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Upper Extremity Surgery: Tissue Oxygenation and Block Quality in Infraclavicular Block with Different Arm Angles

Üst Ekstremite Cerrahisi: Farklı Kol Açıları ile uygulanılan İnfraklaviküler Blokta Doku Oksijenasyonu ve Blok Kalitesi

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Abstract

Background: The aim of this study was to evaluate tissue oxygenation and block quality using Near Infrared Spectroscopy (NIRS) in infraclavicular block application performed at different arm angles under ultrasonography (USG) guidance in upper extremity surgeries.

Materials and Methods: The study included patients aged 18-65 years, in the ASA I-II risk group, scheduled for unilateral upper extremity (hand, wrist and forearm) surgery, who accepted the infraclavicular block. The arm was abducted at 0°, 45° and 90° respectively and hemodynamic data, StO2, SpHb, PI value, rSO2 and body temperature were recorded from both the blocked and the other extremity at 0, 5, 10, 15, 20, 25 min before and after the block. **Results**: The study included 91 patients who met the inclusion criteria. It has been observed that 90° abduction of the arm with the forearm in the anatomical position during infraclavicular block application increases USG visibility and provides better ease of application. There was a significant increase in StO2, rSO2, PI value and body temperature between the blocked and unblocked extremity in the same patient ($p<0.05$). There was a difference in StO2, rSO2, PI value and body temperature between patients with successful block (n:85) and patients with failed block (n:6) ($p<0.05$). StO2 and rSO2 were significantly higher after 5 minutes, PI value after 10 minutes and body temperature change after 25 minutes between the successful and unsuccessful groups ($p<0.05$).**Conclusions:** We think that 90° abduction of the arm while the forearm is in the anatomical position during infraclavicular block application increases USG visibility and provides better ease of application, and StO2, rSO2, PI value and body temperature measurements can be used to evaluate block success.

Keywords: Infraclavicular block, Near Infrared Spectroscopy (NIRS), Tissue oxygenation, Noninvasive total hemoglobin monitoring (SpHb), Perfusion Index (PI)

ÖZ

Amaç: Bu çalışmanın amacı üst ekstremite cerrahilerinde ultrasonografi (USG) eşliğinde farklı kol açılarında yapılan infraklaviküler blok uygulamasında Yakın Kızılötesi Spektroskopi (NIRS) kullanılarak doku oksijenasyonu ve blok kalitesinin değerlendirilmesidir.

Gereç ve Yöntem: Çalışmaya 18-65 yaş arası, ASA I-II risk grubunda, tek taraflı üst ekstremite (el, el bileği ve önkol) cerrahisi planlanan ve infraklaviküler bloğu kabul eden hastalar dahil edildi. Kol sırasıyla 0°, 45° ve 90°'de abduksiyona getirildi ve hemodinamik veriler, StO2, SpHb, PI değeri, rSO2 ve vücut sıcaklığı bloktan önce ve sonra 0, 5, 10, 15, 20, 25. dakikalarda hem blok yapılan hem de diğer ekstremiteden kaydedildi.

Bulgular: Çalışmaya dahil edilme kriterlerini karşılayan 91 hasta dahil edildi. Aynı hastada bloke edilen ve bloke edilmeyen ekstremite arasında StO2, rSO2, PI değeri ve vücut ısısında anlamlı bir artış vardı ($p<0.05$). Başarılı blok uygulanan hastalar (n:85) ile başarısız blok uygulanan hastalar (n:6) arasında StO2, rSO2, PI değeri ve vücut ısısı açısından fark vardı ($p<0.05$). StO2 ve rSO2 5. dakikadan itibaren, PI değeri 10. dakikadan itibaren ve vücut sıcaklığı değişimi 25. dakikadan itibaren anlamlı olarak daha yüksekti ($p<0.05$).

Sonuç: İnfraklaviküler blok uygulaması sırasında ön kol anatomik pozisyonda iken kolun 90° abdüksiyonda olmasının USG görünürlüğünü arttırdığını ve daha iyi uygulama kolaylığı sağladığını, StO2, rSO2, PI değeri ve vücut ısısı ölçümlerinin blok başarısını değerlendirmede kullanılabileceğini düşünüyoruz.

