1st to the 30th minute. Heart rate (HR), mean arterial pressure (MAP), and sPO_2 values of the patients were also recorded in 5 minutes intervals. Patients, who had complete block or 30 min elapsed after the block, were allowed for surgery.

It was observed that intravenous fentanyl 1-2 mcg/Kg was administered to patients who needed additional intraoperative analgesics, and intravenous ketamine 0.5-1 mg/Kg was administered to patients who needed analgesics despite fentanyl. In cases where anaesthesia was not sufficient despite this additional analgesic administration, general anaesthesia was applied.

In the intraoperative period, additional local anaesthetic or opioid requirement, conversion to general anaesthesia, tourniquet use, tourniquet pain, duration of surgery, and complications were recorded in both groups.

In the postoperative period, the duration of stay in the post-anaesthesia care unit (PACU) and the first postoperative analgesic administration time were recorded.

IBM SPSS Statics version 26 program was used for statistical analysis of the data. Pearson Chi-Square was used to compare categorical data between groups, and Fisher's Exact test was used when the number of data was small. Categorical data were expressed as frequency(n) and percentages (%). The normal distribution feature of continuous data was evaluated with Kolmogorov-Smirnov and Shapiro Wilk ($p < 0.05$), and Mann-Whitney U statistical analyses were used in independent groups according to the distribution feature. Categorical data were expressed as frequency(n) and percentages (%). Quantitative data were presented as mean±SD and median (min-max), depending on the distribution of the data. A value of $p < 0.05$ was considered statistically significant.

RESULTS

Between March 2021 and June 2021, 102 patients who underwent costoclavicular and lateral sagittal infraclavicular blocks for upper limb surgery were identified. Six patients were excluded because 2 patients could not cooperate and 4 patients had rescue block. A total of 96 patients, 46 patients in Group CC and 50 patients in Group LS, were included in the study.

Patients in both groups were similar in terms of age, gender, BMI, ASA scores, and preoperative haemoglobin values. When the surgical types of the patients included in the study were categorised as elbow, forearm, wrist, and hand, there was a similar distribution between the groups. Likewise, total surgical time and the length of stay in the PACU were also similar (Table I).

Sensory block levels evaluated by VRS and motor block levels evaluated by MBS were compared between groups. The sensory block at the 1^{st}, 5^{th}, 10^{th} and 15^{th} minutes were more intense in Group LS compared to Group CC and the motor block at the 1^{st}, 5^{th}, 10^{th}, 15^{th}, 20^{th} and 25^{th} minutes were more intense in Group CC compared to Group LS. When the PI scores measured from the blocked extremity were compared, there was a difference between the groups at the 5^{th} and 10^{th} minutes, and it was significantly higher in Group CC. The number of patients who achieved complete block in Group CC was higher than in Group LS at the 5^{th}, 10^{th}, 15^{th}, and 20^{th} minutes (Table II).

While the mean time to reach complete sensory block was 6.02±4.51 min in Group CC, it was 10.02±6.94 min in Group LS (p: 0.002). While the mean time to reach the full motor block was 9.67±6.74 min in Group CC, it was 15.9±7.60 min in Group LS ($p<0.001$). While the time to complete block was 11.41±6.38 min in Group CC, it was 17.8±7.22 min in Group LS ($p<0.001$). There was no statistically significant difference between the groups in the rate of temperature increase of the patients compared to the preoperative control values.

In the intraoperative period, 6 patients were identified in both groups who needed iv analgesics. Of these additional analgesic needs of 3 patients in Group CC and 2 patients in Group LS were attributed to tourniquet pain. Although complete block occurred in 1 patient in Group LS, it was observed that the patient needed general anaesthesia with LMA due to simultaneous rib fracture, pain, and agitation. When patients were evaluated for complications due to block application, no patient had any complications such as iv injection, hematoma, LA toxicity, or respiratory distress.

In the postoperative follow-up of the patients, no patient with analgesic needs was detected during the PACU period. While the first analgesia requirement, which was determined as VAS>3, was 6.73±1.35 hours in Group CC and 7.15±1.71 hours in Group LS during service follow-ups, there were no statistical differences between the groups ($p=0.263$).

DISCUSSION

In this study, costoclavicular and lateral sagittal infraclavicular blocks were compared in terms of block performance times, sensory and motor block onset times, hemodynamic data, and side effects. The results of the study revealed that costoclavicular block had an earlier onset of sensory and motor block compared to the lateral sagittal approach, and the PI verified this result as an objective evaluation method.

