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Perfusion index (PI) measured in the brachial plexus blocks performed by ultrasonography: investigation of correlation with block success

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Abstract

Background Brachial plexus block is one of the peripheral nerve blocks commonly used in regional anesthesia. We aimed to investigate whether the perfusion index (PI) measurement can be used to evaluate the adequacy of the upper limb blocks accompanied by ultrasonography. Thirty-three patients between the ages of 18 and 65 who were in the ASA I–II group who will have a hand, forearm, and arm operation were included in the study. An appropriate type of brachial plexus block was applied to these patients under the guidance of ultrasonography. After the block application was completed, the sensory and motor blocks were evaluated at the 5th, 10th, and 20th min. In addition, perfusion indices measured from both extremities of the patient were recorded at the 5th, 10th, and 20th min.

Results In 32 of 33 patients who underwent brachial plexus block, our block was successful, and perfusion index measurements in the applied limb increased continuously from the 5th min over the 20-min observation period. In one patient who failed the block and in the arm group without block, no statistically significant difference was detected in the 5th, 10th, and 20th min perfusion index measurements.

Conclusions Perfusion index measurement is a very valuable and usable method to evaluate the success of peripheral nerve blocks early, easily, and objectively.

Keywords Brachial plexus block, Axillary block, Infraclavicular block, Perfusion index

Background

Peripheral nerve block is one of the commonly used blocks in regional anesthesia. Peripheral nerve blocks provide more advantageous conditions in cases where general anesthesia or spinal anesthesia are risky, as in heart, kidney, respiratory disease, chest trauma, and diabetic patients. Block is limited to the region covering the area innervated by the plexus or terminal branches; in other regions, the physiological order of the body remains as it is (Ting and Sivagnanaratnam 1989; Ang et al. 1984; Mezzatesta et al. 1997). Peripheral nerve block allows patients to leave the recovery room early or to be discharged from the hospital early (Cockings et al. 1987; Arciero et al. 1996). In order for the peripheral nerve blockage to be successful, it is necessary to choose the best approach and method while performing the blockage and use the right drug in the appropriate volüme (Brown and Bridenbaugh 1998; Ünaldı et al. 2008). The technique of loss of response to sensory stimuli that requires collaboration with the patient, which is the traditional method, is used to start the surgical operation or evaluate the adequacy of the block. The objectivity of this method is

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low and time consuming (Curatolo et al. 2000). Successful peripheral nerve blockage, depending on the blocking of sympathetic fibers, is observed as local vasodilation, increased local blood flow, some increase in skin temperature, and loss of sensation in the extremity (Sorensen et al. 1996; Kus et al. 2013). However, in a busy and cold operating room environment, these clinical findings may not appear fast enough to confirm block adequacy before or during surgery, and these findings that require patient cooperation may not be used to make clinical decisions. In order to evaluate the success of the block, non-invasive, easy, and objective methods are required that do not require patient cooperation and provide rapid evaluation. Perfusion index (PI) is a noninvasive and easily applicable method that reflects the measurement of vasomotor tone with a pulse oximeter attached to the fingertip (Galvin et al. 2006). It is calculated as the ratio of pulsatile arterial flow (AC) to nonpulsatil (static) blood flow (DC) in the peripheral tissues measured by the Masimo pulse oximeter. It gives values from 0.02 to 20. Its normal mean value is 1.4. Increased values indicate an increase in the circulation in the sensor area (Lima et al. 2009). Thanks to the PI value, peripheral perfusion can be monitored continuously and non-invasively via pulse oximetry.

We aimed to investigate whether PI measurement can be used as a reliable and objective method to evaluate the adequacy of upper limb blocks.

