IJCMBS

THE INTERNATIONAL JOURNAL OF CURRENT MEDICAL AND BIOLOGICAL SCIENCES e-ISSN: 2791-8815

Orgınal Article

Tissue Oxygenation Change on Upper Extremities After Ultrasound-Guided Axillary Brachial Plexus Blockade; Prospective Observational Study

Ultrason Kılavuzluğunda Aksiller Brakial Pleksus Blokajı Sonrası Üst Ekstremitelerde Doku Oksijenasyonu Değişimi; Prospektif Gözlemsel Çalışma

Maruf Sürücü[1*], Mahmut Alp Karahan[1], Şaban Yalçın[2], Nuray Altay[3], Evren Büyükfırat[3], Aytekin Yeşilay[3]

[1]Department of Anesthesiology and Reanimation, University of Health Science, Mehmet Akif İnan Training and Search Hospital, Şanliurfa, Turkiye,

[2]Kayseri Training and Research Hospital, Intensive Care, Kayseri, Turkiye

[3]Department of Anaesthesiology and Reanimation, Harran University, Faculty of Medicine, Sanliurfa, Turkiye

**Corresponding author:*

Dr. Maruf Sürücü , MD

Adress:University of Health Science Turkey, Mehmet Akif İnan Training and Search Hospital Haliliye, 63000, Sanliurfa , Turkiye.

E-mail:msurucu1986@gmail.com

Received:12/07/2023

Accepted:12/09/2023

Cite as:SURUCU. M. and et al. Tissue Oxygenation Change on Upper Extremities After Ultrasound-Guided Axillary Brachial Plexus Blockade; Prospective Observational Study. IJCMBS 2023;3(3):156-61 doi.org/10.5281/zenodo.10047189

Highlights

•The Tissue oxygen saturation increases after peripheral plexus blockade and may be used as an indicator for successful block placement in awake patient.

• Tissue oxygen saturation monitoring may provide a highly valuable tool to quickly evaluate the success of regional anesthesia of the upper extremity in clinical practice.

Abstract

Background: The aim of the study was to investigate whether tissue oxygen saturation (St02) using the Near Infrared Spectroscopy method (NIRS), is a reliable and objective method for assessing the adequacy of axillary blockade and to describe the time course of StO2 changes.

Materials and Methods

The study was approved by the Ethical Committee and met the Declaration of Helsinki criteria. In this prospective observational study, St02 was measured in 30 patients scheduled for elective hand surgery under axillary nevre block. Non-invasive StO2 -monitoring (InSpectra™ StO2, Hutchinson Technology Inc., Hutchinson, Minnesota, USA) was used in patients before ultrasound guided axillary brachial plexus blockade and during the first 30 minute of the blockade.

Results

StO2 measurements were statistically increased in 1st ,5th, 10th, 15th, 20th, 25th, 30th minutes compared to baseline levels ($p< 0.05$ for all comparisons). Mean StO2 levels of the hand with axillary brachial plexus blockade were statistically increased compared the levels of the hand StO2 without blockade in 15th, 20th, 25th, 30th. minutes ($p< 0.05$ for all comparisons).

Conclusion

There has been found a significant correlation between tissue StO2 values of two limbs using NIRS in axillary blockage operations of upper extremity.

Keywords: Brachial plexus, Axillary block, Near Infrared Spectroscopy, Tissue oxygenation, Regional anesthesia

ÖZ

Amaç: Near-infrared Spektroskopi (NIRS) yöntemi kullanılarak doku oksijen satürasyonunun (St02), aksiller blokajın yeterliliğini değerlendirmede güvenilir ve objektif bir yöntem olup olmadığını ve StO2 nin zaman içindeki değişikliklerinin tespit etmektir. **Gereç ve Yöntem** Harran Üniversitesi Araştırma ve Uygulama Hastanesi Etik Kurul ve hastaların onayı alındıktan sonra aksiler bolk uygulanan elektif el cerrahisi planlanan 30 hastada St02 ölçüldü. Non-invaziv StO2 takibi (InSpectra™ StO2, Hutchinson TechnologyInc., Hutchinson, Minnesota, ABD), hastalarda ultrason kılavuzluğunda aksiller brakiyal pleksus blokajı öncesinde ve blokajın ilk 30 dakikasında kullanıldı.