Anahtar kelimeler: İnfraklaviküler blok, Near İnfrared Spektroskopisi, Doku oksijenizasyonu, Noninvaziv total hemoglobin monitörizasyonu, Perfüzyon İndeksi

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Highlights

- In upper extremity surgeries, infraclavicular block application with ultrasonography is a frequently preferred method because it is considered a safe anesthesia method.
- Near Infrared Spectroscopy is used as a device for tissue oxygenation and block quality.
- Tissue oxygenation was measured using Near Infrared Spectroscopy while the block was applied.

Introduction

Regional anesthesia (RA) is defined as the temporary blocking of nerve functions in certain parts of the body without inducing a state of unconsciousness and elimination of pain sensation (1).

The fact that airway reflexes are preserved and the risk of aspiration is very low, analgesia continues in the postoperative period, hospital stay is short and it is low cost makes regional anesthesia superior to general anesthesia (2).

Infraclavicular block performed under ultrasonography (USG) guidance in upper extremity surgeries is a brachial plexus block technique that is easy to perform and can be used in day surgery (3). Different methods such as modified raj technique, coracoid block technique, vertical block technique and lateral sagittal block technique have been described in practice (4).

The position of the arm at different angles during infraclavicular block affects the placement and position of the medial, lateral and posterior cord nerves (5). Wang et al. investigated the optimal upper arm position in infraclavicular brachial plexus block via coracoid approach and reported that the optimal position was 90° abduction of the upper arm with external rotation of the shoulder. In this position, the brachial plexus is closer to the skin and further away from the pleura compared to other angles (6).

Various methods have been used to evaluate block success. Holmenn scale, Bromage scale, Modified bromage scale, Lovett Rating scale are the most commonly used scales to evaluate motor block (7). These tests are subjective tests and require good patient communication, and the evaluations are different can be interpreted (8). Objective evaluation methods eliminate these negativities (9).

In peripheral nerve blocks, local vasodilatation, increased local blood flow, increased skin temperature and skin vasoconstrictor reflexes occur as a result of blockade of sympathetic nerve fibers in the applied area. These changes indicate a successful and adequate peripheral nerve blockade (10). In the literature, various methods have been described to quantitatively evaluate block-related autonomic innervation (11). NIRS, PI, Peripheral Flow Index (PFI), color Doppler sonography, electrical resistance changes in the skin, noninvasive tissue hemoglobin measurement and body temperature measurement are among these methods (12,13,14).

NIRS is a noninvasive method that measures tissue oxygen saturation with a sensor placed on the skin (15). Oxygen saturation of subcutaneous tissue may be affected as a result of decreased sympathetic activity in regional anesthesia. Based on this principle, the success of peripheral nerve blocks can be evaluated non-invasively and rapidly. Changes in tissue oxygen saturation measured by NIRS can give us an idea about the intensity and depth of the block (16). Perfusion index (PI) can be measured noninvasively by pulse oximetry and provides quantitative information about peripheral perfusion (11,12,17). Minville et al. reported that skin temperature measured with a simple infrared thermometer after infraclavicular brachial plexus blockade is a reliable, simple and early indicator of a successful nerve block (18).

In this study, we planned to investigate the success of USG-guided infraclavicular block application in upper extremity surgeries in evaluating tissue oxygenation and block quality according to different arm angles using Near Infrared Spectroscopy (NIRS), perfusion index (PI) and Noninvasive total haemoglobin monitoring (SpHb).

Material and Methods

Study design

It was conducted with 91 patients aged 18-65 years, in the American Society of Anesthesiologists (ASA) I, II group, undergoing upper extremity (hand, wrist and forearm) surgery and who accepted the infraclavicular block. Of a total of 91 patients who underwent usg-guided infra-clavicular application, block failed in 6 patients. Patients in whom infraclavicular block was contraindicated, uncooperative patients, patients with renal insufficiency, patients with hepatic insufficiency, pregnant and lactating women, and ASA III, IV, V group patients were excluded from the study. Patients who were accepted to the study were informed verbally and in

