Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2022;47(3):931-941
DOI: 10.17826/cumj.1031005

ARAŞTIRMA / RESEARCH

Effect of infraclavicular and interscalene block on oxygenation of the forearm: a randomized controlled study

İnfraklaviküler ve interskalen bloğun önkol oksijenasyonuna etkisi: randomize kontrollü bir çalışma

Eren Açıkgöz[1], Özcan Pişkin[2], Bengü Gülhan Aydın[2], Dilek Okyay[2], Gamze Küçükosman[2], Hilal Ayoğlu[2]

[1]Karadeniz Ereğli State Hospital (Formerly: Department of Anesthesiology and Reanimation, School of Medicine, Zonguldak Bulent Ecevit University), Clinic of Anesthesiology and Reanimation, Zonguldak, Turkey
[2]Zonguldak Bulent Ecevit University, Department of Anesthesiology and Reanimation, School of Medicine, Zonguldak, Turkey

Cukurova Medical Journal 2022;47(3):931-941

Abstract

Purpose: Infraclavicular block (ICB) and interscalene block (ISB) accompanied by ultrasonography imaging (USI) are the most frequently used brachial plexus block techniques in upper extremity surgeries. It is already known that sympathetic blockage occurs after the application of these blocks, and blood flow increases with vasodilatation caused by the blockage. This study aimed to compare the effect of ICB and ISB, which are applied together with USI, on forearm tissue oxygenation.
Materials and Methods: A hundred-four patients were included in this study belonging to ASA I-III risk groups, aged 18–65 years, who were scheduled for elective or emergency arm, elbow, or forearm surgery**.** The patients were divided into two groups: Group ICB and Group ISB. In addition to the baseline hemodynamic measurements, PI, time average velocity (TAV), brachial artery diameter (BAD), brachial arterial area (BAA), brachial artery beat flow (BF), and tissue oxygen saturation (rSO_2) data were recorded before block and at the 10th, 20th, and 30th min after the block was completed.
Results: The demographic data of the patients in the Group ICB and Group ISB were compared, no significant differences were detected between the groups. When the distribution of the percentage increase in PI and rSO_2 values according to time was examined, significant differences were found between the groups. There were no significant differences in the percentage increases in BF, TAV, BAA, and BAD values between the 0th minute and at 10th, 20th, and 30th min (p>0.05). Horner syndrome

Öz

Amaç: Ultrasonografi görüntüleme (USG) eşliğinde yapılan infraklaviküler blok (İKB) ve interskalen blok (İSB), üst ekstremite ameliyatlarında en sık kullanılan brakiyal pleksus blok teknikleridir. Bu blokların uygulanmasından sonra sempatik blokaj oluştuğu ve blokajın neden olduğu vazodilatasyon ile kan akımının arttığı bilinmektedir. Bu çalışmada USG ile birlikte uygulanan İKB ve İSB'nin önkol doku oksijenasyonuna etkisinin karşılaştırılması amaçlandı.
Gereç ve Yöntem: Bu çalışmaya elektif veya acil kol, dirsek veya önkol cerrahisi planlanan 18-65 yaş arası ASA I-III risk gruplarına ait yüz dört hasta dahil edildi. Hastalar iki gruba ayrıldı: Grup İKB ve Grup İSB. Bazal hemodinamik ölçümlere ek olarak, blok öncesi ve blok tamamlandıktan sonra 10., 20. ve 30. dakikalarda Perfüzyon indeksi(PI), ortalama akım hızı(TAV), brakiyal arter çapı(BAÇ), brakiyal arter alanı(BAA), brakiyal arter atım akımı (BF) ve doku oksijen satürasyonu(rSO2) verileri önceden kaydedildi.
Bulgular: Grup İSB ve Grup İKB'deki hastaların demografik verileri karşılaştırıldı, gruplar arasında anlamlı fark saptanmadı. PI ve rSO2 değerlerindeki artış yüzdelerinin zamana göre dağılımı incelendiğinde, gruplar arasında anlamlı farklılıklar bulundu. 0. dakika ile 10., 20. ve 30. dakikalar arasında BF, TAV, BAA ve BAÇ değerlerindeki yüzde artışlarında anlamlı fark yoktu. Grup İSB'de 8 hastada (%15) Horner sendromu, 3 hastada (%5) ani ses kısıklığı gözlendi. Grup İKB'de komplikasyon gelişmedi.

Yazışma Adresi/Address for Correspondence: Dr. Bengü Gülhan Aydın, Zonguldak Bulent Ecevit University, Department of Anesthesiology and Reanimation, School of Medicine, Zonguldak, Turkey E-mail: bengukoksal@gmail.com
Geliş tarihi/Received: 01.12.2021 Kabul tarihi/Accepted: 03.06.2022

was observed in 8 patients (15%) and sudden hoarseness was observed in 3 patients (5%) in Group ISB. No complications developed in the Group ICB.

