KLİNİK ÇALIŞMA / CLINICAL RESEARCH

VAN TIP DERGİSİ Medical Journal
Van Tıp Derg 27(1): 38-44, 2020
DOI: 10.5505/vtd.2020.15679

Evaluation of Ultrasound Guided Supraclavicular Block With Traditional Methods And Perfusion Index On Upper Extremity Surgeries

Üst Ekstremite Cerrahilerinde Ultrasonografi Eşliğinde Uygulanan Supraklavikular Bloğun Geleneksel Yöntemlerle ve Perfüzyon İndeksi ile Değerlendirilmesi

Onur Avcı*, Oğuz Gündoğdu

Cumhuriyet Üniversitesi Tıp Fakültesi Anesteziyoloji ve Reanimasyon Anabilim Dalı

ABSTRACT

Introduction: Ultrasound (USG) guided supraclavicular block in upper extremity surgery is a popular approach. In recent years, many studies have been published on the perfusion index (PI) in the evaluation of block success. The main objective of this study is to evaluate the success and efficiency of the supraclavicular block with traditional methods **(**Pin-prick test, Modified Bromage Scale) and perfusion index.

Materials and Methods: After the approval of the ethics committee (2018-11/01) was taken for the study; 30 volunteer patients who were 18-75 years old with American Society of Anesthesiologists (ASA) I-II scores undergoing a hand, forearm, arm surgery, were included in the study. In this prospective study; after ultrasound-guided supraclavicular block has been applied by injecting local anesthetic that consists of prilocaine 12.5 ml + bupivacaine 12.5 ml to all patients, sensory block was checked with pin-prick test every 3 minutes, motor block was checked by using modified Bromage scale every 2 minutes, hemodynamic parameters and PI values were recorded every 5 minutes. Times of motor block onset and total motor block onset, sensory and motor block ending time, the duration of block technique, the time of first postoperative analgesia consumption and positivity time for pin-prick test were recorded.

Results: When the measured perfusion index values were compared, the differences were significant. When we compared the PI values in pairs, the differences between basal and 5th min, 10th min, 15th min, 20th min, 25th min, and 30th min were significant. Positivity time for pin-prick test was 8.83 ± 2.70 min (minimum 5 minutes and maximum 15 minutes), motor block onset time was 6.7 ± 2.89 min (minimum 2 minutes and maximum 13 minutes), time of total motor block onset was 10.83 ± 3.07 min (minimum 6 minutes and maximum 19 minutes). In the 5th minute PI values, an average increase of 148% was observed compared to basal PI values.

Conclusion: As a result; the supraclavicular block provided faster sensory-motor block than other upper extremity blocks. It was concluded that the perfusion index was faster, more objective and simpler method than traditional methods in assessing the block success, due to vasodilatation that occurred before sensory and motor block.

Key Words: Brachial plexus block, supraclavicular block, perfusion index, prilocaine

ÖZET

Amaç: Üst ekstremite cerrahisinde ultrasonografi rehberliğinde supraklaviküler blok popüler bir yaklaşımdır. Blok başarısını değerlendirmede son dönemlerde perfüzyon indeksi (PI) ile ilgili birçok çalışma yapılmaktadır. Çalışmamızın amacı supraklaviküler blok başarısını ve yeterliliğini geleneksel yöntemlerle (Pin-prick testi, Modifiye Bromage Skalası) ve perfüzyon indeksi ile değerlendirmektir.