writing about the anesthesia method to be applied for the surgery to be performed and the thesis study, and their written informed consent was obtained.
Standard monitoring with noninvasive arterial blood pressure (BP), electrocardiography (ECG) and pulse oximetry (SpO2) was performed in the preoperative preparation room before the infraclavicular block. All patients received midazolam 0.02-0.03 mg/kg IV. A regional oximetry probe (rSO2 sensor) (Masimo, Irvine, CA, USA) was placed on the inside of the wrists of the upper extremities of the patients, both in the upper extremity where the block was to be performed and in the upper extremity where the block was not to be performed, to measure peripheral tissue oxygen saturation. A pulse oximeter sensor (R1 25 SpHb SpO2 SpMet Adult Pulse CO-Oximeter Adhesive Sensor) was placed on the 3rd finger of both hands of the patients to measure PI value and SpHb. These sensors and probes were used to record data from the Masimo IC model: RDS7A device and recorded the data. A NIRS probe (Inspectra™ StO2 Spot Check- Model 300 (Hutchinson Technology Inc., Hutchinson, MN, USA) was placed on the tenar parts of both upper extremities of the patients for StO2 measurement and recordings were taken. Heart rate (HR), systolic and diastolic blood pressure values, oxygen SpO2, StO2, SpHb, PI, rSO2 and body temperature (Mesilife DT-8806 Infrared Thermometer) were measured at the midpoint of the inside of both wrists 5 min before the block (pre-anesthetic value).
A 22 G, 50 mm, insulated facet type needle (B.Braun Stimuplex, Melsungen AG, Germany) was used for the block. Local anesthetic solution was prepared with 15 mL of 0.5% bupivacaine and 15 mL of 2% lidocaine. The block was performed with the Lateral Sagittal Infraclavicular Brachial Plexus Block (LSIB) technique described by Klaastad et al. (19). Nerve blocks were performed and evaluated by the same person with at least four years of experience.The practitioner was positioned at the head of the patient, the forearm was in the anatomical position on the side to be blocked, the arm was abducted 0°, 45° and 90° respectively, and the plexus-skin distance and the appearance of the axillary arteries, veins and cords were recorded as poor (0), fair (1) and good (2) for ease of visualization on USG. For the arm abduction angle, the patients were randomly divided into 3 groups: 21 patients in the 0° group, 35 patients in the 45° group and 35 patients in the 90° group. After the arm was angled, the area to be blocked was sterilized with povidine iodine. The block was performed with in-plane technique using an ultrasound device (Esaote My Lab 30 Gold, Italy) and a linear probe (10-18 MHz). The probe was placed medial to the coracoid process and oriented in the parasagittal plane to obtain a cross-sectional view of the axillary artery. After visualization of the axillary artery and vein, the brachial plexus branches (lateral, median, posterior branch) around the artery were visualized and approached with a needle using in-plane technique. 15 mL of local anesthetic solution was mixed around the posterior cord and 7.5 mL each around the lateral and medial cords. Negative aspiration test was repeated every 5 mL. Ease of application was recorded as difficult (0), moderate (1), or easy (2) according to the ease of guiding the needle to the desired site during application, whether additional maneuvering or re-entry was required, and whether the clavicle interfered with needle guidance.
During the follow-up, the 0th minute was considered as the moment when the block was terminated, and the needle was removed from the skin. At 0. 5. 10. 15. 20. and 25 min, HR, TA, SpO2, StO2, PI, SpHb, rSO2 and body temperature data were recorded from both the blocked extremity and the other extremity. Bromage scale and Pinprick test using a 27-gauge blunt-tipped dental needle were checked 30 minutes after the block procedure and recorded.

Ethical approval
This study approval was obtained from the Harran University Faculty of Medicine. Ethics Committee (number: HRU/20.07.17; date: 13.04.2020). Informed consent was obtained from all patients. Our study was conducted according to the Declaration of Helsinki.

Statistical analysis
The conformity of the numerical data to normal distribution was tested by Shaphiro wilk test. Mann whitney u test was used to compare non-normally distributed variables between block successful and unsuccessful groups. In addition, Wilcoxon test was used to compare the non-normally distributed measurements between the block and control group, Freidman test was used to compare the measurements obtained at 7 different times over time and Dunn multiple comparison test was used to determine the significant times. The agreement between the methods was tested with Kappa statistics. Mean±standard deviation values, difference between means and 95% confidence intervals were used to summarize numerical variables, and number and % values were given for

categorical variables. SPSS windows version 24 was used in the analyses and a p value less than 0.05 was considered significant.