Conclusion: This study shows that the effects of ICB and ISB on forearm tissue oxygenation were compared and it was found that ICB increased rSO_2 and PI values.

Keywords:. Regional anaesthesia, infraclavicular block, interscalene block, perfusion index, tissue oxygen saturation

Sonuç: Bu çalışmada İKB ve İSB'nin önkol doku oksijenasyonu üzerindeki etkilerinin karşılaştırıldığı ve İKB'nin rSO2 ve PI değerlerini arttırdığı tespit edilmiştir.

Anahtar kelimeler: Rejyonal anestezi, infraklavikular blok, interskalen blok, perfüzyon indeksi, doku oksijen saturasyonu

INTRODUCTION

Presently, the use of brachial plexus block techniques in upper extremity surgeries is increasing[1]. As compared to general anesthesia, plexus block is advantageous due to reduced need for postoperative analgesia and antiemetic use, short duration of stay in the recovery room and the hospital ward, increased blood flow to the upper extremity, and the patient being conscious[2]. With the increasing use of ultrasonography imaging (USI) in peripheral blocks, the time of block application has shortened and success rates have increased[3].

Infraclavicular block (ICB) and interscalene block (ISB) accompanied by USI are the most frequently used brachial plexus block techniques in upper extremity surgeries. It is already known that sympathetic blockage occurs after the application of these blocks, and blood flow increases with vasodilatation caused by the blockage[4]. Previous studies have shown that blood flow (BF), which is measured with Doppler USI, increases after brachial plexus block [5,6].

The evaluation of macro and micro-hemodynamic variables, using “whole body” markers, such as arterial pressure, serum lactate, central venous oxygen saturation, or cardiac output, is often insufficient to assess tissue hypoperfusion risk[7]. Therefore, easy-to-use, minimally invasive, and reliable tissue monitoring techniques that can be used at the bedside are needed[8]. One of these methods is the perfusion index (PI), and the other is near-infrared spectroscopy (NIRS). PI represents continuous tissue perfusion obtained non-invasively using pulse oximeter technology and is expressed as the ratio of the pulsatile component of light to its non-pulsatile component. It can be used to show increased tissue perfusion with vasodilatation after peripheral nerve block[9]. NIRS allows the continuous measurement of the regional tissue oxygenation at bedside and provides an indirect estimate of the balance between tissue oxygen delivery and consumption [10]. Thus, it can be used to show oxygen saturation changes in tissues with increased perfusion following peripheral nerve block [11].

The aim of the present study was to compare the effect of ICB and ISB, which are applied together with USI, on forearm tissue oxygenation. We believe that regional techniques, which will be selected by observing the effect on tissue oxygenation, will be much more beneficial. To our knowledge, this is the first randomized study to determine the effectiveness of both blocks on forearm oxygenation.

MATERIALS AND METHODS

The present study was conducted between June 15, 2018, and June 15, 2019, at the Department of Anesthesiology and Reanimation, Faculty of Medicine, in Zonguldak Bulent Ecevit University Hospital. The study protocol was approved by the Local Ethical Committee (2017-116-06/12), and the study protocol was registered at clinicaltrials.gov (Identifier: NCT04748211). Written approval was obtained by providing the patients the necessary information about the study.

Study design and patient selection

After obtaining written informed consent, 104 patients were included in this study belonging to the American Society of Anesthesiologists (ASA) I-III risk groups, aged 18–65 years, who were scheduled for elective or emergency arm, elbow, or forearm surgery

This was a prospective, randomized, single-blind design study and the randomization was performed using the closed envelope method. The patients were divided into two groups: Group ICB and Group ISB. Block applications were performed by the same anesthesiologist (E.A), and USI measurements were measured and recorded by a different anesthesiologist. The exclusion criteria were as follows: patients' refusal to receive brachial plexus blockage; any neurological disorders preventing the evaluation of the sensory block in the upper extremity; infection in the area to be blocked with ICB or ISB; non-cooperative patients; patients with coagulopathy; morbidly obese patients; patients with diabetes mellitus, hypertension and peripheral artery disease; allergy to the drugs used; trauma in the area scheduled for the block; deterioration of anatomical integrity due to previous surgery; pregnant women; patients in whom the block failed. The demographic data of the patients (i.e., age, height, weight, sex) and ASA risk groups were recorded.

Patients were placed in rooms with a temperature of 21–24 ^{o}C and a 20 G cannula was used for venous access on the patient's other arm. Intravenous normal saline was started at a speed of 5 mL $kg^{-1}st^{-1}$ from vascular access. Electrocardiogram (ECG), noninvasive blood pressure, and peripheral oxygen saturation were monitored, and heart rate (HR), mean arterial pressure (MAP), and peripheral oxygen saturation (SpO_2) control values were measured before the intervention.