Gereç ve Yöntem: Çalışma için etik kurul onayı (2018-11/01) alındıktan sonra; el, ön kol, kol operasyonu uygulanacak, yaş aralığı 18-75 yıl olan, Amerikan Anestezistler Derneği (ASA) I-II olan 30 gönüllü hastanın yazılı onamı alındıktan sonra dâhil edilmiştir. Bu prospektif çalışmada tüm hastalara 12.5 ml prilokain + 12.5 ml bupivakain'den oluşan 25 ml'lik lokal anestezik ile ultrasonografi rehberliğinde supraklaviküler blok uygulandıktan sonra 3 dakikada bir pin-prick testi ile duyusal blok, 2 dakikada bir Bromage skalasına göre motor blok, 5 dakikada bir ise hemodinamik parametreler ve PI değerleri kaydedildi. Motor blok başlangıç zamanı, pin-prick testi (+) olma zamanı, tam motor blok oluşma zamanı, duyusal ve motor blok sonlanma zamanları, tekniğin uygulanma süresi, postop ilk analjezik uygulanma zamanı kaydedildi.

Bulgular: Pin-prick testi (+) olma zamanı 8.83 ± 2.70 dk (min: 5, max: 15), motor blok başlama zamanı 6.7 ± 2.89 dk (min: 2, max: 13), tam motor bloğun oluşma zamanı 10.83 ± 3.07 dk (min: 6 dk, max: 19 dk) olarak tespit edildi. Perfüzyon indeksi değerleri karşılaştırıldığında, farklılıklar anlamlı bulundu. Ölçümler ikişerli olarak karşılaştırıldığında, bazal ile 5. dk, 10. dk, 15. dk, 20. dk, 25. dk, 30. dk arası farklılıklar anlamlı bulundu. 5. dakika PI değerlerinde ise bazal PI değerlerine oranla ortalama %148'lik bir artış tespit edildi.

Sonuç: Çalışmamızın sonucunda; supraklaviküler blokta diğer üst ekstremite bloklarına göre daha hızlı duyu-motor blok sağlandı. Blok başarısını değerlendirmede, duyu ve motor bloktan önce gelişen vazodilatasyon nedeniyle perfüzyon indeksinin geleneksel yöntemlere göre daha hızlı, objektif ve basit bir yöntem olduğu sonucuna varıldı.

Anahtar Kelimeler: Brakial pleksus bloğu, supraklaviküler blok, perfüzyon indeksi, prilokain

*Sorumlu Yazar: Onur Avcı, Kardeşler Mah. Birlik Cad. Eğriköprü 2 Konakları No:85 A Blok D:20 Merkez/Sivas
E-mail: dronuravci@gmail.com, Tel: 0 (530) 112 64 08
Geliş Tarihi: 04.02.2019, **Kabul Tarihi:** 03.07.2019

Introduction

The most commonly used method of peripheral nerve block applications is the brachial plexus block which is often used in upper extremity surgeries, orthopedic manipulations, diagnosis of some diseases and in pain therapy (1). Ultrasound (USG) guided supraclavicular block in upper extremity surgery is a popular approach. Sensory, motor, sympathetic block and regional anesthesia of hand, forearm, and arm can be performed. The supraclavicular block appears to be advantageous in practice because of the more compact structure of the brachial plexus in this region and because it is superficial, but some anesthesiologists are hesitant to apply this block because it is proximal to the pleura. With the widespread use of USG, this expected risk has decreased, and the supraclavicular block has become an alternative to axillary and infraclavicular blocks in upper extremity surgery (2, 3).

The success of the peripheral nerve block is determined by the evaluation of sensory and motor functions. But these traditional methods (Pin-prick test and Modified Bromage Scale) are subjective, and they depend on patients' cooperation (4). Many objective methods have been developed to evaluate block success (5, 6, 7). These methods are generally aimed at assessing the sympathetic blockade's physiological effects, such as body temperature changes and vasodilatation.

Perfusion index (PI); is a ratio of pulsatile blood flow to non-pulsatile blood flow which is measured by a special pulse oximeter (8). In studies, PI values that are evaluated in the axillary block, sciatic block, infraclavicular block, and supraclavicular block applications have been found to be an effective method for evaluating block success (9, 10).

The aim of this study was to assess the success of US-guided supraclavicular block in patients undergoing upper extremity surgery with PI and traditional methods such as pin-prick test and motor movement evaluation.