Methods

The study was carried out with patients who underwent elective hand, forearm, and arm surgery between April 2019 and October 2019. The Ethics Committee Approval (No: 2019/2–17) was obtained before starting the study. The G*Power (v3.1.9) program was used to determine the number of samples. The effect size was calculated as 0.85 based on the "mean values of perfusion indice" obtained from a previous study (Bereket MM et al. 2019). When the power of the study was 90%, the effect size was 0.85, and the α error was 0.05, it was calculated that at least 29 patients should be included in the sample.

This is a prospective cross-sectional observational study of 33 patients aged 18–65 years, which were included in the ASA (American Society of Anesthesiologists) classification I–II. An informed consent was obtained from each patient. Patients who did not want to participate in the study, patients who did not accept the application of the block, patients with brachial plexus block contraindicated, those who could not cooperate, those with kidney failure, those with liver failure, those who are pregnant and breastfeeding, and those who were in the ASA III–IV–V group were excluded from the study. Anesthetic procedures were performed by the same anesthesiologist.

Eight hours before the operation, oral intake of all patients was interrupted. Sedation was not applied to the patients on the morning of the operation. Before the procedure, standard monitoring (electrocardiography, oxygen saturation, noninvasive mean arterial pressure) was performed to each patient. Systolic arterial pressure (SAB), diastolic arterial pressure (DAB), heart rate (HR), and oxygen saturation (SpO_2) were followed before and during the application. PI values were recorded at the 5th, 10th, and 20th min by attaching the PI probe to both the secondfingertip of the upper extremity where the block will be applied and the second fingertip of the opposite limb where the block will not be applied. It was investigated whether there was a significant increase in PI measurements in limbs with or without blockage. Also, whether there is a significant difference in PI measurements between the applied block types and genders was added to the study.

The axillary or infraclavicular block was applied by checking the brachial plexus branches with ultrasound and neurostimulator. One milligram of midazolam for sedation was applied to each patient to be treated with block, and fentanyl at a dose of 0.5 µg/kg was used to protect against block pain. Local anesthesia was performed with 1 cc 2% lidocaine after the necessary sterilization procedures were performed in the area where the block will be applied and the block area was covered sterile. Then, using the Siemens brand ultrasound device and a neurostimulator (StimuplexDig®, B-Braun, Germany), the terminal branches of the brachial plexus (median, ulnar, radial) with 22 G, 50 mm isolated needle (Stimuplex, B-Braun, Germany), and musculocutaneus motor response was evaluated by electrical stimulation of 0.4–0.8 mA. Extension of the fingers or wrist was evaluated as sufficient response for the radial nerve, flexion of the second and third fingers for the median nerve, flexion of the fourth and fifth fingers, or the adduction of the fist for the ulnar nerve. After detecting at least three of these terminal branches of the brachial plexus, a local anesthetic injection was made with a needle perpendicular to the ultrasound probe. For the block, 20 ml 0.5% bupivacaine and 10 ml lidocaine were prepared separately. A total of 30 ml (20 ml bupivacaine + 10 ml lidocaine) local anesthetic was used in all patients. In response to the electrical stimulation given (0.4–0.8 mA), an adequate volume of injected solution was injected around each nerve after sufficient muscle contraction was observed and following the aspiration test (Figs. 1, 2, and 3).

After completion of the block sensory and motor block within 20 min, it was evaluated at the 5th, 10th, and 20th min. Block sitting time was accepted as 20 min. In the

Fig. 1 Block making with ultrasound

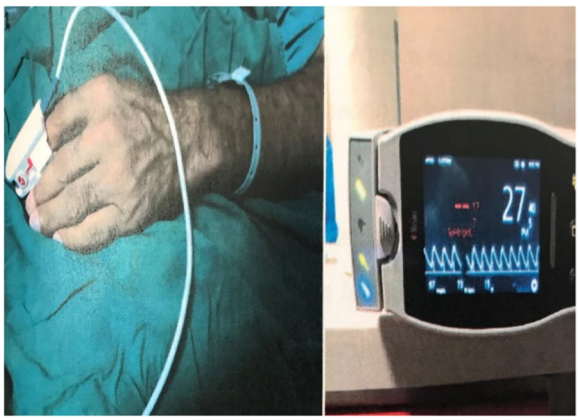

Fig. 3 Perfusion index measurement

20th min, after the patient's sensory block level "Pin-prick" test was evaluated with the motor block degree "Bromage" scale, the surgical operation of the patients was allowed.