All patients who participated in the present study were premediated with 0.01 mg kg^{-1} midazolam and 1µg kg^{-1} fentanyl intravenously, 10 min before the block was applied. Patients were administered 2–4 L min^{-1} oxygen with a face mask during the block procedure.

Ultrasonography imaging measurements

To measure the PI and tissue oxygen saturation (rSO_2), a pulse oximeter sensor (RZ-25 sensor Masimo SET® Radical™ pulse oximeters; Masimo Corp, Irvine, CA, USA) was attached to the second finger of the upper extremity of the side to which the procedure was performed, and an rSO_2 sensor was attached to the 1/3 of the proximal lateral part of the forearm, respectively. The pulse oximeter and rSO_2 sensors were attached to a Radical-7™ Pulse CO-Oximeter (Masimo) and a 03 Moc-9 module device (Masimo). The linear probe of the Esaote MyLab™ 30 USI device was used for the Doppler USI measurements.

Ultrasonography

The basal hemodynamic data, PI, and rSO_2 values of the patients were recorded before the procedure. Doppler USI measurements were made 2-4 cm proximal to the antecubital fossa on the side of the procedure, with the sagittal screening of the brachial artery. The B-mode USI image was optimized, the Doppler USI mode was switched, and five consecutive cardiac cycles were detected to minimize measurement errors. The time-average velocity (TAV, cm s^{-1}) was recorded. The end of the diastole brachial artery diameter (BAD, mm) was measured in the B-mode USI image and recorded by drawing the distance vertically between the two lumens of the vein. The brachial artery area (BAA, mm^2), which was calculated automatically with the USI device, and blood flow (BF, mL min^{-1}), which was calculated using field and TAV values, were also recorded. The first place where brachial artery Doppler USI measurements were performed was marked with a skin marking pen for the standardization of the measurements to be performed after the procedure. The initial sensory examination of the patients was performed and recorded using the pinprick test.

Regional techniques

The values of the patients before the procedure were recorded, and then ICB was applied to patients in Group ICB. The patients were instructed to lie in the supine position with their heads turned to the other side of the application. The physician applied the block procedure to the head of the patient. The area to be injected was cleaned with povidone- iodine. A 6-10 MHz linear probe was used for the block. Ultrasound gel was applied to the linear probe which was then covered with a sterile nylon sheath, and a long axle (in-plane) image was obtained using USI with sterile gel on the area to be treated.

The USI probe was positioned in the medial part of the coracoid process to obtain a cross-sectional image of the axial artery that passes under the pectoralis minor muscle in the parasagittal plane. An 85 mm, 21 G echogenic needle (Echoplex, Vygon, France) with electro-neuro-stimulation port was used for the block. When the image of the axial artery was obtained with ultrasonography, subcutaneous infiltration of 2 mL prilocaine was applied with a 25 G needle at the injection point. The stimulation needle used for the block was simultaneously connected to the nerve stimulator (Plexygon, Vygon). The anode (+) pole of the nerve stimulator was connected to the ECG electrode, which was positioned on the shoulder of the side where the block was applied. After entering through the skin, the tip of the stimulation needle was positioned at the lower part of the axillary artery or at 7-8 level with the "in-plane" method that was accompanied by realtime imaging with the USI probe. The prepared local anesthetic (LA) solution was applied as a single injection after the negative aspiration test (by repeating this test after every 5 mL LA injection) when the fine motor movement of the hand (i.e., radial movement or finger or wrist extension) was observed in simultaneously operated nerve stimulator (0.5 mA)., LA agents, 10 mL of 2% lidocaine and 10 mL of 0.5% bupivacaine were applied. During the injection, the LA solution was displayed with USI, filling around the axial artery in a U-shape.

Similarly, the data obtained before the procedure were recorded, and the ISB was applied to the patients in the Group ISB. The patients were positioned in the supine position, with their faces facing the other side of the application at about 45°. After aseptic preparation of the area with povidone-iodine, it was covered with a sterile cover and LA was performed to the skin with 2 mL prilocaine and a 25 G needle. For the block, a 50 mm, 21 G echogenic needle with electro-neuro-stimulation port (Echoplex, Vygon) was used in the USI linear probe, the USI gel was applied, the area was covered with a sterile nylon sheath, and the probe was placed in the supraclavicular fossa. In this position, the brachial plexus was defined on the lateral and superficial sides of the subclavian artery. The probe was moved upward and was fixed when two or more branches of the brachial plexus were seen in the space between the skin muscles. Then, the needle was directed from the lateral to the medial area and under the paravertebral fascia with the in-plane technique to the interscalene gap. The location of the needle was confirmed by observing the shoulder movement with a nerve stimulator (0.5 mA), and 1-2 mL LA agent was first administered after the negative aspiration test to discard the intravascular placement. Then, 10 mL of 2% lidocaine and 10 mL of 0.5% bupivacaine were injected. The procedure was completed by viewing the distribution of the LA agent around the plexus using USI.