Bulgular: StO2 ölçümleri 1.,5., 10., 15.,20.,25.,30. dakikalarda başlangıca göre istatistiksel olarak arttı (tüm karşılaştırmalar için $p< 0.05$). Aksiller brakiyal pleksus blokajı yapılan elin ortalama StO2 seviyeleri blokaj yapılmayan elin StO2 seviyelerine göre 15.,20., 25., 30. dakikalarda istatistiksel olarak yüksek bulundu. (tüm karşılaştırmalar için $p< 0.05$). **Sonuç:**Üst ekstremite operasyonlarında uygulanan aksiller blokajda NIRS kullanılarak iki ekstremite StO2 değerleri arasında anlamlı bir ilişki bulunmuştur.

Anahtar Kelimeler: Brakiyal pleksus, Aksiller blok, Near İnfrared Spekstroskopisi, Doku oksijenizasyonu, Rejyonal anestezi

Introduction

A peripheral nerve block is one of the blocks commonly used in regional anesthesia. In cases where general anesthesia poses risks, such as in heart, kidney, respiratory system diseases, chest trauma, and diabetic patients, peripheral nerve blocks provide more advantageous conditions (1). The brachial plexus block, which is one of the most frequently used peripheral nerve blocks, can be used in surgical procedures and pain management involving the upper extremities. The block is limited to the region innervated by the plexus or its terminal branches, while the rest of the body remains under physiological control (2). Axillary block is a technique in which the brachial plexus is blocked in the axillary area. The brachial plexus nerves, along with the axillary artery, are located in an easily accessible position in the axilla. Due to its anatomical structure, it is more reliable and easily accessible, which makes it more easily accepted by the patient. Axillary brachial plexus block has fewer side effects, is easy to perform with ultrasound, and has a high success rate (3).

The measurement of the success of peripheral nerve blocks is a subject of discussion and generally relies on patient-based traditional methods. However, multi-purpose techniques have been discussed in recent literature for the success of peripheral nerve blocks. These techniques include perfusion index (PI), plethysmographic variability index (PVI), non-invasive tissue hemoglobin monitoring (SpHb), tissue oxygen saturation (StO2), tissue hemoglobin index (THI), and body temperature (4-8).

Near-Infrared Spectroscopy (NIRS) is a technique that non-invasively measures the oxygenation of biological tissues such as muscle tissue, providing relatively low-cost information. It works based on the principle that near-infrared light at different wavelengths (680–800 nm) is absorbed to varying degrees by oxygenated and deoxygenated hemoglobin molecules in the measured area, and the ratio of oxygenated hemoglobin to total hemoglobin is expressed as a percentage. It provides local oxygen saturation during measurement. It is analyzed to determine the ratio of oxygenated hemoglobin to total hemoglobin and expressed as a percentage, known as StO2 (6).

We defined our hypothesis as the local effects generated by successful upper extremity peripheral nerve blocks leading to detectable increases in tissue oxygen saturation levels measured by the NIRS method. In line with our hypothesis, we aimed to determine whether the changes observed with axillary block using the NIRS method affect microcirculation and tissue oxygen saturation and also investigate whether NIRS is a reliable and objective method for assessing the adequacy of peripheral nerve blocks.

