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Original Article

Comparison of the effects of interscalene, supraclavicular and infraclavicular peripheral nerve blockades on perfusion index

Interskalen, supraklaviküler ve infraklaviküler periferik sinir blokajlarının perfüzyon indeksi üzerine etkilerinin karşılaştırılması

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ABSTRACT

Background: The perfusion index (PI) is a non-invasive method that measures the monitoring and success of peripheral nerve blocks in regional anesthesia. The perfusion index (PI) is an objective non-invasive method of measuring and monitoring the success of peripheral nerve blocks. We compare the effects of interscalene, supraclavicular and infraclavicular blocks on the perfusion index, with the aim being to contribute to the decision-making process regarding the type of block to be selected for surgeries in which increased perfusion is important.

Methods: Included in the study were 60 patients aged between 18 and 60 years with an ASA (American Society of Anesthesiologists) I-II risk rating who were scheduled for upper extremity surgery. An equal number of patients were applied supraclavicular, interscalene and infraclavicular blockades, and the PI was measured non-invasively using a pulse-oximetry probe on the fingers on the same and opposite side of blockade at the beginning, at the 10th, 20th and 30th minutes, postoperatively and in the post-anesthetic care unit (PACU).

Results: After a successful blockade of brachial plexus in all patients, a statistically significant increase in PI values was detected. Aside from the initial values, the mean rate of change in PI was significantly higher in the interscalene group than the supraclavicular and infraclavicular groups ($p < 0.001$).

Conclusion: PI can be used as a non-invasive monitoring method for the determination of the success of a brachial plexus blockade. Based on the results of the present study, an interscalene blockade may be preferred especially for surgeries in which an increase in tissue perfusion is desired due to its perfusion-enhancing properties when compared to supraclavicular and infraclavicular blocks.

Keywords: perfusion index, interscalene block, supraclavicular block, infraclavicular block

ÖZ

Amaç: Perfüzyon indeksi (PI), bölgesel anestezide uygulanan periferik sinir bloklarının monitörizasyonunu ve başarısını ölçen non-invaziv bir yöntemdir. Çalışmamızda interskalen, supraklavikular ve infraklavikular sinir bloklarının perfüzyon indeksi üzerindeki etkilerini karşılaştırdık. Amaç, artan perfüzyonun önemli olduğu ameliyatlar için seçilecek periferik bölgesel anestezi şekline karar alma sürecine katkıda bulunmaktır.

Metod: Çalışmaya 18-60 yaş arası 60 hasta ve üst ekstremite cerrahisi için ASA (Amerikan Anestezistler Derneği) skoru I veya II olan hastalar dahil edildi. Eşit sayıda hastaya supraklavikular, interskalen ve infraklavikular blokaj uygulandı. Başlangıçta, 10., 20. ve 30. Dakika ve anestezi sonrası bakım ünitesinde (PACU) PI değerleri non-invasif olarak ölçüldü.

Bulgular: Tüm hastalarda başarılı bir brakiyal pleksus blokajından sonra PI değerlerinde istatistiksel olarak anlamlı bir artış tespit edildi. İlk tespit edilen değerlere göre, PI'deki ortalama değişim oranı, interskalen grubunda, supraklavikular ve infraklavikular gruplara göre anlamlı derecede yüksekti ($p < 0{,}001$).

Sonuç: PI, brakiyal pleksus blokajının başarısının belirlenmesinde invazif olmayan standart bir izleme yöntemi olarak kullanılabilirliği gösterilmiştir. Bu çalışmanın sonuçlarına dayanarak, bir supraklavikular ve infraklavikular bloklara kıyasla perfüzyon arttırıcı özelliklerinden dolayı doku perfüzyonunda bir artışın istendiği ameliyatlar için inteskalen blokaj tercih edilebilir.

Anahtar kelimeler: perfüzyon indeksi, interskalen blok, supraklavikular blok, infraklavikular blok

INTRODUCTION

Ultrasound-guided peripheral nerve blocks are commonly used to provide anesthesia and analgesia in upper extremity surgeries and are performed as single injections or continuous blockades in procedures in which increased perfusion is desired (such as flap shifting and re-implantation procedures), especially in the postoperative period [1-3].

