

Effect of Brachial Plexus Block on Tissue Oxygenation in Arteriovenous Fistula Surgery: A Randomized Clinical Trial

Arteriyovenöz Fistül Cerrahisinde Brakiyal Pleksus Blokunun Doku Oksijenasyonuna Etkisi: Randomize Klinik Çalışma

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ABSTRACT

Objectives: Anesthesia methods have changed tissue blood flow. Near-infrared spectroscopy (NIRS) monitoring shows tissue oxygenation and indirectly blood flow. We aimed to investigate the effects of local infiltrative anesthesia and supraclavicular brachial plexus block on tissue oxygenation and fistula patency in arteriovenous fistula operations.

Methods: Patients operated for arteriovenous fistula were divided into two groups. Group L (n=30) patients received 5% bupivacaine 15 ml local infiltrative anesthesia, while group B (n=30) patients received 0.5% bupivacaine 20 ml + 2% lidocaine 10 ml around the brachial plexus in the supraclavicular region. NIRS measurements of the patients were evaluated from the thenar region of both hands. Surgeon and patient satisfaction were evaluated with the Likert satisfaction rating scale. Patients were questioned for primary patency 1 month after the operation.

Results: NIRS values of the arm with AV fistula were higher compared to values of other arm in group B and values of both arms in group L. Patient and surgeon satisfaction were higher in Group B. Primary fistula patency was similar between groups.

Conclusion: In arteriovenous fistula surgery, tissue oxygenation measured by NIRS monitoring was higher in the extremity with brachial plexus block, but it did not have a positive effect on fistula patency evaluated at 1 month.

Keywords: Arteriovenous fistula, brachial plexus, NIR spectroscopy, regional anesthesia

ÖZ

Amaç: Uygulanan anestezi yöntemleri doku kan akımını değiştirmektedir. "Near-Infrared Spectroscopy (NIRS)" doku oksijenasyonunu ve dolaylı olarak kan akışını gösterir. Bu çalışmada, arteriyovenöz fistül ameliyatlarında lokal infiltratif anestezi ve supraclaviküler brakiyal pleksus blokunun doku oksijenasyonu ve fistül açıklığı üzerine etkilerinin araştırılması amaçlanmıştır.

Yöntem: Arteriyovenöz fistül için ameliyat edilen hastalar iki gruba ayrıldı. Grup L (n=30) hastalarına %5 bupivakain 15 mL lokal infiltratif anestezi uygulanırken, grup B (n=30) hastalarına supraclaviküler bölgede brakiyal pleksus çevresine %0,5 bupivakain 20 mL+%2 lidokain 10 mL uygulandı. Hastaların NIRS ölçümleri her iki elin tenar bölgesinden değerlendirildi. Likert memnuniyet değerlendirme ölçeği ile cerrah ve hasta memnuniyetine bakıldı. Ameliyattan bir ay sonra hastalardan primer patensileri sorgulandı.

Bulgular: Grup B'de fistül açılan elin NIRS ölçümleri, açılmayan elden ve grup L'nin her iki elinden daha yüksek değerlerdeydi. Grup B'de hasta ve cerrah memnuniyeti daha yüksekti. Primer fistül açıklığı gruplar arasında benzerdi.

Sonuç: Arteriyovenöz fistül cerrahisinde NIRS monitörizasyonu ile ölçülen doku oksijenasyonu brakiyal pleksus bloku uygulanan ekstremitede daha yüksekti, ancak birinci ayda değerlendirilen fistül patensi üzerine olumlu etkisi görülmedi.