All blocks were performed by the same anesthesiologist. All data were recorded by an anesthesiologist. The SpO_2, MAP, HR and PI, TAV, BAD, BAA, BF, and rSO_2 data were recorded again at the 10^{th}, 20^{th}, and 30^{th} min after the block was completed (the removal of the needle from the skin was taken as the 0^{th} min). When the block was completed, the sensory examination was recorded with the pinprick test, and motor strength examination was performed using the Holmen Scale.

Statistical analysis

A power analysis to determine sample size was based on to determine the correlation between the infraclavicular and interscalene block on oxygenation of the forearm. Using a two sided test, 5% significance level test (α=0.05) with power 80% power (β=0.2) for 0.75 effect size, the required sample size is approximate 110 (n=110). SPSS (ver:22.0) (Statistical Package for Social Sciences) for Windows 10.0 program was used for all statistical analysis. The normal distribution of the data was evaluated using the Shapiro Wilk test. Descriptive statistics are presented as numbers or mean ± standard deviation. The numbers were used categorical data (gender). The Yates corrected chi-square test was used to analyze categorical variable (gender) in independent groups. For continuous variables (regional hemodynamic parameters and demographic datas except for gender), the independent sampling t-test was used for the independent groups and the paired sample t-test was used for dependent groups (for different time measurements of regional hemodynamic parameters within the group). Statistical significance was set at $p<0.05$.

RESULTS

The patients' flowchart is shown in Figure 1. Among patients included in the study, one patient was excluded from each group due to block failure. Of 104 patients, 35 (34.4%) were women and 67 (65.6%) (n=67) were men. When the demographic data of the patients in the Group ICB and Group ISB were compared, no significant differences were detected between the groups ($p>0.05$). The demographic data are presented in Table 1. Statistically significant differences were detected in both groups when MAP values were compared between that at 0^{th} min and those at 10^{th}, 20^{th}, and 30^{th} min except for the 10^{th} min measurement in the Group ISB ($p<0.05$). No statistically significant differences were detected in the inter-group comparisons for the HR and MAP values at all measurement times. When the distribution of the percentage increase in PI and rSO_2 values according to time was examined, significant differences were found between the Group ICB and Group ISB ($p<0.05$) (Table 2). Statistically significant differences were detected in all parameters of regional hemodynamic values in each group when compared between the 0^{th} min and at 10^{th}, 20^{th}, and 30^{th} min ($p<0.05$) (Table 3)