A successful peripheral nerve blockade leads to sympathetic, sensory and motor blocks, respectively. While the evaluation of a sensory and motor block depends on the patient's cooperation, a deep sympathetic block after a brachial plexus blockade may be evaluated from physiological changes that may occur, such as vasodilation, blood flow and skin temperature [4-6]. However, these methods are subjective, time-consuming and may be difficult due to sedation, and may vary depending on environmental conditions. In addition, grades of sympathetic blockade and perfusion in the blocked extremity cannot be evaluated using these subjective criteria.

The perfusion index (PI) is a numerical value defining the ratio between the pulsatile and non-pulsatile blood flow, and is automatically measured at the finger using a pulse oximeter, indicating an increase in peripheral perfusion [7,8]. A relative increase in pulsatile flow in the event of vasodilation leads to an increase in PI. PI is a non-invasive monitoring method that uses pulse oximetry waves to garner information about perfusion [9]. It has been reported that non-invasive measurements of PI have been effective in determining the success of brachial plexus blockades [10,11].

In this prospective study, we compare interscalene, supraclavicular and infraclavicular blocks in terms of their effects of PI, thus contributing to decision-making processes regarding the type of block to be selected for the surgeries in which an increase in perfusion is important.

MATERIAL AND METHODS

After the approval of the Local Ethics Committee, female and male patients aged between 18 and 60 years with an ASA I-II risk rating who were scheduled for upper extremity orthopedic surgery were included in the study. Patients in whom other anesthetic procedures were preferred, those with inadequate peripheral nerve blockade and those with signs of infection in the region of the blockade, with known coagulopathy, with findings of peripheral neuropathy, with peripheral vascular disease and with diabetes mellitus were excluded from the study.

Standard monitoring was carried out on the patients in the operating room. An intracath was inserted over the hand on the non-surgical side, a physiologic saline infusion was started at a rate of 100 ml.h^{-1}, and then midazolam 0.03 mg.kg^{-1} was administered intravenously for premedication. On the operational side, a local anesthetic (20 ml of 5%

Bupivacaine + 10 ml of 2% Lidocaine + 5 ml of physiologic saline) was injected for all types of nerve blockades witha 22-gauge stimulated needle (Unipex Nanoline TM pajunk, Geisingen, Germany) using an 8–14 MHz linear ultrasonic probe (EDGE® ultrasound machine, Sonosite Inc., Bothell, Washington, USA).

For the interscalene blockade, the brachial plexus was visualized between the anterior and middle interscalene muscle, and each half of the total local anesthetic volume was administered to the anterior and posterior of the plexus; for the supraclaviculary blockade, the brachial plexus was visualized on the lateral and superior of the supraclavicular artery in the supraclavicular fossa and for the infraclaviculary blockade, the cords of the plexus were visualized around the axillary artery by placing the probe perpendicular to the clavicle at the intersection of the clavicle and coracoid process. Local anesthetic was then injected to surround the axillary artery in a U-shape, and five minutes after the injection, it was confirmed by ultrasound that the local anesthetic material had completely surrounded the plexus.

PI was measured non-invasively using a pulse-oximetry probe (LNCS adult adhesive sensor connected to Masimo SET_ Radical- 7TM Pulse CO-Oximeter; Masimo Corp, Irvine, CA, USA) from the fingers on the same and opposite sides of blockade at the outset, at the 5th, 10th, 20th and 30th minutes, postoperatively and in the post-anesthesia care unit (PACU). The success of the block was also evaluated with a pin-prick test and a motor blockade test. Patients who required additional anesthesia as a result of a failed block were excluded from the study. The changes in PI values obtained from the successful supraclavicular, infraclavicular and interscalene blocks were recorded.

Statistical Analysis

Data was analyzed using the SPSS package program version 21.0 (IBM SPSS Inc., Chicago, IL). The threshold for statistical significance was accepted as $p<0.05$. Continuous data was presented as mean±standard deviation, while categorical data was presented as frequency and percentage in the descriptive statistics. For the categorical variables, the distribution of the groups was analyzed with a Pearson's Chi-square test, with normal distributions examined with a Kolmogorov-Smirnov test. For the normally distributed variables, the average of the groups was compared with the One-Way ANOVA. The distribution of the groups was compared with the Kruskal Wallis test for variables that did not meet the parametric assumptions. In case of statistical significance, the source of the difference was investigated with a Mann-Whitney U-test with a Bonferroni correction.