Results

A total of 91 patients who underwent hand. wrist and forearm operations between April 2019 and April 2019 were included in the study. Age. height. weight. BMI. gender. ASA physical scores. comorbidities and smoking status of the patients are given in **Table 1**.

Table 1. Demographic data. ASA risk group. comorbidities. smoking

Variables	Descriptive statistics (n=91)
Age (years)	36.31±13.08 (min=18-max=64)
Height (cm)	169.16±7.57
Weight (kg)	73.52±12.97
Body mass index (kg/m²)	25.71±4.44
Gender Female/ Male, (%)	39(42.9)/52(57.1)
ASA score I, (%)	40(44.0)
II, (%)	51(56.0)
Comorbidity Yes, (%)	21(23.1)
No, (%)	70(76.9)
Smoking Yes, (%)	27(29.7)
No, (%)	64(70.3)

A significant correlation was found between arm angle and USG visibility (P=0.001). Of those with poor USG visualization, 95.2% were in the 0° arm abduction group, all of those with fair USG visualization, were in the 45° arm abduction group and 97.1% of those with good USG visualization, were in the 90° arm abduction group **(Table 2)**.

Table 2. Ease of USG appearance according to different arm angles

	USG visibility		
	Bad	**Middle**	**Good**
Arm angle 0° abduction, (%)	20(95.2)	00(0.0)	1(2.9)
45° abduction, (%)	0(0.0)	35(100.0)	00(0.0)
90° abduction, (%)	1(4.8)	00(0.0)	34(97.1)

Of those who were easily applied, 51.2% were in the 90° arm abduction group **(Table 3)**.

Table 3. Ease of block application according to different arm angles

	Ease of implementation		
	Difficult	**Middle**	**Easy**
Arm angle 0° abduction,(%)	2(28.6)	15(36.6)	4(9.3)
45° abduction, (%)	2(28.6)	16(39.0)	17(39.5)
90° abduction, (%)	3(42.9)	10(24.4)	22(51.2)

No significant agreement was observed between the Bromage scale and pinprick test **(Table 4)**.

Table 4. Agreement between Bromage scale and Pin-prick test

		Bromage Scale			Total
		Motor power reduced but arm moving (0)	Arm is immobile but fingers are mobile(1)	Complete block. no movement in the hand and arm (2)	
Pinprick Test	No sensory block (0),(%)	6 (40)	0(0)	00(0)	6(6.6)
	There is a sense of touch. no pain (1),(%)	9(60)	18(48.6)	3(7.7)	30(33)
	No touch sensation and no pain (2),(%)	00(0)	19(51.4)	36(92.3)	55(60.4)
Total		15(100)	37(100)	39(100)	91(100)

The changes in temperature, StO2, rSO2, PI, SpHb in the measurements in the successful and unsuccessful groups are given in Table 5. StO2, rSO2 values at 5th min, PI value at 10th min and temperature (°C) values at 25th min block success significant difference was found in favor of the SpHb values, while a significant difference was found at any time in terms of SpHb values no difference was observed **(Table 5).**

Table 5. Changes in Temperature, StO_2, rSO_2, PI, SpHb Between Groups Over Time

Time	Variables	Successful (n=85)	Failed (n=6)	*p*
5. min	Temperature (°C)	36.06 ± 0.48	35.93 ± 0.69	0.671
	StO_2	84.95 ± 5.77	79.5 ± 4.42	0.020*
	rSO_2	75.92 ± 8.45	69.5 ± 2.95	0.018*
	PI	5.65 ± 2.41	3.54 ± 2.56	0.057
	SpHb	11.92 ± 1.09	12 ± 0.58	0.597
10. min	Temperature (°C)	36.26 ± 0.49	35.98 ± 0.74	0.400
	StO_2	86.33 ± 5.3	79.33 ± 6.31	0.012*
	rSO_2	77.27 ± 8.51	70.83 ± 3.66	0.023*
	PI	6.41 ± 2.4	4.32 ± 2.58	0.033*
	SpHb	11.95 ± 1.17	12.28 ± 0.58	0.294
15. min	Temperature (°C)	36.4 ± 0.45	35.98 ± 0.72	0.163
	StO_2	86.71 ± 5.42	79.83 ± 4.26	0.007*
	rSO_2	78.13 ± 8.68	71.5 ± 5.43	0.026*
	PI	6.34 ± 2.26	4.57 ± 2.5	0.038*
	SpHb	11.92 ± 1.15	12.25 ± 0.65	0.353
20. min	Temperature (°C)	36.5 ± 0.46	36.05 ± 0.71	0.112
	StO2	86.86 ± 4.92	81.17 ± 5.27	0.018*
	rSO2	78.87 ± 8.29	74.33 ± 9.14	0.078
	PI	6.12 ± 2.07	3.87 ± 1.39	0.009*
	SpHb	11.88 ± 1.18	12.33 ± 0.61	0.212
25. min	Temperature (°C)	36.59 ± 0.44	36.12 ± 0.65	0.050*
	StO_2	87.46 ± 4.7	81.5 ± 6.25	0.021*
	rSO_2	79.31 ± 8.73	73.33 ± 7.79	0.054
	PI	5.97 ± 1.97	3.38 ± 0.94	0.001*
	SpHb	11.86 ± 1.18	12.47 ± 0.57	0.096