Material and Method

A total of 30 patients between the ages of 18 and 65, classified as ASA (American Society of Anesthesiologists) I-II, who were scheduled for hand, forearm, and arm surgery, were included in our hospital's study. Patients who did not want to participate in the study, those for whom axillary block was contraindicated, those who were unable to cooperate, those with renal or liver failure, pregnant and lactating women, anemic patients and patients classified as ASA III-IV-V were excluded from the study. Anesthetic procedures were performed by the same anesthesiologist. Starting at midnight before the operation, all patients were instructed to refrain from oral intake, and a balanced electrolyte solution (Isolyte®) was initiated at a rate of 2 ml/kg/hour. Sedation was not administered to the patients on the morning of the surgery. Prior to the procedure, an 18-20 G intravenous catheter was inserted into the dorsum of the hand or antecubital region of each patient, and volume replacement was performed with 10 ml/kg of 0.9% isotonic NaCl solution. Standard monitoring (ECG, SpO2, and non-invasive arterial blood pressure) was performed. Baseline systolic arterial blood pressure (SAB) and heart rate (HR) were recorded. NIRS probes were placed on the palm (thenar region) of both the upper extremity to be blocked and the other extremity (thenar region), and baseline StO2 was recorded. The arm was positioned in 90 degrees of abduction for the axillary region and in a position creating a 90-degree angle with the arm for the forearm. After necessary sterilization procedures were performed in the axillary region and the block site was covered with sterile drapes, axillary artery palpation was performed. Using a portable ultrasound device (MyLab™Sat portable ultrasound, Italy) with a frequency range of 2–18 MHz (MyLab™Sat Linear Probe, Italy), a 4 cm linear ultrasound probe was placed above and below the palpated area in contact with a neurostimulator (StimuplexDig®, B. Braun, Germany) attached to a 22G 50 mm electrically insulated needle (Stimuplex®, B. Braun, Germany). The in-plane technique was used to inject equal volumes (10 ml) of the prepared solution around each nerve after providing a motor response of 0.2-0.5 mA electrical stimulation to the terminal branches of the brachial plexus (median, ulnar, radial, and musculocutaneous) and observing sufficient muscle contraction following the aspiration test. For the block, a total of 40 ml of local anesthetic (LA) solution was prepared, consisting of 24 ml of 0.5% bupivacaine and 16 ml of 0.9% saline solution. All patients received a total of 40 ml (24 ml of bupivacaine and 16 ml of 0.9% saline) from the prepared solution.

After the completion of the axillary block, sensory and motor blocks were evaluated every 5 minutes within the first 30 minutes. Additionally, SpO2, heart rate, non-invasive arterial blood pressure, and StO2 were recorded every 5 minutes. The block onset time was considered to be 30 minutes. At the 30-minute mark, sensory block level was evaluated using the pinprick test, and motor block degree was assessed using the Bromage scale. Subsequently, patients were allowed to proceed with their surgical procedures.

Statistical Analysis

The numerical data obtained in the study were expressed as mean ± standard deviation, while categorical data were presented as percentages and frequencies. SPSS Version 24 software was used for statistical analysis. Compliance of numerical data to normal distribution was tested with Shapiro–Wilk test. Furthermore, the Wilcoxon test was used to compare the non-normally distributed variables between the block group and the control group, while the Freidman test was used to compare the measurements obtained at different times (intragroup comparison).The data were presented in tables as mean and standard deviation, with a significance level of 0.05.

Results

A total of 30 individuals were included in the study, of whom 19 (63.33%) were female and 11 (36.66%) were male (Table 1). Meanagewas 42.5 ± 11.53 years. In all patients, it was determined that the performed nerve block was effective for intraoperative anesthesia or postoperative analgesia, and no patient suffered from pain after surgery.

Table-1. Demographic Data of Our Study

Varaibles	n: 30
Age (year), mean	42.5(14.04)
Gender	
Male (%)	11 (36.7)
Female (%)	19 (63.3)
ASA	
I (%)	12 (40)
II (%)	18 (60)
Additional disease	
No (%)	12 (40)
Yes n(%)	18 (60)

A significant decrease was found in heart rate measured at different time points compared to the baseline **(Figure 1).** When comparing systolic blood pressure measured at different time points, significant decreases were observed at 1 minute (p = 0.027), 5 minutes (p=0.012), 10 minutes (p=0.011), and 15 minutes (p= 0.05) compared to the baseline measurements, while there was no significant difference between the other time points [20 minutes (p= 0.229), 25 minutes (p= 0.333), and 30 minutes (p= 0.259)]. When comparing diastolic blood pressure measured at different time points, significant decreases were found at 1 minute (p=0.004), 5 minutes (p= 0.003), and 10 minutes (p=0.009) compared to the baseline measurements, while there was no significant difference between the other time points [15 minutes (p=0.136), 20 minutes (p=0.084), 25 minutes (p=0.421), and 30 minutes (p=0.118)] in diastolic blood pressure measurements.