The rates of the change in the PI of patients who underwent supraclavicular, infraclavicular and interscalene blocks, the rate of change of the seven repetitive measurements (at the beginning, at the 5th, 10th, 20th and 30th minutes, postoperatively and in the PACU) over time (Within-Subjects Effects (Time)), and the difference between the supraclavicular, infraclavicular and interscalene groups (Between-Subjects Effects (Group)) were determined with a Mixed-type ANOVA. The homogeneity of variance was evaluated with a Levene's test, and a MANOVA was used, as the assumption of sphericity was not met. The result of the MANOVA was evaluated through a Pillai's Trace test. A simple effect analysis with a Bonferroni adjustment was used to find the source of the difference when the effect of interaction was found to be statistically significant. On the other hand, the sources of significant differences of the main effect of the group and time were determined by a Bonferroni adjustment post-hoc test when the effect of interaction was not statistically significant. Clinical significance for ANOVA was determined based on the partial-etasquare (η^2) and the values recommended by Cohen (1988) (0.0099 small, 0.0588 medium, and 0.1888 large effect).

RESULTS

Our study consisted of 60 patients. The mean age was 42.56±14.04 years, the average of body mass index (BMI) was 23.69±1.92, and 20 were female and 40 were male. A comparison of the patients and groups in terms of gender, age, body mass index (BMI), hemoglobin values and ASA scores revealed no statistically significant differences (**Table 1**). Surgical data of the patients and operation time are given in **Table 2**.

The difference between the mean change in the PI in patients who underwent supraclavicular, infraclavicular and interscalene blocks were statistically significant ($F = 14,589$, $p <0.001$, $\eta^2 = 0.623$, (**Table 3**). At the beginning, the mean change in PI among the three groups was found to be similar, while the mean change in PI in the interscalene group was significantly higher than the supraclavicular and infraclavicular groups at the other times. A comparison of the mean change in PI in binary, PI increased significantly from the beginning until the 20th minute after each of the three blocks. After the 20th minute, PI increased significantly in supraclavicular and interscalene blocks when compared to the initial values, while insignificantly when compared to the values at the 30th minute and in the PACU (**Figure 1**).

Table 1. Demographic data of the patients

		Supraclavicular (1)	Infraclavicular (2)	Interscalene (3)	Test Statistics and p value
Age		38,950±12,841	43,350±12,192	45,400±16,605	F=1,106* p=0,338
VKI		23,473±1,926	23,918±1,890	23,695±2,017	F=1,982 p=0,771
Hemoglobin		12,500±1,693	12,375±1,669	12,025±1,750	χ^2 =1,045** p=0,593
Gender	**Female**	n=7, 35.0%	n=7, 35.0%	n=6, 30.0%	χ^2 =0,150***
	Male	n=13, 65.0%	n=13, 65.0%	n=14, 70.0%	p=0,928
ASA risk group	**1**	n=12, 60.0%	n=12, 60.0%	n=13, 65.0%	χ^2 =0,141
	2	n=8, 40.0%	n=8, 40.0%	n=7, 35.0%	p=0,932

Table 2. Surgical data of the patients

		Supraclavicular (1)	Infraclavicular (2)	Interscalene (3)	Test Statistics and p value
Operational time		102,750±33,382	102,500±31,892	99,500±25,644	F=65,417 p=0,932
Reason for operation	**Debridement+VAK**	n=1, 5.0%	n=1, 5.0%	n=0, 0.0%	
	Arth. of wrist	n=0, 0.0%	n=2, 10.0%	n=0, 0.0%	
	Fr. of wrist	n=4, 20.0%	n=5, 25.0%	n=0, 0.0%	
	Fr. of humerus	n=4, 20.0%	n=4, 20.0%	n=5, 25.0%	
	Fr. of clavicula	n=0, 0.0%	n=0, 0.0%	n=4, 20.0%	
	Fr. of olecranon	n=4, 20.0%	n=0, 0.0%	n=2, 10.0%	
	Arth. of shoulder	n=0, 0.0%	n=0, 0.0%	n=9, 45%	
	Fr. of forearm	n=4, 20.0%	n=7, 35.0%	n=0, 0.0%	
	Laceration of tendon	n=3, 15.0%	n=1, 5.0%	n=0, 0.0%	