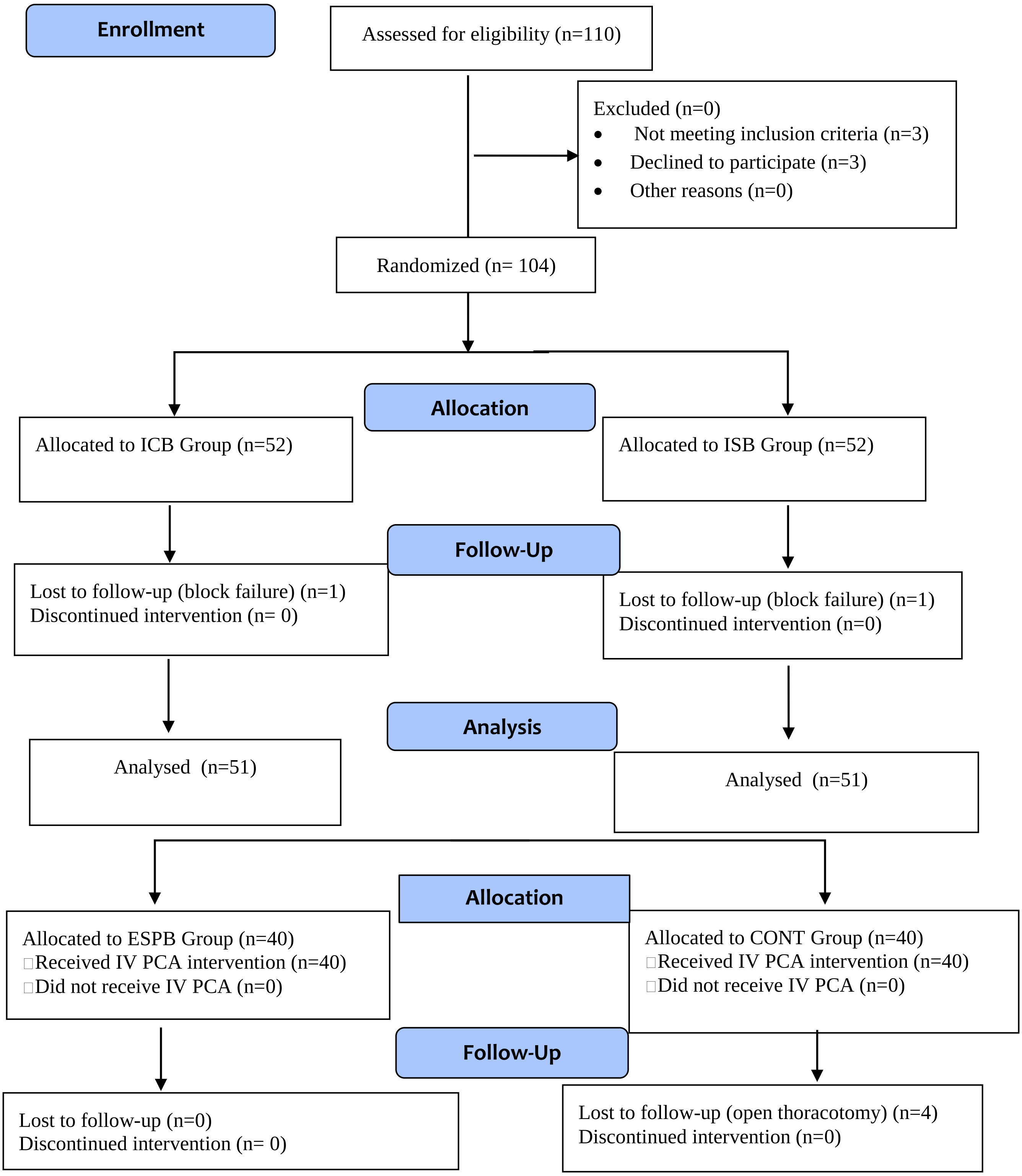

Figure 1. CONSORT flow diagram

Table 1. Comparison of demographic data between the groups.

	Grup ICB (n=51)	Grup ISB (n=51)	*P* Value
Male/Female	35/16	32/19	0.677
Age (years)	40.43±14.46	44.11±14.39	0.241
Weight (kg)	73.57±11.72	76.16±14.36	0.181
Height (cm)	170.12±8.62	168.2±8.95	0.272
BMI (kg m^{-2})	25.3±3.18	26.11±4.36	0.116

Table 2. Comparison of percent changes of parameters measured in time intervals.

Parameters		0-10 min (%)	0-20 min (%)	0-30 min (%)	P^1	P^2	P^3
PI	Grup ICB	136.36	237.19	298.29	0.009	0.002	0.005
	Grup ISB	80.35	130.04	171.32			
BF, mL min^{-1}	Grup ICB	107.57	166.87	216.52	0.21	0.30	0.26
	Grup ISB	88.20	141.94	180.96			
rSO_2, %	Grup ICB	6.00	9.31	12.17	0.027	0.033	0.02
	Grup ISB	4.35	7.88	9.99			
TAV, cm s^{-1}	Grup ICB	79.41	116.55	135.15	0.255	0.433	0.442
	Grup ISB	66.67	102.86	120.34			
BAD, mm	Grup ICB	5.96	9.91	14.95	0.672	0.560	0.405
	Grup ISB	5.36	8.87	12.88			
BAA, mm^2	Grup ICB	13.68	22.25	34.26	0.405	0.593	0.274
	Grup ISB	11.11	20.19	27.45			

PI: Perfusion Index; BF: blood flow; TAV: time average velocity; BAD: brachial artery diameter; BAA: brachial artery area;

Table 3. Comparison of the regional hemodynamic characteristics

Parameters		0. min	10.min	20.min	30.min	P^1	P^2	P^3
PI	Grup ICB	3.51±2.24	6.46±2.80	8.52±2.90	9.69±2.93	0.000	0.001	0.001
	Grup ISB	2.83±1.38	4.58±1.83	5.75±1.95	6.55±1.98	0.000	0.001	0.000
	P	0.178	0.001	0.001	0.001			
BF, mL min^{-1}	Grup ICB	118.06±71.85	214.74±98.12	265.14±114.83	303.92±123.66	0.001	0.000	0.001
	Grup ISB	85.51±47.50	163.51±73.75	224.10±115.03	259.02±126.07	0.001	0.000	0.000
	P	0.047	0.005	0.017	0.008			
rSO_2, %	Grup ICB	72.47±5.15	76.82±6.21	79.16±5.76	81.24±6.23	0.001	0.001	0.001
	Grup ISB	72.86±3.75	76.04±4.57	78.55±3.91	80.08±3.91	0.000	0.001	0.001
	P	0.654	0.423	0.370	0.179			
TAV, cm s^{-1}	Grup ICB	19.14±8.07	31.38±10.44	36.36±10.76	39.06±10.74	0.001	0.001	0.001
	Grup ISB	14.43±7.48	24.06±10.39	30.01±12.06	32.33±12.50	0.000	0.000	0.001
	P	0.178	0.001	0.001	0.001			
BAD, mm	Grup ICB	3.58±0.61	3.78±0.60	3.91±0.59	4.08±0.62	0.000	0.001	0.001
	Grup ISB	3.60±0.59	3.81±0.57	3.97±0.62	4.11±0.67	0.001	0.001	0.001
	P	0.636	0.696	0.752	0.911			
BAA, mm^2	Grup ICB	10.35±3.46	11.56±3.67	12.36±3.79	13.39±4.16	0.000	0.001	0.001
	Grup ISB	10.42±3.44	11.76±3.62	12.88±3.87	13.71±4.49	0.001	0.001	0.001
	P	0.566	0.652	0.573	0.847			