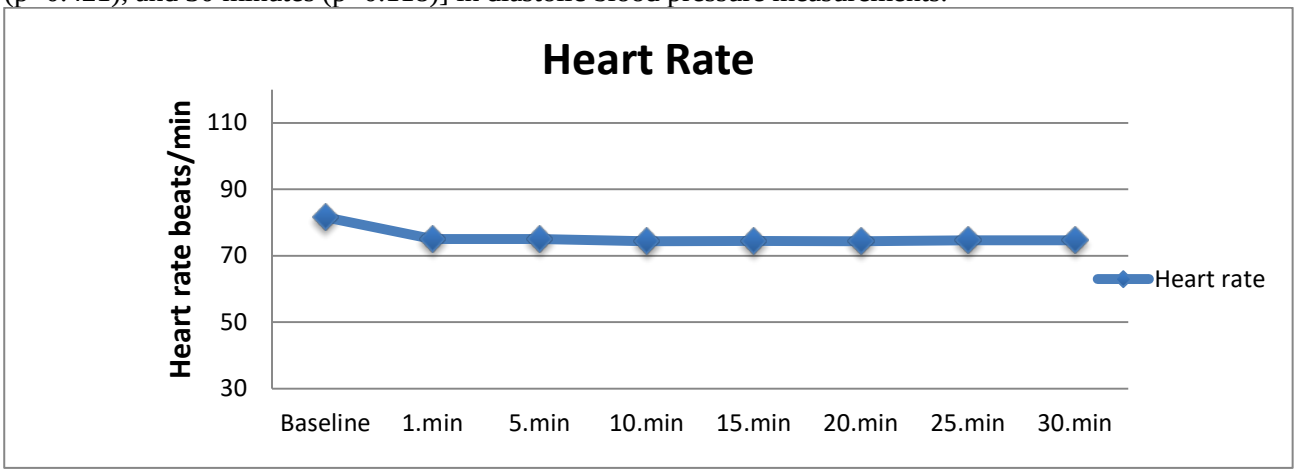
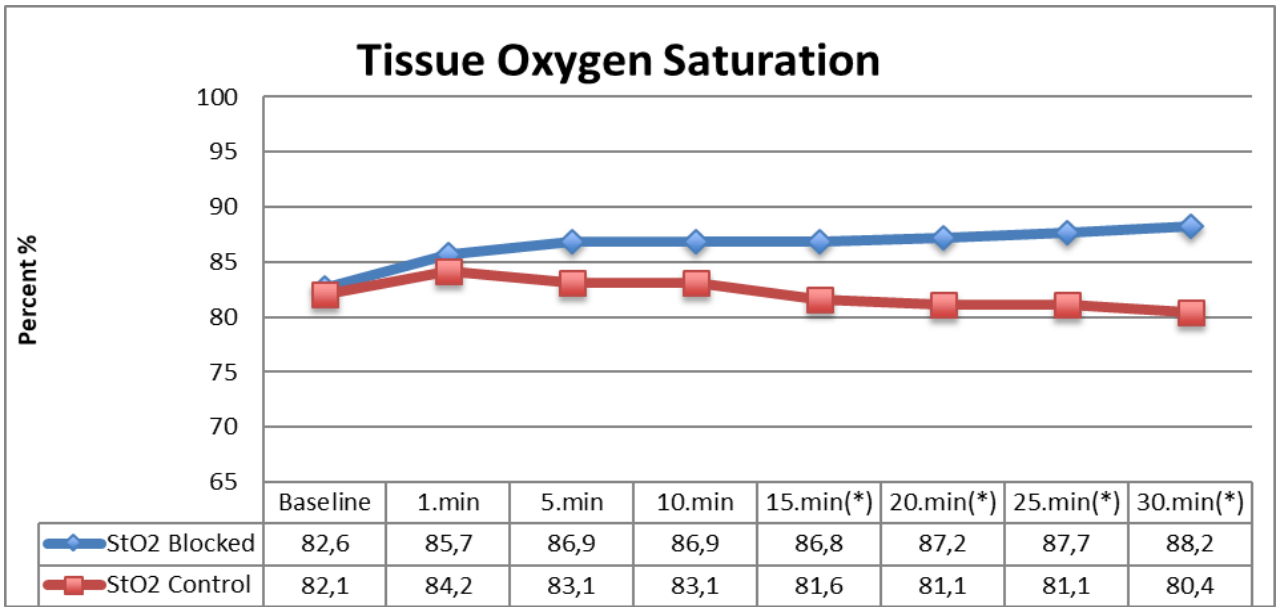