Arth: arthroscopy, **Fr:** fracture

Table 3. The difference between the groups in terms of mean change in the PI

(n=24)	Supraclavicular (A) Mean ± SS (n=8)	İnfraclavicular (B) Mean ± SS (n=8)	İnterscalene (C) Mean ± SS (n=8)	TOTAL	Main Effect: Time	Main Effect: Group	Interraction Effect
At the beginning (1)	0,030±0,086	0,020±0,136	0,000±0,107	0,003±0,111	V=0,990* F=879,48 9** p<0,001* ** η^2=0,990 ****	F=158,378 p<0,001 η^2=0,847	V=1,246 F=14,589 P<0,001 η^2=0,623
5^{th} min. (2)	0,515±0,175	0,325±0,125	1,055±0,296	0,631±0,374			
10^{th} min. (3)	1,395±0,182	1,170±0,205	4,300±1,470	2,288±1,669			
20^{th} min. (4)	2,755±0,348	2,040±0,353	5,730±1,560	3,508±1,860			
30^{th} min. (5)	4,475±0,845	2,945±0,287	6,980±1,039	4,800±1,848			
Posoperative (6)	4,260±0,536	3,710±0,261	6,965±0,940	4,978±1,567			
In the PACU (7)	4,610±0,558	3,985±0,281	6,690±0,938	5,095±1,330			
TOTAL	2,568±1,876	2,027±1,497	4,531±2,885				

Source of Difference for Interaction (Group x Time) for Time		Source of Difference for Interaction (Group x Time) for Group	
	Pairwise Comparison ***** (Time)	Pairwise Comparison (Group)	
Supraclavicular	5-6, 5-7 There is a difference	At the beginning	-
Infraclavicular	6-7 There is a difference	5^{th} min.	A-C, A-B, B-C
Interscalene	5-6, 5-7, 6-7 There is a difference	10^{th} min.	A-C, B-C
		20^{th} min.	A-C, B-C
		30^{th} min.	A-C, A-B, B-C
		Postoperative	A-C, A-B, B-C
		In the PACU	A-C, A-B, B-C