PI: Perfusion Index; BF: blood flow; TAV: time average velocity; BAD: brachial artery diameter; BAA: brachial artery area;

There were no significant differences in the percentage increases in BF, TAV, BAA, and BAD values between the 0th minute and at 10th, 20th, and 30th min (Figure 2,3).In the present study, Horner syndrome was observed in 8 patients (15%) and sudden hoarseness was observed in 3 patients (5%) in Group ISB. No complications developed in the Group ICB.

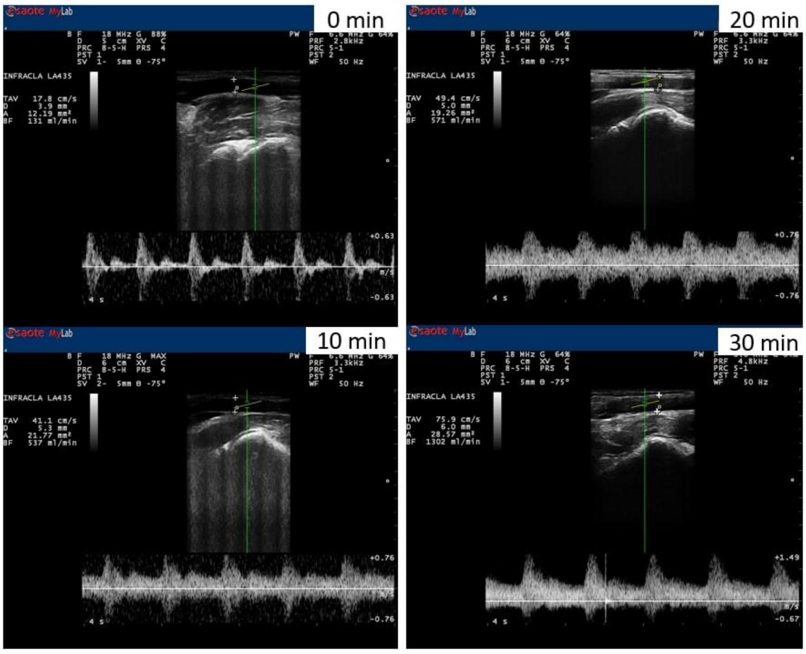

Figure 2. Change in the Blood Flow (BF) after infraclavicular block

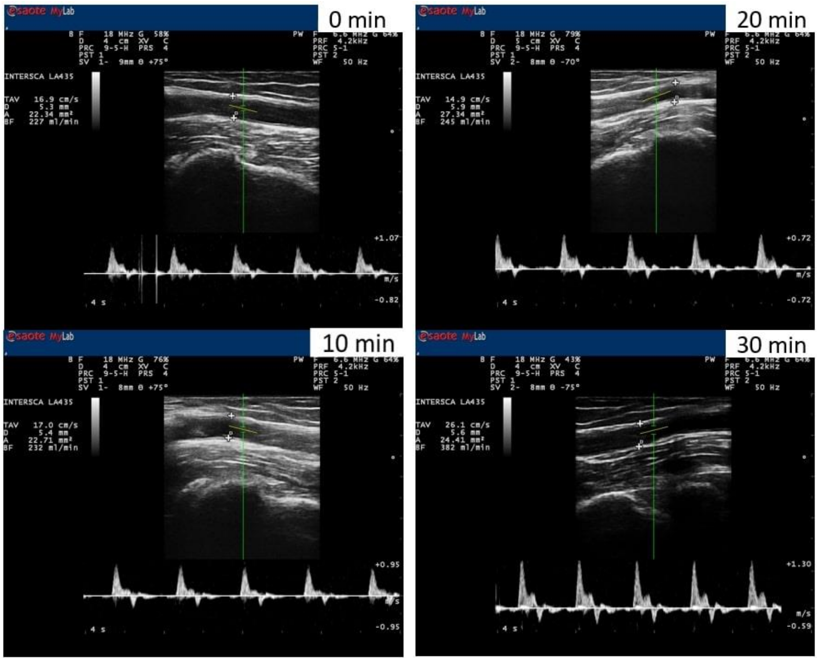

Figure 3: Change in the Blood Flow (BF) after interscalene block

DISCUSSION

In the present study, the effects of ICB and ISB on forearm tissue oxygenation were compared and it was found that ICB increased rSO_2 and PI values.