"Pin-prick" test 0: no sense block; 1: touch feeling, no pain; 2: no touching feeling and pain were used. "Bromage" scale 0: no block, can lift arm; 1: motor power is reduced but arm is moving; 2: arm is still but fingers are moving; 3: full block, no hand and arm movement are used (Guzel et al. 2013).

Statistical analysis

The data were analyzed in SPSS Windows 25.0 version. The distribution of variables was checked with the Kolmogorov–Smirnov test. Average, standard deviation, and frequency values were used in the descriptive statistics of the data. Mann–Whitney *U* test was used to compare numerical nonparametric data, and Spearman correlation analysis was used to compare quantitative data. Analysis of repetitive clinical measurements was investigated using variance analysis in repeated measurements. If the results of Wilks' lambda test statistics were found to be significant among the groups, Bonferroni-corrected multiple comparison test was used to determine the situations that caused the difference. Paired sample test was used for dual time comparison. Unless otherwise stated, $p < 0.05$ value is statistically significantly accepted.

Results

The study continued with 32 patients who met the inclusion criteria and had successful block and 1 patient with a failed block. The average age of the

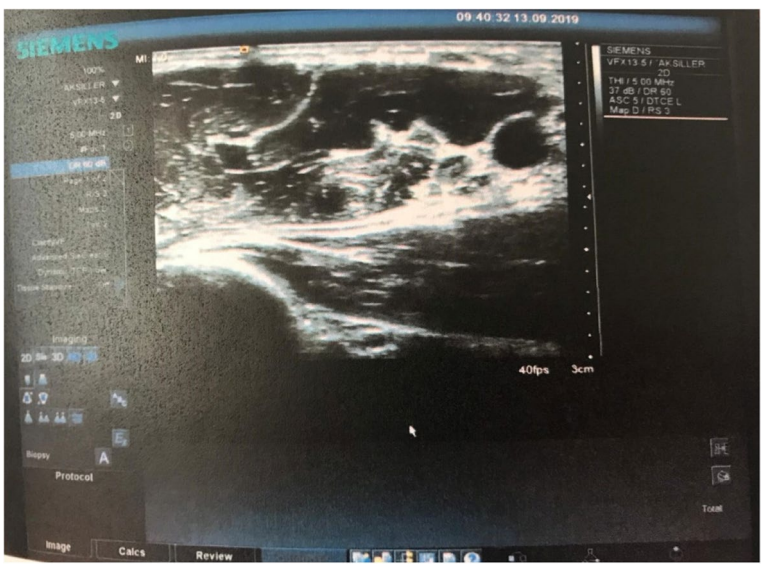

Fig. 2 Ultrasound image

Table 1 Demographic data of patients

	Mean ± SD/*n* (%)	Min–max
Age	38.0 ± 12.9	16–59
Gender		
Male	20 (60.6%)	
Female	13 (39.4%)	
Weight	75.2 ± 13.8	44–105
Size	169.6 ± 8.2	155–183
BMI	26.3 ± 5.4	15.2–43.7

Table 2 Differences in perfusion index between blocks with and without blocks

Perfusion index (PI)			
	Unblocked	**Blocked**	***p* value**
PI before block	3.7 ± 2.4	3.3 ± 2.1	0.608
5th min PI	3.7 ± 2.7	7.3 ± 3.6	< 0.001
10th min PI	3.6 ± 2.6	9.7 ± 3.4	< 0.001
20th min PI	3.6 ± 2.7	10.9 ± 3.0	< 0.001

patients was 38.0 ± 12.9/years; 20 (60.6%) were male, and 13 (39.4%) were female. Dermographic data are shown in Table 1.