Materials and Methods

Ethics committee approval was obtained for the study with the decision dated 27/11/2018 and numbered 2018-11/01. 30 voluntary orthopedics and traumatology patients with American Society of Anesthesiologists (ASA) scores of I-II, and ages of 18-75 years who were going to have a hand, wrist, forearm, elbow and arm surgery, were included in the study. The presence of any neurological sequelae in the limb to be blocked, infection in the region where skin puncture will be performed, presence of nerve blockage contraindications such as open wound, coagulopathy, having a history of allergy to one of the study drugs, the presence of contraindications to the brachial plexus block such as patients who cannot communicate during and after the procedure, phrenic nerve paralysis on the opposite side, severe chronic obstructive lung disease were determined as exclusion criteria. The patients were taken to the operation table, and their routine monitoring was performed including electrocardiography, noninvasive arterial blood pressure, and a pulse oximeter (SpO_2) (Drager Infinity Vista XL monitor). In addition to the basic hemodynamic measurements, pulse oximetry sensor (M-LNCS adult adhesive sensors Masimo SET® Radical ™ pulse oximeters; Masimo Corp., Irvine, CA USA) was installed to the second finger of the upper extremity that was going to be blocked to perform PI measurement. And this was connected to the Rad-87 ™ Pulse CO-Oximeter.

In the extremity of operation; sensory block was tested by using pin-prick test (with 27G blunt-tipped dental needle, the patient was questioned whether the pain was present in the related dermatomes in every 2 minutes. Assessment; 1 = pain, 2 = no pain), motor block was tested with Modified Bromage Scale (0 = No block, 1 = Motor power is reduced but arm is moving, 2 = Arm is still moving but fingers are moving, 3 = Full block, no movement in hand and arm). All results were recorded. When the modified Bromage Scale was evaluated as 1, motor block started to develop and this was recorded as the motor block onset time. When the result was 3, it was evaluated as the total motor block onset time.

After the basal values were recorded, the application of the method was started. Povidone-iodine was used to clean the area to be injected. EZono ™ 3000 portable ultrasound model (Germany) USG device with a 6-10 MHz linear probe was used for the block. The needle used for the blocks was an echogenic needle (Stimuplex, B. Braun, Melsungen AG) with an 80-mm, 22-G, electro-neurostimulation port. 25 mL of local anesthetic (LA) was used for injection in all patients. This LA mixture consisted of 12.5 ml of 0.5% bupivacaine (Bustesin® 0.5%) + 12.5 ml of 2% prilocaine (Priloc® 2%). After entry through the skin, the tip of the stimulation needle was placed in supraclavicular fossa at the superior of

midclavicular point in the coronal-oblique plane and the needle was guided to the brachial plexus, which appears superficial and compact on the lateral side of the subclavian artery using a real-time image-guided in-plane method with the USG probe. Firstly, the local anesthetic (LA) solution was applied inferior and then superior to brachial plexus, followed by a negative aspiration test (repeating this test after every 5 mL injection) and a total of 25 ml LA distribution was performed. The time between the needle entering and exiting the skin after the injection was recorded as the duration of block technique. All blocks were administered by the same anesthesiologist. All data were recorded by another anesthesiologist.

After the block operation was completed (removal of the needle from the skin is considered as 0^{th} min), SpO_2, mean arterial pressure (MAP), heart rate (HR) values were recorded every 5 minutes. Also, in the same time intervals, the measured PI value in the pulse oximeter (Masimo SET® Radical ™ pulse oximeters), Pin-prick test, the motor power which was measured with Modified Bromage Scale were measured and all these values were recorded. In the sensory examination 30 minutes after the injection, the absence of pain in all dermatomes was accepted as a successful block and the patient was delivered to the surgeon for the operation.