Figure 1: Average Values of Peak Heart Rate

When comparing the StO2 levels measured at different time points (1 minute, 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, and 30 minutes) on the side where axillary block was not performed, no significant difference was found compared to the baseline values (p=0.151, p=0.171, p= 0.42, p= 0.151, p= 0.511, p= 0.215, p= 0.093).
When comparing the StO2 levels measured at different time points (1 minute, 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, and 30 minutes) on the side where axillary block was performed, significant differences were found at 15 minutes (p=0.005), 20 minutes (p=0.003), 25 minutes (p=0.001), and 30 minutes (p= 0.001) compared to the baseline values and compared to the contralateral non-blocked side. The StO2 values measured at those time points were significantly higher. Statistically, the mean StO2 values on the blocked side were significantly higher than the contralateral side at 15 minutes, 20 minutes, 25 minutes, and 30 minutes ($p < 0.05$) .

Changes in Tissue Oxygenation After Peripheral Nerve Block

Statistically, the mean StO2 values were significantly higher on the blocked side compared to the contralateral side at 15 minutes, 20 minutes, 25 minutes, and 30 minutes ($p < 0.05$). The mean StO2 value on the blocked side was 85.7 at 1 minute, while it was 84.2 on the other arm. At 30 minutes, the mean StO2 value on the blocked side increased to 88.2, whereas it was 80.4 on the other arm **(Figure 2).** No complications or adverse effects were observed in our study.



	Baseline	1.min	5.min	10.min	15.min(*)	20.min(*)	25.min(*)	30.min(*)
StO2 Blocked	82,6	85,7	86,9	86,9	86,8	87,2	87,7	88,2
StO2 Control	82,1	84,2	83,1	83,1	81,6	81,1	81,1	80,4

(*): The mean StO2 values were significantly higher on the blocked side at the indicated minutes ($p < 0.05$).

Figure 2: StO2 Values in Blocked and Non-Blocked Arms

Discussion

The aim of our study was to evaluate the effects of changes induced by axillary block on microcirculation and tissue oxygen saturation using the NIRS method and to measure the success of the block. In our study, in the extremity where the axillary block was performed, the tissue oxygen saturation value measured at 15,20,25 and 30.minutes was found to be significantly higher compared to the baseline and the non-blocked extremity.
Regional anesthesia is a commonly preferred anesthesia technique in upper extremity surgery due to its many advantages. These advantages, such as minimal analgesic and antiemetic consumption, shorter recovery room and hospital stays, facilitated pain control transition, increased blood flow in the extremity, theoretically lower frequency of reflex sympathetic dystrophy, less urinary retention, and no need for tracheal intubation (9).
The fundamental requirement for a successful block in regional anesthesia is the proper application of the LA around the nerve tissue. (10, 11).Successful peripheral nerve blockade results in local vasodilation, increased local blood flow, and some increase in skin temperature due to sympathetic fiber blocking.Since it can be used to evaluate arterial vasodilation caused by sympathetic blockade after peripheral nerve block, as well as to measure the increase in blood, this method may be the primary method of choice to evaluate flow rate and block efficiency. At this point, numerical values such as StO2, PI, and PVI become important for objectively measuring block success. Assessing block success in a more objective manner prevents unnecessary opioid

administration and unnecessary general anesthesia. This will ensure that surgical durations do not unnecessarily extend and that additional costs are not incurred. NIRS reflects changes in vasomotor tone that vary between patients; therefore, block adequacy can only be assessed by determining the NIRS rate of increase from baseline (12).