Infraclavicular brachial plexus block is traditionally performed in the lateral infraclavicular fossa (LIF). However, in LIF, the cords are separate from each other and their positioning with respect to the axillary artery may show various differences. Therefore, it can be difficult to view all three cords simultaneously in a single ultrasound window.[11] The close proximity of all cords in the costoclavicular region may contribute to the application of the USG-guided costoclavicular block.[3]

In studies conducted to compare blocks in terms of the onset or success, the sensory block is evaluated with a cold or pinprick test, and the motor block is evaluated with traditional methods such as the patient's response to verbal commands.[12,13] Therefore, it was found appropriate to add a more objective criterion such as PI, in addition to these data in this study.

In the study of Songthamwat *et al*. in which they compared lateral sagittal and costoclavicular block approaches with 40 patients, sensory block was found to be significantly faster in Group CC at 5, 10, 15, and 20 minutes compared to Group LS. Motor blockade was also found to be faster in Group CC at the 10^{th} minute after the block. The time to readiness for surgery was also found to be significantly faster in Group CC than in Group LS.[4] The data in this study show parallelism with the data in the study of Songthamwat *et al*., in terms of sensory block and motor block. In fact, motor block starts earlier in the current study in comparison with Songthamwat's study. This could be the result of the difference in the type and dose of LA used in both studies.

Table I: Distribution of demographics for block performance and surgical data among the groups.

	Group CC n:46	Group LS n:50	p
Age (year)	43.72±16.11 43.5 (23)	39.74±17.45 39.5 (28.5)	0.189
Gender, F/M	14 (30.4 %) / 32 (69.6%)	11 (22%) / 39 (78%)	0.347
BMI, Kg/cm²	25.6±4.28	25.75±4.14	0.939
ASA I/II/III	12 (26.1%) / 34 (73.9%)	17 (34%) / 32 (64%) / 1(2%)	0.374
Types of surgery (hand / wrist / forearm / elbow)	2 (4.3%) / 5 (10.9%) / 16 (34.8%) / 23 (50%)	2 (4%) / 6 (12%) / 16 (32%) / 26 (52%)	0.982
Preoperative haemoglobine, gr/dL	13.72±1.84 13.7 (2.85)	14.34±1.63 14.2 (2.45)	0.099
Block performance time (min)	5.57±1.54 5 (1)	5.84±2.35 5 (3)	0.964
Total surgery time (min)	90.98±45.59 75 (48.75)	99.3±52.22 90 (52.5)	0.285
PACU stay time (min)	66.85±17.24 60 (0)	72.6±29.12 60 (0)	0.486

Data are presented as mean± SD, median (IQR), and frequency (percentage) n (%). Mann-Whitney U, Fisher's Exact Test, Pearson Chi-square, p<0.05.

Table II: Sensory and motor block comparison of groups, perfusion index scores, and the number of patients who were blocked completely by measurement times.