Abbreviations: *Significant at 0.05 level. Mann whitney u test.

When block and control measurements were compared, StO2, rSO2, PI, SpHb values were found to be significantly higher in the block group compared to the non-block group at all times starting from the 0th minute **(Table 6).**

Table 6. Time dependent changes between the blocked group and the non-blocked group.

Variables	Block (n=91)	Unblocked extremity (n=91)	Median [min-max]	p
Temperature (°C) Before	35.84 ± 0.49	35.76 ± 0.5	0.08 [0.02 -0.13]	0.012*
Temperature (°C) 0. min	35.89 ± 0.48	35.76 ± 0.46	0.13 [0.07 -0.2]	0.001*
Temperature (°C) 5.min	36.05 ± 0.49	35.75 ± 0.49	0.3 [0.23 -0.38]	0.001*
Temperature (°C) 10.min	36.24 ± 0.51	35.71 ± 0.49	0.54 [0.46 -0.61]	0.001*
Temperature (°C) 15.min	36.38 ± 0.48	35.68 ± 0.48	0.7 [0.61 -0.78]	0.001*
Temperature (°C) 20.min	36.47 ± 0.49	35.67 ± 0.47	0.8 [0.71 -0.88]	0.001*
Temperature (°C)25.min	36.56 ± 0.47	35.66 ± 0.47	0.9 [0.8 -0.99]	0.001*
StO2 Before	80.55 ± 5.87	80.21 ± 5.74	0.34 [0.58 -1.26]	0.658
StO2 0.min	81.8 ± 5.99	79.19 ± 5.91	2.62 [1.57 -3.66]	0.001*
StO2 5.min	84.59 ± 5.83	78.53 ± 5.98	6.07 [4.98 -7.15]	0.001*
StO2 10.min	85.87 ± 5.61	78.48 ± 6.21	7.38 [6.25 -8.52]	0.001*
StO2 15.min	86.25 ± 5.6	78.27 ± 6.26	7.98 [6.7 -9.26]	0.001*
StO2 20.min	86.48 ± 5.11	78.04 ± 6.6	8.44 [7.13 -9.75]	0.001*
StO2 25.min	87.07 ± 5	77.73 ± 6.55	9.34 [8.07 -10.62]	0.001*
rSO2 Before	70.6 ± 8.07	68.67 ± 7	1.93 [0.57 -3.29]	0.003*
rSO2 0	71.74 ± 8.59	68.58 ± 7.09	3.15 [1.5 -4.81]	0.001*
rSO2 5	75.49 ± 8.35	67.18 ± 7.57	8.32 [6.42 -10.21]	0.001*
rSO2 10	76.85 ± 8.42	66.98 ± 7.29	9.87 [7.93 -11.8]	0.001*
rSO2 15	77.69 ± 8.64	67.08 ± 7.57	10.62 [8.66 -12.57]	0.001*
rSO2 20	78.57 ± 8.37	66.59 ± 7.73	11.98 [9.93 -14.02]	0.001*
rSO2 25	78.91 ± 8.76	66.64 ± 7.78	12.27 [10.23 -14.31]	0.001*
PI Before	3.17 ± 1.94	3.24 ± 2.1	-0.07 [-0.45 -0.32]	0.799
PI 0.min	3.85 ± 2.31	3.07 ± 2.14	0.78 [0.3 -1.26]	0.001*
P 5.min	5.51 ± 2.46	2.85 ± 2.16	2.66 [2.16 -3.16]	0.001*
P 10.min	6.27 ± 2.45	3.01 ± 2.3	3.27 [2.66 -3.88]	0.001*
P 15.min	6.22 ± 2.3	2.82 ± 2.08	3.41 [2.86 -3.95]	0.001*
P 20.min	5.97 ± 2.11	2.52 ± 1.86	3.46 [2.97 -3.95]	0.001*
PI 25.min	5.8 ± 2.02	2.42 ± 1.66	3.38 [2.93 -3.83]	0.001*