There are not many studies in the literature regarding the use of NIRS in the field of regional anesthesia. Okano et al. (13) investigated the effects of NIRS on the success of stellate ganglion block. They concluded that NIRS had successfully confirmed the stellate ganglion block.

Tsai et al. performed brachial plexus blocks (interscalene, supraclavicular, infraclavicular, and axillary) in 15 patients undergoing elective upper extremity orthopedic surgery and examined regional oxygen saturations in both extremities (operated extremity and healthy extremity). Although there was no difference at baseline, approximately 15% increases in oxygen saturation were observed in the blocked extremity starting in the 5th minute, and these increases were considered statistically significant (14).

Tighe et al. conducted a similar study to Tsai et al. They performed peripheral nerve blocks (cervical paravertebral nerve block, femoral nerve block, infraclavicular nerve block, and sciatic nerve block) in 40 elective patients undergoing surgery on the extremity and attempted to measure their effectiveness and differences compared to the other extremity using the NIRS method at 5-minute intervals. The initial StO2 values were found to be high in both extremities, and as the block became effective, the values started to increase (15).

Tsai et al. applied interscalene, supraclavicular, infraclavicular, and axillary block techniques for brachial plexus blocks (14). The LA they used and the dosage administered showed similarities to our study. Tighe et al., on the other hand, performed upper and lower extremity plexus blocks (cervical paravertebral nerve block, femoral nerve block, infraclavicular nerve block, sciatic nerve block) (15). Multiple LA were used in different doses. In our study, we applied a single type of block compared to the two studies conducted on the effectiveness of peripheral nerve blocks. Our results show similarities to those of Tsai et al.

Karahan et al. conducted a prospective observational study in which StO2 measurements were performed in 40 patients scheduled for elective hand surgery under infraclavicular block. StO2 measurements were taken before and during the first 30 minutes of the infraclavicular brachial plexus block under ultrasound guidance. Median StO2 values significantly increased by 4.5% at 5 minutes, 5.5% at 30 minutes, and an average of 1% between 5 and 30 minutes compared to the baseline values on the blocked side (16).

In the study by Topcam et al., the effects of local infiltrative anesthesia and supraclavicular brachial plexus block on tissue oxygenation and fistula patency were investigated in arteriovenous fistula surgeries. The patients undergoing arteriovenous fistula surgery were divided into two groups. Group L (n = 30) received local infiltrative anesthesia, while group B (n=30) received supraclavicular brachial plexus block. NIRS measurements of the patients were evaluated from the thenar region of both hands. One month after the surgery, Tissue oxygenation measured by NIRS monitoring in arteriovenous fistula surgery was found to be higher in the extremity where brachial plexus block was applied (17).In our studyTissue oxygenation of the upper extremities with and without axillary block was evaluated using NIRS; StO2 was found to be higher in the arm where the block was performed compared to the baseline value and the non-blocked side .

Study limitations

Our study was limited in two ways. First, our study was not a randomized and placebo-controlled study. Instead, the other extremity that did not undergo surgery was used as a control.The volume of the LA solution was quite high. A total of 40 mL of LA solution, 10 ml for each nerve, which is commonly used as a standard dose in our hospital, was applied to the blocked area. In extremity peripheral nerve blocks, administration of low volume and high concentration of LA is associated with a higher success rate and shorter onset time than high volume and low concentration solution. Therefore, we think that low volumes and high concentrations of LA may have an effect on axillary block and postoperative analgesia. However, to our knowledge, there is no study reporting LA dose, LA concentration and LA type in NIRS administration.

Conclusion

After the axillary block, it was determined that measuring StO2 using NIRS is a useful method to evaluate the success of the block. It was concluded that axillary block application is a successful and reliable method for patients undergoing upper extremity surgery. It was recommended to include axillary block in routine practice and use it more frequently in upper extremity surgeries. It was also concluded that further studies are needed in this regard.