Time (min)	Sensory Blockade (VRS) [1]		Motor Blockade (MBS) [2]		Perfusion Index (PI) [3]		Complete Block [4]		p
	Group CC n:46	Group LS n:50	Group CC n:46	Group LS n:50	Group CC n:46	Group LS n:50	Group CC n (%)	Group LS n (%)	
Pre Op.	-	-	-	-	2.8±1.9 2.1 (0.7-8.6)	2.5±1.5 2.3 (0.5-7.5)	-	-	- - p_3 0.959 -
1.	58.02±26.09 50 (0-100)	71.98±24.47 80 (30-100)	1.3±0.47 1 (1-2)	0.98±0.38 1 (0-2)	5.6±3.6 4.6 (1.2-15)	4.3±2.3 3.8 (1.2-10)	0	0	p_1 0.010 p_2 <0.001 p_3 0.103 p_4 –
5.	25.65±22.67 25 (0-80)	46±25.07 50 (10-100)	1.93±0.57 2 (1-3)	1.26±0.53 1 (0-2)	8.5±4.5 8.6 (1.8-20)	6.3±3.4 5.7 (1.5-17)	15 (33%)	2 (4%)	p_1 0.001 p_2 <0.001 p_3 0.011 p_4 <0.001
10.	9.89±15.07 0 (0-50)	24.4±29.91 10 (0-100)	2.41±0.54 2 (1-3)	1.86±0.67 2 (1-3)	10.5±4.5 10.9 (2.1-20)	8.4±4.4 8.4 (1.5-18)	29 (63%)	16 (32%)	p_1 0.022 p_2 <0.001 p_3 0.036 p_4 0.002
15.	3.91±10.43 0 (0-50)	12.4±20.95 0 (0-70)	2.76±0.43 3 (2-3)	2.28±0.61 2 (1-3)	10.6±4.1 10 (2.8-20)	9.6±4.5 9.2 (1.6-20)	39 (85%)	23 (46%)	p_1 0.046 p_2 <0.001 p_3 0.243 p_4 <0.001
20.	1.52±5.95 0 (0-30)	5.8±14.01 0 (0-50)	2.91±0.28 3 (2-3)	2.58±0.5 3 (2-3)	11.2±4 11 (2.7-20)	10.3±4 10 (1.5-19)	44 (96%)	37 (74%)	p_1 0.079 p_2 <0.001 p_3 0.407 p_4 0.004
25.	0.65±4.42 0 (0-30)	2.4±9.16 0 (0-50)	2.96±0.21 3 (2-3)	2.82±0.39 3 (2-3)	11.6±4 11 (3.5-20)	10.3±3.9 10 (1.5-19)	44 (96%)	44 (88%)	p_1 0.202 p_2 0.037 p_3 0.142 p_4 0.271
30.	0±0 0 (0-0)	1.4±6.06 0 (0-30)	2.96±0.21 3 (2-3)	2.9±0.3 3 (2-3)	11.7±3.8 11 (3.5-20)	10.3±3.72 9.8 (1.7-20)	46 (100%)	50 (100%)	p_1 0.093 p_2 0.290 p_3 0.095 p_4 –

All data are presented as mean ± SD, median (min-max) and n (%) unless otherwise stated. Mann-Whitney U analysis, Fisher's Exact Test, Pearson Chi-Square, p<0.05. 1: Sensory Blockade (VRS) states VRS values from "100" to "0" in given times (p_1) 2: Motor Blockade (MBS) states MBS values from "0" to "3" in given times (p_2) 3: Perfusion Index (PI) states PI score in given times (p_3) 4: Complete Block states percentage of patients reaching complete block in given times (p_4).

A similar study comparing these two block techniques was conducted by Leurcharusmee *et al*. with 45 patients in each group. It was observed that the onset time of sensory and motor blocks was similar in both techniques. Both groups were given a mixture of 35 ml of 1% lidocaine, 0.25% bupivacaine, and epinephrine 5 µg/ml.[14] The lack of difference in sensory and motor block time in this study may be due to the different LA volume used than the current study. In addition, there was no difference between the groups in terms of performance time. Similarly, in this study performed with USG and neurostimulator, no significant difference was found between block performance times.

In a recent study by Dost *et al*., it was concluded that the costoclavicular block provides a shorter performance time and faster onset of sensory block compared to lateral sagittal infraclavicular block.[15] However, while the significance at the onset of sensory block emerged within 10 minutes, it was

significantly faster in Group CC starting from the 1st minute in this study. While only 20 ml of 0.5% bupivacaine was used in the study, the use of bupivacaine+lidocaine mixture in the study may be the reason for the rapid onset. In a study by Ozmen *et al*., in which they investigated whether adding lidocaine to bupivacaine in the lateral sagittal infraclavicular block had an effect on the onset of anaesthesia and the duration of the block, they concluded that adding lidocaine to bupivacaine significantly shortened the time of block onset.[16] This explains the faster onset time of sensory block in this study compared to the study of Dost *et al.*[15]

The effectiveness of the block is measured by the level of sensory, motor, and sympathetic blockade. Sympathetic block is manifested by local vasodilation and associated tissue perfusion increase. The PI value indicates peripheral perfusion and is calculated based on the ratio between pulsatile and non-pulsatile blood flow using a pulse oximeter.[17,18] The main factors affecting PI are; stroke volume, vasomotor tone, skin temperature, and blood flow in the monitored area. Therefore, PI can be an objective parameter that can be used to evaluate sympathetic block.[19,20]