In recent years, the use of brachial plexus block techniques in upper extremity surgeries has been increasing.[1] Despite its various advantages as listed before, the most important disadvantage is that plexus block applications take time, and the effects of LA start late.

To evaluate the success of brachial plexus block applications, many methods (e. g., Bromage scale, Modified Bromage scale, Lovett Rating scale, and Holmen scale) have been used[12]. For the evaluation of the resulting sensory block, the pinprick test, loss of cold sensation, and vibration sensation loss were used [13,14]. We used the Holmen scale in our study because we aimed to evaluate the sensory and motor blocks together.

In patients who undergo regional anesthesia, the sympathetic blockage is formed first, followed by sensory and motor blocks. Vasodilatation occurs in areas where the sympathetic blockage is applied, and therefore, skin temperature increases[4]. In the ICB applications accompanied by USI, Nieuwveld D. et al.[15] showed that the increase in humeral artery blood flow and skin temperature occurred due to sympathetic blockage. Similarly, Iskandar et al.[5] showed with USI measurement that vasodilatation occurred on the side where the block was applied to the upper extremity, and the arterial blood flow increased accordingly. However, no previous study showed the effects of plexus blocks applied at different levels on sympathetic blockage and blood flow. For this purpose, we compared the effects of ICB, which is applied below the clavicle at the cord level, and ISB, which is applied at the level of C_6 vertebral level, on regional hemodynamic changes[16].

In the present study, hemodynamic parameters were recorded at certain intervals. For this purpose, the values of MAP and HR were recorded in both groups before (at 0th min) and after the block (at 10th, 20th, and 30th min), and MAP decreased in both groups. However, in patients who underwent ISB, there was an increase in MAP values at 20th min post-block, though this increase was not statistically significant. A study conducted by Hernandez et al.[17] reported that compared to the previous values, blood pressure increased 40%–60% between the 5th and 10th min after ISB among 12 patients who had normal blood pressure, HR, and no history of hypertension. They assumed that this was due to the proximity of the area given LA in ISB application to carotid sinus baroreceptors, and due to the blockage of these receptors. In our study, we believe that the temporarily elevated blood pressure in patients with ISB may be due to baroreceptor blockage. The decrease in MAP values, particularly in the Group ICB, might be due to vasodilatation caused by sympathetic blockage and decreased patient pain.

The most important complication of peripheral nerve block is systemic LA toxicity which is due to the use of LA at high doses and volumes[18,19]. We preferred to use low-volume LA, which would provide anesthesia in sufficient time for both groups and minimize the toxicity risk. For this purpose, we conducted a study with a combination of 10 mL of 2% lidocaine and 10 mL of 0.5% bupivacaine. No findings of LA toxicity were detected in any of the patients in our study.

PI reflects the strength of tissue perfusion by calculating the relationship between pulsatile (arterial blood) and non-pulsatile (venous or tissue blood) light in a pulse oximeter [20]. The beat volume and vasomotor tonus are the main factors that affect skin temperature and blood flow in the monitored area affects PI measurements[21]. The sympathetic block is formed following regional anesthesia. Subsequently, the sensory block and motor block are formed[4]. Local vasodilatation and related tissue perfusion increase in the area with sympathetic blocks. Therefore, PI can be used to show sympathetic block formation[9,14]. Abdelnasser et al.[22] showed that the PI value and its rate of increase showed 100% sensitivity for block success in patients who underwent block application. In a study in which sympathectomy was evaluated after epidural anesthesia, Ginosar et al.[24] reported that the PI value showed sympathetic block earlier and more successfully than MAP and skin temperature. In a study conducted by Kuş et al.[9], in which the effectiveness of PI in evaluating ICB success was investigated, they reported that PI value increased by 120% at the 10th min post-block as compared to the initial value. In our study, the same amount of LA was used in both groups, and the PI values at 10th, 20th, and 30th min increased in a time-dependent manner in both groups. PI values increased consistently in both groups and were statistically significant, which is in line with other studies in the literature. In addition, the difference in the increase between the two groups was also evaluated. In the Group ICB, the PI value increased by 136% at the 10th min and by 80% in Group ISB. The PI increase rate in the Group ISB was significantly lower than that in the Group ICB, which suggested that tissue perfusion in the arm increased less in the Group ISB because of the failure in the block of the C_8-T_1 roots of the ISB.

The BF change, which indicates vasodilatation due to peripheral blocks performed in upper extremity surgeries using the Doppler technique, is an important parameter to show block success[5,24]. Iskandar et al.[5] reported a 175% increase in BF at 30 min after ISB was performed in shoulder surgeries, rising from 32 mL min^{-1} to 88 mL min^{-1}. Li et al. [25], on the other hand, showed that BF increased significantly as the concentration increased. Bereket et al.[26] reported that there was a 132% increase in BF at the 10th min and a 263% increase at the end of the 30th min with 10 mL 2% lidocaine and 20 mL 0.5% bupivacaine. In our study, BF increased by 216% in the Group ICB and by 180% in the Group ISB, indicating that ICB provides vasodilatation more effectively.