Acknowledgements: *none*

Ethical Approval: *The study protocol was approved by the Harran University, Faculty of Medicine, Clinical Research Ethics Committee (Date 12/12/2014 Meeting Number: 26).*

Author Contributions: *Concept: MS, MAK, ŞY Literature Review: MAK,MS,AY Design: MS,NA,EB Data acquisition: MS,ŞY,EB Analysis and interpretation: MS,MAK,NA Writing manuscript: MAK,MS,AY Critical revision of manuscript: ŞY,MAK*

Conflict of Interest: *The author(s) do not have any potential conflict of interest regarding the research, authorship and/or publication of this article.*

Financial Disclosure: *This thesis was supported by Harran University Scientific Research Board with the date 22.04.2015 and project number 15068.*

References

1. Moorthy SS, Schmidt SI, Dierdorf SF, et al. A supraclavicular lateral paravascular approach for brachial plexus regional anesthesia. Anesth Analg1991;72 (2): 241- 4.
2. Brown DL, Bridenbaugh LD. The upper extremity-somatic block. In: Neural blockade in clinical anesthesia and management of pain. M.J. Cousine, P.O. Bridenbaugh (Eds) 3rd edition Lippincot Raven. 1998; 345-72.
3. Ting PL, SivagnanaratnamV. Ultrasonographic study of the spread of local anaesthetic during axillary brachial plexus block. Br J Anaesth 1989 63(3): 326-9
4. Sebastiani A, Philippi L, Boehme S, et al. Perfusion index and plethysmographic variability index in patients with interscalen nevre catheters. Can J Anaesth. 2012; 59 (12): 1095-101.
5. Cannesson M, Desebbe O, Rosamel P,et al.Pleth variability index to monitor the respiratory variations in the pulse oximeter plethysmographic wave form amplitude and predict fluid responsiveness in the operating theatre. Br J Anaesth 2008;101(2) :200–6.
6. Cohn SM. Near-infrared spectroscopy: potential clinical benefits in surgery. J Am Coll Surg. 2007;205(2):322-32.
7. Barker SJ, Shande A, Ramsay MA. Continuous Noninvasive Hemoglobin Monitoring: A Measured ResponseTo A Critical Review, Anesth Analg. 2016; 122(2): 565-72.
8. Minville V, Gendre A, Hirsch J,et al. The Efficacy of Skin Temperature for Block Assessment After Infraclavicular Brachial Plexus Block, Anesth Analg. 2009;108(3):1034-6.
9. Collins VJ. Regional Anesthesia. In: Collins VJ. (Ed.). Principles of Anesthesiology: General and regional anesthesia. 3rd ed. Philadephia: Lea&FebigerCo; 1993: 1445-571.
10. Liu GY, Chen ZQ, Jia HY, et al. The technique comparison of brachial plexus blocks by ultrasound guided with blocks by nevre stimulator guided. Int J ClinExpMed. 2015 15;8(9):16699-703.
11. Elshamaa HA. Stress response in shoulder surgery under interscalene block, randomized controlled study comparing ultrasound guidanceto nevre stimulation. Saudi J Anaesth. 2015; 9(4):359-64.
12. Çelik E, Kavak GÖ. Evaluation of Brachial Plexus Block With PlethysmographicVariability Index and Perfusion Index. Journal of Harran University Medical Faculty. 2021;18(2):170-5.
13. Okano T, Okuda Y, Kimura Y, et al. Use of near-infrared spectroscopy to evaluate stellate ganglion block. Reg Anesth Pain Med 2001; 26(2): 186-7.
14. Tsai PB, Tokhner V, Li J, et al. A new application fornear-infrared spectroscopy in regional anesthesia? JAnesth. 2011; 25(1):140-1.
15. Tighe PJ, Elliott CE, Lucas SD ,et al. Noninvasive tissue oxygen saturation determined by near-infrared spectroscopy following peripheral nevre block. Acta Anaesthesiol Scand. 2011; 55(10):1239-46.
16. Karahan MA, Binici O, Büyükfırat E. Tissue Oxygen Saturation Change on Upper Extremities After Ultrasound-Guided Infraclavicular Brachial Plexus Blockade; Prospective Observational Study. Medicina (Kaunas). 2019 14;55(6):274.
17. Topçam T, Özden MGN, Kocaarslan C, et al. Effect of Brachial Plexus Block on Tissue Oxygenation in Arteriovenous Fistula Surgery: A Randomized Clinical Trial. GKDA 2022;28(3):247-53.