After the block operation, during the operation and up to 24 hours postoperatively, sensory and motor block ending time, complications associated with the block and the time of first analgesic need of the patient were questioned. The ending time of the sensory block was defined as the time when the patient described pain or when a positive response was taken to pin-prick test in all dermatomes in the operated extremity, and these periods were recorded in all patients. The ending time of the motor block was defined as the time when the finger movements were taken (when the modified Bromage Scale was evaluated as 2) in the extremities of the patient who underwent the operation and it was recorded in all patients. The time for the first analgesic need was defined as the time of administration of the first analgesic drug to the patient and it was recorded in all patients. From the time of application of the technique to the postoperative 24 hours, patients were observed for convulsion, systemic toxicity, vein puncture, pneumothorax, hematoma, phrenic nerve paralysis, laryngeal nerve paralysis, Horner syndrome and when any complications were detected, they were recorded.

Statistical Method: The data obtained from our study were uploaded to SPSS (22.0) program and the normality test of the variables was done with the Kolmogorov Smirnov Z test. In the variation of HR, MAP, SpO_2, PI variables according to time; ANOVA and Friedman tests were used for multiple comparisons and dependent sample t-test and Wilcoxon sign tests were used for binary comparisons. Spearman and Pearson correlation tests were used to examine the relationship between the variables.

Results

When demographic data is examined; 18 (60%) of the patients were male and 12 (40%) were female. Other demographic data of individuals are shown in Table 1.

The mean arterial pressure (MAP) values were significantly different ($p<0.05$) (Table 2). When the heart rate (HR) measurements were compared, the difference was significant ($p<0.05$) (Table 3). There was no significant difference in SpO_2 values ($p>0.05$).

When we compared the PI values in pairs; differences between basal and 5^{th} min, 10^{th} min, 15^{th} min, 20^{th} min, 25^{th} min, 30^{th} min; difference between 5^{th} min and 10^{th} min, 15^{th} min, 20^{th} min, 25^{th} min, 30^{th} min; 10^{th} min and 15^{th} min, 20^{th} min, 25^{th} min, 30^{th} min; the difference between 15^{th} min and the 20^{th} min, 25^{th} min, 30^{th} min; the differences between the 20^{th} min and the 25^{th} min, 30^{th} min and the difference between the 25^{th} and 30^{th} min were found to be significant ($p<0.05$) (Table 4).

The time of motor block onset was found as 6.7 ± 2.89 min (min: 2 minutes; max: 13 minutes) and the time of total motor block onset was 10.83 ± 3.07 min (min: 6 minutes; max: 19 minutes). Pin-prick test positivity time was 8.83 ± 2.70 min (min: 5 minutes; max: 15 minutes). The sensory block ending time was 8.51 ± 1.98 hours (min: 2 hours; max: 11.5 hours) and the motor block ending time was 7.46 ± 1.54 hours (min 3 hours; max 10.5 hours). The time of first analgesic need was found to be 8.78 ± 1.56 hours (min 6 hours; max 11.5 hours) (Table 5).

The duration of the blocking technique was 124 ± 86.28 seconds (minimum 10 seconds; maximum 360 seconds). Only one patient required additional anesthesia. At the 90^{th} minute of the operation, that patient described the pain. The patient did not require additional analgesia and anesthesia after sedation with midazolam. No complication

Table 1. Demographic data

	Mean±SD
Age (year)	43.67±15.57
Weight (kg)	81.03±14.45
Height (cm)	170.30±10.07

Table 2. Comparison of mean arterial pressure (MAP) values measured at different times

Time	Mean±SD	Result
Basal value	96.43a±16.15	p<0.001*
5th minute	96.6b±15.20	p<0.001*
10th minute	94.5c±14.62	p<0.001*
15th minute	93.5±12.93	p<0.001*
20th minute	93.3d±14.10	p<0.001*
25th minute	93e±14.30	p<0.001*
30th minute	91.83±13.03	p<0.001*

[a]p<0.05; When basal MAP values are compared to values of 15th, 20th, 25th and 30th minutes
[b]p<0.05; When MAP values at 5th minute are compared to values of 15th, 20th, 25th and 30th minutes
[c]p<0.05; When MAP values at the 10th minute are compared to values at the 30th minute
[d]p<0.05; When MAP values at the 20th minute are compared to values at the 30th minute
[e]p<0.05; When MAP values at the 25th minute are compared to values at the 30th minute