While no difference was observed between the PI values measured in both arms before the block ($p > 0.05$), the PI at the 5.10 and 20th min in the post-block arm was statistically significantly higher than the non-block arm. In the arm without block, all time intervals were compared with each other, and no significant difference was observed. When the PI measurements were compared in the blocked arm, it has been shown that the 5th min measurements are significantly higher than the pre-block measurements, the 10th min measurements are significantly higher than the 5th min measurements, and the 20th min measurements are significantly higher than the 10th min measurements (Table 2).

In PI measurements on the arm with and without block applied, there was no significant difference between men and women. For the locked arm, although the PI measurements in women were lower in all time periods, this difference was not statistically significant ($p > 0.05$) (Table 3).

In the comparison of the applied block types, there was no statistically significant difference in PI measurements between the blocks. For the block applied arm, although PI was lower in the axillary type block in all time periods, this difference was not statistically significant ($p > 0.05$) (Table 4).

Table 3 Comparison of perfusion indices in the block applied arm and in the arm without block over time

	Blocked Mean ± SD	***p* value**	**Unblocked Mean ± SD**	***p* value**
PI before block	3.3 ± 2.1	**< 0.001**	3.7 ± 2.4	0.457
5th min PI	7.3 ± 3.6		3.7 ± 2.7	
5th min PI	7.3 ± 3.6	**< 0.001**	3.7 ± 2.7	0.364
10th min PI	9.7 ± 3.4		3.6 ± 2.6	
10th min PI	9.7 ± 3.4	**< 0.001**	3.6 ± 2.6	0.251
20th min PI	10.9 ± 3.0		3.6 ± 2.7	

Paired-sample *t* test

Table 4 Comparison of the perfusion index in the block applied arm with the block type

Perfusion index (PI)			
	Axillary block (*n*:25)	**Infraclavicular block (*n*:8)**	***p* value**
PI before block	3.2 ± 2.1	3.5 ± 2.0	0.550
5th min PI	6.7 ± 2.7	9.3 ± 5.3	0.150
10th min PI	9.6 ± 3.6	10.0 ± 3.0	0.352
20th min PI	10.7 ± 2.7	11.7 ± 3.7	0.374

Mann–Whitney *U* test

Discussion

In our study, we investigated whether PI measurement is a reliable, fast, and objective method to evaluate the adequacy of upper limb blocks.

Successful peripheral nerve blockage, depending on the blocking of sympathetic fibers, is observed as local vasodilation, increased local blood flow, some increase in skin temperature, and loss of sensation in the extremity (Galvin et al. 2006; Lima et al. 2009). In order to start the surgical operation, it is necessary to evaluate the adequacy of the block with these parameters. However, in a busy and cold operating room environment, evaluation of these clinical findings to confirm block adequacy before or during surgery is both time-consuming and non-objective (Clinical Applications of Perfusion Index n.d.).

We investigated the adequacy of fingertip PI measurement as a noninvasive, easy, and objective method that does not require patient cooperation, provides rapid evaluation, and is a noninvasive, easy, and objective method for evaluating the success of the block.

Although there are very few studies in the literature to evaluate the success of the block after block by measuring PI, the results of almost all studies are in line with each other. Bereketet al. in their study aimed to determine whether the regional hemodynamic changes measured by PI and ultrasound were reliable parameters in assessing the early success of the infraclavicular block; forty