In the study of Abdelnasser *et al*., in which they investigated the rate of increase in PI in evaluating the success of supraclavicular block, PI scores measured from the 10th minute were significantly higher in the arm with block. Thus, they revealed that PI is a 100% sensitive parameter in demonstrating the success of the block.[6]

In the study by Galvin *et al*. in which they applied sciatic and axillary block with 1.5% mepivacaine, they concluded that PI is an objective and simple method that gives earlier findings compared to traditional methods. In this study, a 1.55-fold increase in PI scores compared to baseline scores was evaluated in favor of successful block.[11]

Nieuwveld *et al*., in their study evaluating the effect of costoclavicular block application on regional perfusion, reported that costoclavicular block application increased PI, and the PI value measured at the 5th minute increased 1.25 times compared to the initial value.[21]

Kuş *et al*. evaluated PI change in 46 patients who applied lateral sagittal infraclavicular block using 20 cc 0.5% levobupivacaine and 10 cc 2% lidocaine. In this study, an increase of 120% was detected in PI at the 10th minute compared to the baseline scores, and it was stated that the increase continued at the 20th and 30th minutes, and this increase meant a successful block.[19]

All these studies using PI provided guidance for this research. When PI scores were compared between the two groups, the PI value was found to be significantly higher in Group CC at the 5th and 10th minutes. In the non-blocking arm, no significant change was observed in both groups over time.

The PI data of this study also supports that costoclavicular block starts earlier than a lateral sagittal infraclavicular block. While the increase in PI scores created a significant difference at the 5th and 10th minutes, the difference between the two groups lost its significance after the increase. This shows us that PI increases more in the first minutes of the fast-starting block.

This study is prospective but observational. Patients were not randomised to research groups. Anaesthesiologists performed the blocks according to their own practice patterns. Although anaesthesiologists were familiar with the technique, different anaesthesiologists performed the blocks. This may have an effect on the outcome.

CONCLUSION

The costoclavicular approach produced earlier sensory and motor block than the lateral sagittal approach for the infraclavicular block. The earlier increase in the PI in patients undergoing costoclavicular block also supports that block onset times are shorter than the lateral sagittal approach. Since costoclavicular block provided faster block onset time with similar complication rate and block performance times in comparison with the lateral sagittal block, the authors conclude that this approach can be the preferred technique.

ETHICAL APPROVAL:
Approval was obtained from the Ethics Committee of Izmir Katip Celebi University (No: 2021-0165).

PATIENTS' CONSENT:
Written consent was obtained from all patients to participate in the study.

COMPETING INTEREST:
All authors declare that there is no competing interest.

AUTHORS' CONTRIBUTION:
BCS: Helped with conceptualisation, methodology, data collection, writing, reviewing, editing, visualisation, and supervision.
DAY: Helped with data collection, software, validation, formal analysis, investigation, resources, and supervision.
All the authors have approved the final version of the manuscript to be published.

REFERENCES

1. Albrecht E, Mermoud J, Fournier N, Kern C, Kirkham KR. A systematic review of ultrasound-guided methods for brachial plexus blockade. *Anaesthesia* 2016; **71(2)**: 213-27. doi: 10.1111/anae.13347.
2. Williams LM, Singh K, Dua A, *et al*. Infraclavicular Nerve Block. [Updated 2022 Nov 9]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; Jan 2022
3. Karmakar MK, Sala-Blanch X, Song tham wat B, Tsui BC. 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. doi: 10.1097/AAP.00000000 00000232.