Table 3. Comparison of heart rate (HR) values measured at different times

Time	Mean±SD	Result
Basal value	82.7a±12.94	p<0.001*
5th minute	79.8±12.04	p<0.001*
10th minute	79.86±11.66	p<0.001*
15th minute	79.36±12.26	p<0.001*
20th minute	79.03±12.16	p<0.001*
25th minute	78.83±11.8	p<0.001*
30th minute	77±11.27	p<0.001*

was observed in any of the patients, no general anesthesia was performed, and no patient was excluded from the study.

Discussion

In patients undergoing regional anesthesia, sympathetic block develops initially, followed by sensory block and motor block. Peripheral vasodilatation occurs in the extremity of the sympathetic block and accordingly increases the perfusion in the same extremity. In a successful brachial plexus block, there is an effective vasodilatation due to sympathetic blockade (6). PI; informs the effectiveness of vasodilatation by measuring the ratio of pulsatile blood flow to non-pulsatile blood flow. It was also emphasized that hypovolemia can be predicted by PI without a reduction of stroke volume by more than 20% (11). The PI value increases in consequence of the increase in pulsatile blood flow due to vasodilatation. Therefore, in a successful block application, an increase in the perfusion index is expected due to increased peripheral perfusion.

The perfusion index was used as an early predictor of hypotension in the cesarean section with spinal anesthesia (12, 13), block success (14) and effective sympathectomy (15).

In our study; we used prilocaine and bupivacaine which are widely used in peripheral blocks in our clinic. It is important to choose the drugs that the team has experience to deal with their possible side effects. In addition, prilocaine use has become more reliable because we also monitored methemoglobin level with the pulse oximeter that we used for measuring the perfusion index. In patients with the blockade; rapid onset was achieved because of prilocaine preference.

Table 4. Comparison of perfusion index (PI) values measured at different times

Time	Mean±SD	Result
Basal value	2.36[a]±0,83	p<0.001*
5th minute	5.87[b]±1,17	p<0.001*
10th minute	6.42[c]±1,22	p<0.001*
15th minute	6.77[d]±1,22	p<0.001*
20th minute	7.11[e]±1,24	p<0.001*
25th minute	7.40[f]±1,28	p<0.001*
30th minute	7.93±1,29	p<0.001*

[a]p<0.05; When basal PI values are compared to values of 5th, 10th, 15th, 20th, 25th and 30th minutes
[b]p<0.05; When PI values at the 5th minute are compared to values of 10th, 15th, 20th, 25th and 30th minutes
[c]p<0.05; When PI values at the 10th minute are compared to values of 15th, 20th, 25th and 30th minutes
[d]p<0.05; When PI values at the 15th minute are compared to values of 20th, 25th and 30th minutes
[e]p<0.05; When PI values at the 20th minute are compared to values of 25th and 30th minutes
[f]p<0.05; When PI values at the 15th minute are compared to values of the 30th minute

Table 5. Evaluation of time measurements for supraclavicular block and first analgesic need

	Minimum	Maximum	Mean±SD
Motor block onset time (minute)	2	13	6.7±2.89
Total motor block onset time (minute)	6	19	10.83±3.07
Positivity time for Pin-prick test (minute)	5	15	8.83±2.70
Sensory block ending time (hour)	2	11.5	8.51±1.98
Motor block ending time (hour)	3	10.5	7.46±1.54
Duration of technique implementation (second)	10	360	124±86.28
Time of first analgesic need (hour)	6	11.5	8.78±1.56

Peripheric temperature measurement (7), electrical resistance on the skin (16), laser Doppler perfusion imaging (6) were used to evaluate block success. In the study of Galvin et al., they have compared the cold sensation test and pin-prick test in patients who underwent axillary block and they have found the cold sensory test to be more sensitive (7).