Abbreviations: *Significant at 0.05 level. Mann whitney u test.

Discussion

In our study evaluating tissue oxygenation and block quality using NIRS in USG-guided infraclavicular block application at different arm angles in upper extremity surgeries, we found that 90° abduction of the arm while the forearm was in the anatomical position increased USG visibility and provided better ease of application, and StO2, rSO2, PI value and body temperature measurements gave significant results in evaluating block success.

During ultrasound-guided infraclavicular block application, different angles can be given to the arm and forearm to increase visibility, facilitate needle manipulation and apply the block faster. Studies have shown that 90° abduction of the arm improves image quality, decreases the distance of the brachial plexus to the skin, facilitates needle guidance, and reduces the risk of pneumothorax and arterial puncture (5,6). We evaluated the visibility on USG by giving the arm an abduction angle of 0 degrees, 45 degrees and 90 degrees respectively while the forearm was in the anatomical position on the side to be blocked. We found that the 90° abduction group had better and significant USG visibility (P=0.001).

In their study, Auyong et al. reported that the brachial plexus became more superficial with 90 degrees of arm abduction, at the same time the clavicle was displaced cranioposteriorly and thus needle manipulation was easier (19). In our study, similar to the study of Auyong et al. we observed that the ease of application of the block

increased as the arm abduction angle increased.
In our study, we investigated whether we could objectively evaluate the success of infraclavicular block using rSO2 and StO2 values obtained by NIRS. NIRS is a non-invasive and relatively low-cost technique that provides information about the oxygenation of a biological tissue such as muscle tissue. Its use as cerebral regional oxygen saturation measured by NIRS has been approved by the FDA (20).
There are a limited number of studies in the literature on the use of NIRS in regional anesthesia. For the first time, Tsai et al. found a statistically significant increase of approximately 15% in regional oxygen saturation in the blocked extremity before the patients perceived sensory and motor loss starting from the 5th minute (21). They stated that these changes may be due to a sympathectomy-like effect of brachial plexus block, increased diastolic flow and decreased peripheral resistance based on the study of Shemesh et al. (22).
Tighe et al. found a significant increase in rSO2 only in the extremity in which infraclavicular block was applied in their patients in whom they performed cervical paravertebral nerve block, femoral nerve block, infraclavicular nerve block and sciatic nerve block, and they could not detect a significant difference between rSO2 values in other blocks (23).
In the study by Karahan et al. aiming to investigate whether tissue oxygen saturation (StO2) is a reliable and objective method to evaluate the adequacy of infraclavicular block, they applied infraclavicular block in patients undergoing hand surgery and it was reported that it was useful in demonstrating block success and practically noninvasively demonstrated a successful block even in the first 5 minutes (24).
In our study, we found a significant difference in StO2 in both extremities and between the successful and unsuccessful groups of the block. Similar to the study of Tsai et al., in our study, we observed statistically significant increases in tissue oxygen saturation in the blocked extremity from the 5th minute after the block, although there was no difference between basal values and 0.min after the block. In the rSO2 value, we observed a significant difference between the blocked group and the unblocked group at all times. In the blocked group, we observed statistically significant increases in the regional oxygen saturation in the blocked extremity from the 5th minute after the block, while there was no difference between the baseline values and the 0th minute after the block, as in StO2. This significant difference continued between 0 and 5 minutes and other time periods in both StO2 and rSO2, while no significant difference was observed at 10 minutes and later. We attribute this to the fact that there was no statistically significant difference between the 10th minute and the other times since the block level started to settle after the 10th minute and the effect of the block exceeded a certain level.
The perfusion index (PI) represents the ratio of pulsatile to nonpulsatile blood flow in peripheral tissue and represents a continuous, noninvasive measurement of peripheral perfusion obtained from a pulse oximeter. In patients undergoing regional anesthesia, sympathetic block occurs before sensory and motor block develop due to the block, and perfusion increases in the area of sympathetic block due to local vasodilation. As a result, an increase in PI occurs due to an increase in pulsatile blood flow (11,13,25). PI value showed a significant increase from 5 minutes in the studies of Lee JY et al. and from 10 minutes in other studies. In conclusion, it has been concluded that perfusion index (PI) measurement is very valuable and usable in early, easy and objective evaluation of the success of peripheral nerve blocks (26). In our study, an increase of 2.04 was observed between the PI value before anesthesia in the block successful group and the block successful group after the 10th minute.
Bergek et al. investigated the effects of brachial plexus block on SpHb, PVI and PI parameters. In their study, basal values before the block and values up to the 20th minute after the block were recorded. There was no significant change in PI, PVI, SpHb or invasive Hb in the unblocked arm. They stated that these changes in values may be related to dilatation of vascular structures due to blockade (17). In our study, no significant difference was observed in the SpHb value both between the block group and the non-block group and within the groups.
Recently, there have been a number of studies investigating whether an increase in skin temperature in the innervated area precedes sensory block. In the literature, it has been reported that measurement of skin temperature is a reliable and feasible diagnostic tool to evaluate the success or failure of regional anesthesia procedures, especially in patients in whom sensory tests such as pinprick and cold sensation tests cannot be performed, but it occurs later than the loss of sensory and motor functions (27).
When we looked at the comparison of temperature values between and within groups in our study, we observed a significant difference between the block group and the non-block group at all times period from the pre-block measurement. When we evaluated the block group within itself between times, there was a significant difference in the direction of increase in temperature. When we looked at the difference between the block successful and block