patients (ASA I–III) who underwent successful infraclavicular block were evaluated (Bereket et al. 2019). In addition to basal hemodynamic measurements, regional hemodynamic parameters such as PI and brachial artery diameter, brachial artery area (BAA), blood flow (BF), end-diastolic velocity (EDV), resistance index (RI), peak systolic velocity (PSV), and time average speed (TAV) were measured. After the block operation is complete, all values are re-recorded at the 10th, 20th, and 30th min. Patients with successful block for the first 10 min were assigned to group A, and after 10 min, patients with successful block were assigned to group B. As a result, it was found that statistically significant differences were observed for all regional hemodynamic variables and PI after 10 min. Lee et al. (2019) retrospectively analyzed the data of 100 patients who received transforaminal block due to lumbosacral radicular pain in their study evaluating the relationship between perfusion index and analgesic efficacy in the transforaminal block in lumbosacral radicular pain. They observed a significantly higher PI change rate 5 min after the block in the successful group, as a result of the study they evaluated PI before, 5th, 15th, and 30th min after the procedure. In the study of the usefulness of PI in determining the effect of the brachial plexus block performed by Kuset al. (2013), the PI investigated whether it is a reliable and objective method in evaluating the adequacy of infraclavicular blockage. Average PI and average percentage change in PI was calculated from the beginning, 10, 20, and 30 min after the block was applied. The PI has risen continuously over the 30-min observation period. It was determined that the biggest changes in PI occurred 30 min after the block application, but significant changes in the PI occurred 10 min after the application. As a result, PI was detected as an indicator of infraclavicular block success.

In our study, we measured PI in both limbs with and without block in 33 patients with whom we performed brachial plexus block, before the 0th min and 5, 10, and 20 min after the block. In addition, we evaluated the arm we block, the sensory block level at 5, 10, and 20 min after the block with the "Pin-prick" test, and the motor block degree with the "Bromage" scale. Our block in 32 of 33 patients with whom we made block was successful, and PI measurements in the limb applied block increased continuously during the 20-min observation period. In the arm group where block is applied; the 5th min perfusion index measurements were significantly higher compared to pre-block measurements, the 10th min perfusion index measurements were significantly higher than the 5th min measurements, and the 20th min perfusion index measurements were significantly higher compared to 10th min measurements. In 1 patient who failed the block we did, there was no statistically significant increase in the measured PI, and LMA (laryngeal mask) was put into operation. In the arm group without block, there was no statistically significant difference in the perfusion index measurements at the 5th min, 10th min, and 20th min.

The small number of patients included in our study is a limitation of our study. Increasing the number of patients may increase the value of our findings. In the studies performed, no comparison was made between the different block types in PI measurements in patients undergoing blockage. In accordance with the operation to be performed in our study, we applied axillary to 25 patients and infraclavicular type to 8 patients, and we also examined whether there was a significant difference in the increases in PI measurements after block for these two types of blocks. For the block applied arm, although the PI measured in the axillary-type arm in all time frames was lower, this difference was not statistically significant.

Conclusions

There is a statistically significant increase in PI measurements for 20 min from the 5th min on the limb where we block and after the 5th min PI measurement; we saw that we can decide whether the block we have implemented is successful or not. As a result of these findings, we concluded that it is very valuable and useful in early, easy, and objective evaluation of the success of peripheral nerve blocks. However, more studies are needed on the subject.

Abbreviations

ASA	American Society of Anesthesiologist
PI	Perfusion index
AC	Pulsatile arterial flow
DC	Nonpulsatil (static) blood flow
SAB	Systolic arterial pressure
DAB	Diastolic arterial pressure
HR	Heart rate
SpO_2	Oxygen saturation

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Authors' contributions

AB, MD, MB, HN, OU: conception and design, data acquisition, manuscript drafting. AB, HN, MD, OU: data analysis and interpretation, statistical analysis. MD, OU: manuscript drafting and supervision. MD, OU: critical revision of the manuscript, supervision. All authors have read and approved the manuscript.

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Availability of data and materials

The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethics committee approval was received for this study from the Ethics Committee of Faculty of Medicine, AdiyamanUniversity, Ethics Review Committee (2019/2–17). Written informed consent was obtained from all patients participating in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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