Candan et al (17) used 1 mg/kg 0.5% bupivacaine + 5mg/kg 2% prilocaine and 0.09 % NaCl to complete it to 45 ml in their study about infraclavicular block. The results of the study showed a 132% increase in perfusion index when the 5th minute PI value compared to baseline PI value. As a result, the PI in the infraclavicular block was defined as a sensitive test that predicts block success more quickly than traditional methods. In our study we have also found 148% increase in the ratio of PI values in 5th minute to basal PI values. We have used the same local anesthetics but in lower volumes. Because higher volumes of local anesthetics used in the supraclavicular block can cause Horner syndrome.

In other studies using PI, Galvin (18), in the study of 1.5% mepivacaine use, found 155% increase in PI at 10th minute of axillary block and at the 12th minute of the sciatic block; Kuş et al. (9) found an increase of 120% in PI at 10th minute of infraclavicular block using 20 ml of levobupivacaine + 10ml lidocaine. Yamazaki et al. found that an increase of 61.4% in PI in the 5th minute of stellate ganglion block with 6 ml 1% mepivacaine was sufficient for block success (19).

Abdelnasser et al. used 12.5 ml of bupivacaine + 12.5 ml lidocaine in the supraclavicular block and they found an average increase of 151% in the perfusion index at the 10th minute compared to the basal PI (10). In our study; we found an average increase of 148% in the 5th-minute perfusion index values compared to the basal PI. Abdelnasser and his friends reached these values at the 10th minute while we reached them at the 5th-minute because we preferred a local anesthetic with rapid onset (prilocaine). In addition, in the study of Abdelnasser, perfusion index was evaluated at 0th, 10th, 20th and 30th minute, while in our study PI measurements were recorded at 5-minute intervals. In the same study, Abdelnasser defined PI 10.min/PI basal ratio as PI ratio and

found that the block would be successful when PI ratio> 1.4.

Bahar et al also compare levobupivacaine and bupivacaine in their research that consists of 50 patients with the supraclavicular block by using a blind technique (20). In that study researchers divided the fifty patients into two groups: twenty-five patients in group L received 20 ml of levobupivacaine (0.5%; 5 mg/ml) and 20 ml isotonic saline to complete it to 40 ml and twenty-five patients in group B received 20 ml of bupivacaine (0.5%; 5 mg/ml) and 20 ml of isotonic solution to complete it to 40 ml. They used the pin-prick test to evaluate sensory block and motor Bromage scale to detect the motor block. They have found that group B has earlier sensory and motor block onset than group L. Also, Horner syndrome in 4 patients (2 patients in group L and 2 patients in group B) and insufficient block in 5 patients (2 patients in group B and 3 patients in group L) have been described in that study. Probably, Horner syndrome was due to higher drug volume. Horner syndrome can be seen in the supraclavicular block but this complication can be decreased by using ultrasound and a lower volume of local anesthetic. In our study, Horner syndrome was not seen. Also, our sensory block onset time is earlier and motor block onset time is similar in Bahar et al's study.

There are some limitations to our study. A study of 30 patients may not be enough to determine the specificity and the sensitivity of a test. In addition, the lack of an unsuccessful block in our study was another condition that limits the study. This is also due to the limited number of cases.

As a result of our study; supraclavicular block provided faster sensory-motor block than other upper extremity blocks. It was concluded that the perfusion index is a faster, more objective and simpler method compared to traditional methods (pin-prick test, motor movement evaluation) due to vasodilatation occurring before sensory and motor block.