unsuccessful groups, a significant increase was detected in the block successful group after 25 minutes. Contrary to the findings in the literature, temperature gave significantly higher results later in our study.

Study limitations

The study is a measurement study performed with an ultrasound device during clinical practice. The measurements performed with ultrasound may vary depending on the characteristics of the ultrasound, the ultrasound probe, and the weight of the person undergoing the ultrasound. Another limitation of the study is that the measurement may vary depending on whether the person applying the ultrasound presses the probe on the skin.

Conclusion

In conclusion, we believe that during infraclavicular block application, 90° abduction of the arm while the forearm is in the anatomical position increases USG visibility and provides better ease of application, and StO2, rSO2, PI and body temperature measurements will be useful to evaluate block success.

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References

1. Danial Shams, Kaylyn Sachse, Nicholas Statzer, et al. Regional Anesthesia Complications and Contraindications Clin Sports Med. 2022;41(2):329-43.
2. Peter E Amato, Andrew J Winkelman, Grace L Forster, et al. Regional Anesthesia for Hip Arthroscopy Clin Sports Med. 2022;41(2):233-46.
3. Koscielniak-Nielsen ZJ, Rasmussen H, Hesselbjerg L, et al. Infraclavicular block causes less discomfort than axillary block in ambulatory patients. Acta Anaesthesiol Scand. 2005; 49: 1030-4.
4. Framarz Mosaffa, Babak Gharaei, Mehran Rafeeyan, et al. Comparing vertical and coracoid approaches for infraclavicular block in orthopedic surgery of the forearm and hand J Clin Anesth. 2012;24(3):196-200.
5. Ruíz A, Sala X, Bargalló X, et al. The influence of arm abduction on the anatomic relations of infraclavicular brachial plexus: an ultrasound study. Anesth Analg. 2009; 108:36-6.
6. Wang FY, Wu SH, Lu IC, et al. Ultrasonographic examination to search out the optimal upper arm position for coracoid approach to infraclavicular brachial plexus block--a volunteer study. Acta Anaesthesiol. 2007; 45:15-20.
7. Daniela Messineo, Paolo Izzo, Pier Francesco Di Cello, et al. Sensory block in Day Surgery Ann Ital Chir. 2020:91:310-3.
8. Sertan Acar, Yavuz Gürkan, Mine Solak, et al. Coracoid versus lateral sagittal infraclavicular block Acta Orthop Traumatol Turc. 2013;47(1):32-7.
9. Araz C, Gürkan Y, Kuş A, Artificial-coloring in ultrasound-guided regional anesthesia. Agri. 2023;35(1):10-5.
10. Josef Zekry Attia, Rowaida Nabil Gaber, Shadwa Rabea Mohamed, Ultrasound-guided Retroclavicular Approach Versus Costoclavicular Approach of Infraclavicular Brachial Plexus Block for Upper Limb Surgeries Pain Physician. 2023;26(6): E651-60.
11. Alparslan Kus, Yavuz Gurkan, Suna Kara Gormus, et al. Usefulness of perfusion index to detect the effect of brachial plexus block J Clin Monit Comput. 2013;27(3):325-8.
12. Eilish M Galvin, Sjoerd Niehof, Serge Jc Verbrugge, et al. Peripheral flow index is a reliable and early indicator of regional block success Anesth Analg. 2006;103(1):239-43.
13. Abdelnasser, B Abdelhamid, A Elsonbaty, et al. Predicting successful supraclavicular brachial plexus block using pulse oximeter perfusion index Br JAnaesth. 2017;119(2):276-80.
14. Binici O, Karahan MA, Buyukfirat E. Evaluation of tissue oxygenation and block quality using Near Infrared Spectroscopy (NIRS) in patients undergoing ultrasound-guided infraclavicular block at different arm angles A prospective observational study. Ann Ital Chir. 2019:90:357-63.
15. Krzysztof B Beć, Justyna Grabska, Christian W Huck. Near-Infrared Spectroscopy in Bioapplications molecules. 2020;25(12):2948.