4. Songthamwat B, Karmakar MK, Li JW, Samy W, Mok LYH. Ultrasound-guided infraclavicular brachial plexus block: Prospective randomised comparison of the lateral sagittal and costoclavicular approach. *Reg Anesth Pain Med* 2018; **43(8)**:825-31. doi: 10.1097/AAP.0000000000 000822.
5. Bereket MM, Aydın BG, Küçükosman G, Piskin O, Okyay RD, Ayoglu FN, *et al*. Perfusion Index and ultrasonography in the evaluation of infraclavicular block. *Minerva Anestesiol* 2019; **85(7)**:746-5. doi: 10.23736/S0375-9393.18.13046-X.
6. Abdelnasser A, Abdelhamid B, Elsonbaty A, Hassanin A, Rady A. Predicting successful supraclavicular brachial plexus block using pulse oximeter perfusion index. *Br J Anaesth* 2017; **119(2)**:276-280. doi: 10.1093/bja/aex 166.
7. Buono RD, Pascarella G, Costa F, Agro FE. The perfusion index could early predict a nerve block success: A preliminary report. *Saudi J Anaesth* 2020; **14(4)**:442-5. doi: 10.4103/sja.SJA_171_20.
8. Cesur S, Yayik AM, Das AN, Ahiskalioglu A. A randomised comparison between ultrasound-guided costoclavicular and infraclavicular block for upper extremity surgery. *Turk J Med Sci* 2021; **51(4)**:1883-8. doi: 10.3906/sag-2011-126.
9. Moktan SL, Karki M. Comparison of non-invasive hemodynamic monitors of stress response to endotracheal intubation with perfusion index in patients undergoing elective surgery. *J Soc Surg Nep* 2020; **23(2)**:9-13. doi: doi.org/10.3126/jssn.v23i2.35797.
10. Avcı O, Gündoğdu O. Evaluation of ultrasound guided supraclavicular block with traditional methods and perfusion index on upper extremity surgeries. *Van Med J* 2020; **27(1)**:38-44. doi: 10.5505/vtd.2020.15679.
11. Li JW, Songthamwat B, Samy W. Ultrasound-guided costoclavicular brachial plexus block: Sonoanatomy, technique, and block dynamics. *Reg Anesth Pain Med* 2017; **42**:233-40. doi: 10.1097/AAP.000000000 0000566.
12. Galvin EM, Niehof S, Verbrugge SJ. Peripheral flow index is a reliable and early indicator of regional block success. *Anesth Analg* 2006; **103**:239-43. doi: 10.1213/01.ane.0000220947.02689.9f.
13. Galvin EM, Niehof S, Medina HJ, Zijlstra FJ, van Bommel J, Klein J, *et al*. Thermographic temperature measurement compared with pinprick and coldsensation in predicting the effectiveness of regional blocks. *Anesth Analg* 2006; **102**:598–604. doi: 10.1213/01.ane.0000 189556.49429.16.
14. Leurcharusmee P, Elgueta MF, Tiyaprasertkul W. A randomised comparison between costoclavicular and paracoracoid ultrasound-guided infraclavicular block for upper limb surgery. *Can J Anaesth* 2017; **64**:617-25. doi: 10.1007/s12630-017-0842-z.
15. Dost B, Kaya C, Ustun YB, Turunc E, Baris S. Lateral sagittal *versus* costoclavicular approaches for ultrasound-guided infraclavicular brachial plexus block: A comparison of block dynamics through a randomised clinical trial. *Cureus* 2021; **13(3)**:e14129. doi: 10.7759/cureus.14129.
16. Özmen Ö, Alıcı HA, Çelik M, Dostbil A. Cesur M. The effect of addition of lidocaine to bupivacaine on anesthesia beginning time. block time and block quality in lateral sagittal infraclavicular block. *Turk J Med Sci* 2013; **43**:542-7. doi: doi.org/10.3906/sag-1207-22.
17. Sertcakacilar G, Çetingök H, Sabaz MS. Evaluation of block success in patients undergoing ultrasound-guided infraclavicular brachial plexus block with bilateral upper extremity perfusion index. *Indian J Surg* 2022; **84**: 510-16. doi: doi.org/10.1007/s12262-022-03407-2.
18. Kim ED, Yoo WJ, Lee YJ. Perfusion index as a tool to evaluate the efficacy of stellate ganglion block for complex regional pain syndrome. *Clin Auton Res* 2019; **29**:257-9. doi: 10.1007/s10286-018-00585-6.
19. Kus A, Gurkan Y, Gormus SK, Solak M. Toker K. Usefulness of perfusion index to detect the effect of brachial plexus block. *J Clin Monit Comput* 2013; **27(3)**:325-8. doi: 10.1007/s10877-013-9439-4.
20. Kim D, Jeong JS, Park MJ. The effect of epinephrine on the perfusion index during ultrasound-guided supraclavicular brachial plexus block: A randomised controlled trial. *Sci Rep* 2020; **10**:11585. doi: 10.1038/s41598-020-68475-4.
21. Nieuwveld D, Mojica V, Herrera AE. Medial approach of ultrasound guided costoclavicular plexus block and its effects on regional perfusion. *Rev Esp Anestesiol Reanim* 2017; **64**:198-205, doi: 10,1016/j,redar.2016. 09.010.