References

1. Acar S, Gürkan Y, Solak M, Toker K. Coracoid versus lateral sagittal infraclavicular block. Acta Orthop Traumatol Turc 2013; 47(1): 32-7
2. Perlas A, Lobo G, Lo N, Brull R, Chan VW, Karkhanis R. Ultrasound-guided supraclavicular block: outcome of 510 consecutive cases. Reg Anesth Pain Med 2009; 34(2): 171-6.
3. Soares LG, Brull R, Lai J, Chan VW. Eight ball, corner pocket: the optimal needle position for ultrasound-guided supraclavicular block. Reg Anesth Pain Med 2007; 32(1): 94-5.
4. Curatolo M, Petersen-Felix S, Arendt-Nielsen L. Sensory assessment of regional analgesia in humans: a review of methods and applications. Anesthesiology 2000; 93: 1517–30.
5. Smith GB, Wilson GR, Curry CH, et al. Predicting successful brachial plexus block using changes in skin electrical resistance. Br J Anaesth 1988; 60: 703–8.
6. Sørensen J, Bengtsson M, Malmqvist EL-A° , Nilsson G, Sjo¨ berg F. Laser Doppler perfusion imager (LDPI) - for the assessment of skin blood flow changes following sympathetic blocks. Acta Anaesthesiol Scand 1996; 40: 1145–8.
7. Galvin EM, Niehof S, Medina HJ, et al. Thermographic temperature measurement compared with pinprick and cold sensation in predicting the effectiveness of regional blocks. Anesth Analg 2006; 102: 598–604.
8. Goldman JM, Petterson MT, Kopotic RJ, Barker SJ. Masimo signal extraction pulse oximetry. J Clin Monit Comput 2000; 16: 475–83.
9. Kus A, Gurkan Y, Gormus SK, Solak M, Toker K. Usefulness of perfusion index to detect the effect of brachial plexus block. J Clin Monit Comput 2013; 27(3): 325-8.
10. A. Abdelnasser, B. Abdelhamid, A. Elsonbaty, A. Hasanin, A. Rady Predicting successful supraclavicular brachial plexus block using pulse oximeter perfusion index British Journal of Anaesthesia 2017; 119 (2): 276–80.
11. Lima AP, Beelen P, Bakker J. Use of a peripheral perfusion index derived from the pulse oximetry signal as a noninvasive indicator of perfusion. Crit Care Med 2002; 30(6): 1210-3.
12. Toyama S, Kakumoto M, Morioka M, Matsuoka K, Omatsu H, Tagaito Y, et al. Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anaesthesia for Caesarean delivery. Br J Anaesth. 2013; 111(2): 235–41.
13. Xu Z, Xu T, Zhao P, Ma R, Zhang M, Zheng J. Differential Roles of the Right and Left Toe Perfusion Index in Predicting the Incidence of Postspinal Hypotension During Cesarean Delivery. Anesth Analg. 2017; 125(5): 1560–6.
14. Yamazaki H, Nishiyama J, Suzuki T. Use of perfusion index from pulse oximetry to determine efficacy of stellate ganglion block. Local Reg Anesth 2012; 5: 9–14.
15. Jeng EI, Gravenstein N, Klodell CT. Perfusion Index: An Indicator of Success During Endoscopic Thoracic Sympathectomy for Hyperhidrosis. Ann Thorac Surg. 2017; 104(2): 426–30.
16. Smith GB, Wilson GR, Curry CH, et al. Predicting successful brachial plexus block using hanges in skin electrical resistance. Br J Anaesth 1988; 60: 703–8.

17. Candan BF, Özdemir Kol İ, Avcı O, İsbir AC, Kaygusuz K, Gursoy S. Turkiye Klinikleri J Cardiovasc Sci 2018; 30(3): 126-33.
18. Galvin EM, Niehof S, Verbrugge SJ, Maissan I, Jahn A, Klein J, et al. Peripheral flow index is a reliable and early indicator of regional block success. Anesth Analg 2006; 103(1): 239-43.
19. Yamazaki H, Nishiyama J, Suzuki T. Use of perfusion index from pulse oximetry to determine efficacy of stellate ganglion block. Local Reg Anesth 2012; 5: 9-14.
20. Bahar İ, Demirkıran H, Karaman H. Retrospective Investigation of Upper Extremity Blocks Performed with Supraclavicular Approach. Dicle Medical Journal 2018; 45 (2) : 179-185.