16. Hong Wei, Han-Kun Tu, Shang-Long Yao, et al. Regional tissue oxygen saturation as a predictor of post-spinal anesthesia hypotension for cesarean delivery Chin Med J (Engl). 2021;134(19):2353-5.
17. C Bergek, J H Zdolsek, R G Hahn. Non-invasive blood haemoglobin and plethysmographic variability index during brachial plexus block Br J Anaesth. 2015;114(5):812-7.
18. Vincent Minville, Agnés Gendre, Jan Hirsch, et al. The efficacy of skin temperature for block assessment after infraclavicular brachial plexus block Anesth Analg. 2009;108(3):1034-6.
19. David B Auyong, Jeff Gonzales, James G Benonis. The Houdini clavicle: arm abduction and needle insertion site adjustment improve needle visibility for the infraclavicular nerve block Reg Anesth Pain Med. 2010;35(4):403-4.
20. Hernandez-Meza G, Izzetoglu M, Osbakken M, et al. Near-infrared spectroscopy for the evaluation of anesthetic depth. Biomed Res Int. 2015; 2015:939418.
21. Phil B Tsai, Vadim Tokhner, Jichang Li, et al. A new application for near-infrared spectroscopy in regional anesthesia? J Anesth. 2011;25(1):140-1.
22. Shemesh D, Olsha O, Orkin D, et al. Sympathectomy-like effects of brachial plexus block in arteriovenous access surgery. Ultrasound Med Biol. 2006;32(6):817-22.
23. P J Tighe, C E Elliott, S D Lucas, et al. Noninvasive tissue oxygen saturation determined by near-infrared spectroscopy following peripheral nerve block Acta Anaesthesiol Scand. 2011;55(10):1239-46.
24. Karahan MA, Binici O, Büyükfırat E. Tissue Oxygen Saturation Change on Upper Extremities After Ultrasound-Guided Infraclavicular Brachial Plexus Blockade; Prospective Observational Study Medicina (Kaunas). 2019;55(6):274
25. Zifeng Xu, Jianhai Zhang, Hao Shen, et al. Assessment of pulse oximeter perfusion index in pediatric caudal block under basal ketamine anesthesia. Scientific World Journal. 2013:183493.
26. Jin Young Lee, Eung Don Kim, Yoo Na Kim, et al. Correlation of Perfusion Index Change and Analgesic Efficacy in Transforaminal Block for Lumbosacral Radicular Pain. J Clin Med. 2019;8(1):51.
27. H Hermanns, R Werdehausen, M W Hollmann, et al. Stevens Assessment of skin temperature during regional anesthesia What the anesthesiologist should know. Acta Anaesthesiol Scand. 2018;62(9):1280-9