In previous studies, NIRS sensors were attached to different anatomical locations to measure tissue perfusion according to the type of block [27,28]. In our study, the measurements were made by attaching the NIRS sensor to the front part of the forearm, which is the common effect area for both ICB and ISB, to observe the peripheral post-block tissue oxygenation in upper extremity surgeries, which is in line with the studies in the literature. Karahan et al.[28] conducted a study on ICB accompanied by USI, fixed the NIRS probe in the tenor region, and compared the initial values with the post-block values. They reported that there was a 4.5% increase in the rSO_2 values at the 5th min and a 5.5% increase at the 30th min. In our study, the increase in the rSO_2 at the 30th min was 12.1% and 9.99% in the Group ICB and Group ISB, respectively. Because of the lack of C_8-T_1 roots in the ISB, we think that the increase in the rSO_2 values was low due to the lack of complete sympathetic blockage.

The cervical sympathetic truncus is anatomically close to the tile sheath of the brachial plexus roots and carotid sheath. Horner syndrome may develop as a result of the cervical sympathetic ganglia block applied with the interfascial spread of LA substance injected in ISB[29]. In our study, Horner syndrome was observed in 8 patients (15%) and sudden hoarseness (5%) in 3 patients. When compared with many studies in the literature, we observed that our complication rates were quite low. We believe that this depends on the use of the USI device when applying the blockages, keeping the amount of LA at low levels.

There are several limitations to this study. First, since the measurements in our study were made at 10 min intervals, the exact time of the changes in these parameters could not be determined. In addition, in order not to delay the beginning of the surgery, the final measurement was made at the 30th min. For this reason, we could not observe the duration of post-block regional hemodynamic changes. Second, the NIRS probe was fixed only in the forearm, and because of the presence of the affected area of the shoulder in patients undergoing ISB, no comparisons could be made between the two regions by attaching the NIRS probe to the shoulder area. However, we believe that the lack of a study in the literature comparing the changes in rSO_2, BF, TAV, BAA, BAD, and PI values in patients undergoing two different blocks of brachial plexus with LA in the same volume and concentration is the strength of this study. We believe that ICB is more effective than ISB, especially in brachial plexus blocks, in increasing forearm tissue oxygenation.

In conclusion, the present study compared the effects of ICB and ISB plexus blocks on forearm tissue oxygenation, and the rSO_2, PI, BF, TAV, BAD, and BAA values were assessed. All parameters were found to be higher in the ICB group. We also found that the ICB was more effective than ISB in providing forearm tissue oxygenation. In forearm surgeries, ICB should be preferred not only for anesthetic purposes but also because tissue oxygenation is improved due to an increase in tissue blood with vasodilatation. Since there are very few studies in the literature where the blood build-up in the forearm after brachial plexus block is shown with the NIRS technique, we believe that our study may provide insights for future studies in which tissue oxygenation can be examined with different doses or different types of blocks.

Yazar Katkıları: Çalışma konsepti/Tasarımı: EA, ÖP, HA; Veri toplama: GK, EA; Veri analizi ve yorumlama: ÖP, DO; Yazı taslağı: ÖP, DO; İçeriğin eleştirel incelenmesi: BGA, GK, HA; Son onay ve sorumluluk: EA, ÖP, BGA, DO, GK, HA; Teknik ve malzeme desteği: BGA, HA; Süpervizyon: GK, BGA; Fon sağlama (mevcut ise): yok.
Etik Onay: Bu çalışma için Bülent Ecevit Üniversitesi Klinik Araştırmalar Etik Kurulundan 03.01.2018 tarih ve 2018/01-1 sayılı kararı ile etik onay alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazarlar çıkar çatışması olmadığını beyan etmişlerdir.
Finansal Destek: Bu araştırma, kamu, ticari veya kar amacı gütmeyen sektörlerdeki finansman kuruluşlarından belirli bir hibe almamışlardır.
Author Contributions: Concept/Design : EA, ÖP, HA; Data acquisition: GK, EA; Data analysis and interpretation: ÖP, DO; Drafting manuscript: ÖP, DO; Critical revision of manuscript: BGA, GK, HA; Final approval and accountability: EA, ÖP, BGA, DO, GK, HA; Technical or material support: BGA, HA; Supervision: GK, BGA; Securing funding (if available): n/a.
Ethical Approval: For this study, ethical approval was obtained from the Bülent Ecevit University Clinical Research Ethics Committee with the decision dated 03.01.2018 and numbered 2018/01-1.
Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors have declared that there is no conflict of interest..
Financial Disclosure: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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