* Pillai's Trace test statistics value

** F test statistics value.

*** The mean difference is significant at the 0.05 level. (p<0.05)

**** Partial Eta-Square value.

***** Simple effects analysis with Bonferroni adjustment were used

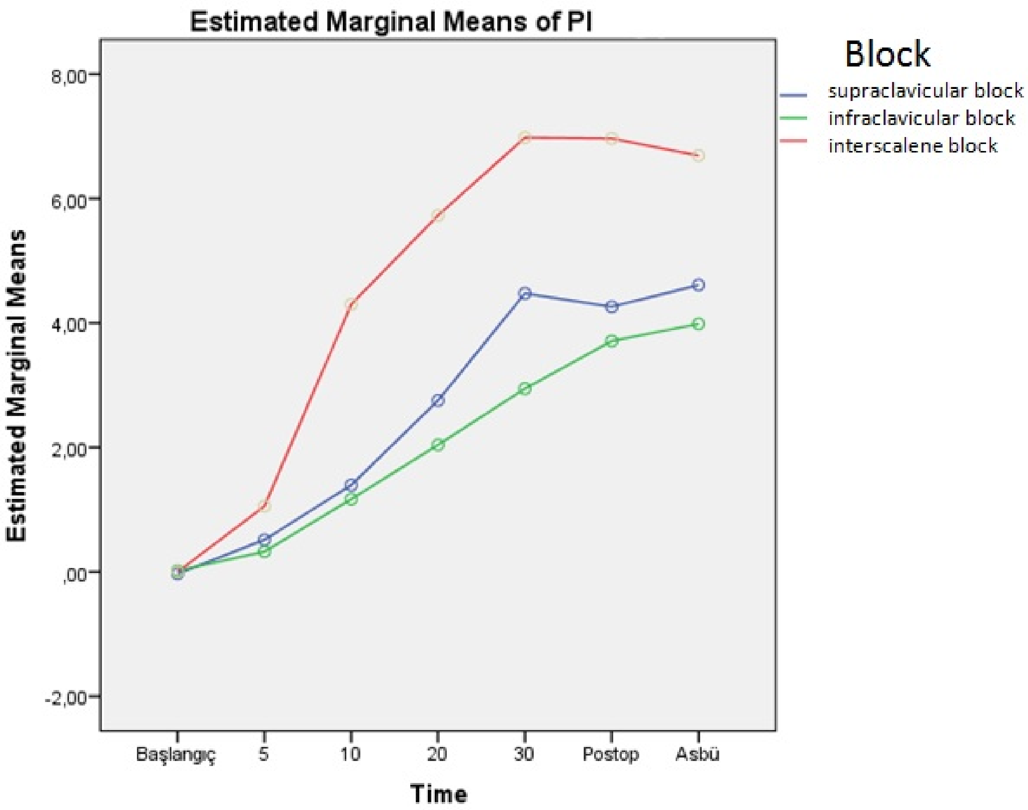

Figure 1. Changes of the effect of blocks on PI over time

After the interscalene block, the PI continued to increase significantly when compared to the initial values, including at the 30th minute. It was observed that the increase in the mean PI was greater in the interscalene group (**Table 3**). The clinical significance of the interaction effect with statistical significance indicates a high level of effect ($\eta^2 = 0.623 > 0.1377$), based on the limit values proposed by Cohen (0.0099 small, 0.0588 medium and 0.1641 large effect).

DISCUSSION

In the present study, a statistically significant increase was identified in the PI of the extremities in all patients after a brachial plexus blockade ($p < 0.001$), and the mean rate of change in PI was significantly higher in the interscalene group than in the supraclavicular and infraclavicular groups ($p < 0.001$). Previous studies in literature have identified PI as useful in determining the success rate of blocks, especially brachial plexus blockades [10-12]. Lima et al. [9] found PI to be a non-invasive indicator of perfusion.

That said, there has to date been no study in literature comparing the rate of change in PI depending on the type of blockade technique applied, and so it was the intention in the present study to determine the difference levels of change in PI after interscalene, supraclavicular and infraclavicular blockades. The ascent rate of PI within the groups was found to be significant in the first 20 minutes according to time. In patients provided with supraclavicular and interscalene blockades, the change in PI started in the first 5 minutes, and the ascent reduced after 20 minutes. However, the change in the PI after infraclavicular blockades started in the first 10 minutes and continued to increase until the 30th minute. These findings indicate that patients applied with supraclavicular or interscalene blockades may be ready for surgery 20 minutes after the blockade has been applied, while this may take 30 minutes after an infraclavicular blockade.

Kuş et al. compared the PI values of an infraclavicular plexus blockade with a non-blocked arm in patients undergoing orthopedic surgery, and reported that PI was an effective method in determining the success of a blockade within the first 10 minutes [11].

PI index was reported to change significantly at the fifth minute after a supraclavicular blockade in the study by A. Abdelnasser et al. [13], and after an interscalene blockade in the study by Hajime Yamazaki et al. [14]. In other studies, it has been reported that the PI index changed significantly at the 10th minute after an infraclavicular blockade [7,14,15].

Yamazaki et al. [14] evaluated the increase in the blood flow in microcirculation by using PI and laser Doppler after a stellate ganglion blockade in 22 patients, and reported that PI was effective in demonstrating the sympathetic blockade efficacy of the sympathetic ganglion blockade. Abdelnasser et al. [13] reported that PI may be useful in determining the success of a supraclavicular blockade in patients undergoing orthopedic surgery. Wenger A et al. [16] suggested that a brachial plexus blockade should be used especially where perfusion is important, in that the increase in skin perfusion remains for 6–12 hours after the brachial plexus blockade. In a study by Han-Hsiang Su et al. [2], a continuous brachial plexus blockade was found to be effective in maintaining the continuity of grafts after a microsurgical implantation. Similarly, in another study performed by Şahin et al. [17], a brachial plexus blockade was found to increase postoperative blood flow in patients who were operated on for an arteriovenous fistula.

We believe that an interscalene blockade should be preferred in surgeries if an increase in perfusion is desired, rather than the supraclavicular and infraclavicular blockades. That said, interscalene blockades come with some limitations, such as transient and potentially long-term respiratory complications, a high risk of phrenic nerve and unilateral diaphragmatic paralysis, the lack of ulnar nerve involvement and the risk of displacement of the catheter due to neck movements in patients undergoing a continuous peripheral nerve blockade [1]. A supraclavicular blockade may be preferred in these cases.

RECOMMENDATIONS

Based on the results obtained from the present study, PI can be proposed as an appropriate non-invasive monitoring method in the follow-up of perfusion in surgeries where increased perfusion is desired, and in determining the success of a brachial plexus blockade. It is further suggested that monitoring PI values by was of a brachial plexus catheter may be helpful in the postoperative long-term follow-up to determine perfusion levels in the extremity, and may contribute to drug dose titration studies. The studies suggested above can be performed in coordination with orthopedic clinic.

DECLARATION OF CONFLICT OF INTEREST

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