Anahtar sözcükler: Arteriyovenöz fistül, brakiyal pleksus, Near-Infrared spektroskopisi, rejyonel anestezi

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Introduction

Arteriovenous fistulas provide suitable vascular access for hemodialysis treatment in patients with chronic renal failure. It provides minimal intervention with low morbidity and mortality rates for long-term usage.^[1] Arteriovenous fistula failure, occurring in approximately one-third of newly created arteriovenous fistulas, may be related to preoperative arterial and venous diameters, and postoperative blood flow through the fistula.^[2] Because thrombosis and fistula failure can be prevented by increasing perioperative blood flow at the surgical site, so adequate post-operative blood flow may play an important role in fistula maturation. While general anesthesia, local infiltrative anesthesia and regional anesthesia can be performed in arteriovenous fistula surgeries, local infiltrative and regional anesthesia are considered first place due to low perioperative risk according to general anesthesia in patients having comorbidities related to end-stage renal disease. It has been shown that regional anesthesia can increase blood flow better by resulting in vasodilation in the affected area.^[3]

Near-infrared spectroscopy (NIRS) was developed for measuring tissue oxygenation by using near-infrared rays.^[4] Since tissue oxygenation depends on the blood flow in the measuring area, we thought that it could be used as an indirect measure showing the blood flow changes due to the anesthesia methods being applied for fistula formation.

The effects of the brachial plexus block on tissue oxygenation have not been fully known yet. Showing increased blood flow with the level of tissue oxygenation can be used as an indicator to see the positive effect of the procedure during arteriovenous fistula surgeries. In our study, we aimed to show the effects of supraclavicular brachial plexus block and local infiltrative anesthesia on tissue oxygenation measuring by NIRS monitoring and to investigate the effects of these anesthesia methods on primary fistula patency in arteriovenous fistula surgeries.

Methods

This single-center, prospective, and randomized study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Istanbul Medeniyet University Goztepe Education and Research Hospital (Date:10.07.2019, No: 2019/0260) with the ClinicalTrials.gov database (NCT04177901).

Sixty patients who were planned arteriovenous fistula surgery, ASA III-IV and aged between 18 and 80 years were included in the study. Before the operation, the necessary informed consent of the patients was completed. Patients with coagulopathy (Thrombocytopenia, increase aPTT, and

inr values), wound and/or infection in the thenar eminence and supraclavicular region, allergy to local anesthetic drugs, peripheral neuropathy, peripheral arterial disease, and mental health problems were not included in the study. The patients were divided into two groups Group L (n=30) and Group B (n=30) by randomization method using closed envelopes. Body mass index (BMI), primary renal diseases, and comorbidities of patients were recorded. All patients were underwent detailed doppler ultrasonography examination preoperatively by the experienced vascular surgeon and also all operations were performed by the same surgeon. Artery diameter of ≥ 2 mm and vein diameter of ≥ 2 mm under tourniquet were deemed appropriate for AV fistula creation. Heart rate, mean arterial pressure, and peripheral oxygen saturation monitoring were performed as standard monitoring of the patients. NIRS probes were placed in the thenar eminence region of both hands of the patients and baseline and other measurements were recorded while the patient was placed in a supine position with both hands at body level to prevent perfusion changes due to hydrostatic difference. NIRS values of all patients have recorded 10 min intervals from the beginning of surgery.

After the appropriate asepsis-antisepsis procedure, local infiltrative anesthesia was performed with 0.5% bupivacaine (Marcaine 0.5%, AstraZeneca, Istanbul, Türkiye) 15 ml subcutaneously at the incision area to the patients in Group L by the same surgeon and supraclavicular brachial plexus block was performed to the patients in Group B.

For performing brachial plexus block, the linear high-frequency transducer was placed in the supraclavicular fossa above the clavicle and angled towards the thorax to display the brachial plexus. On the surface and lateral of the subclavian artery, the brachial plexus was visualized as multiple hypoechoic discs by a linear high-frequency transducer with the aid of the ultrasound (Samsung Ultrasound H60; Hampshire, South Korea) and the image was confirmed by peripheral nerve stimulator (Stimuplex HNS 12[®]- Melsungen, Germany). Total 0.5% bupivacaine 20 ml and 2% lidocaine (Aritmal 2%, Osel drug, Istanbul, Turkey) 10 ml were applied around the brachial plexus by using the 50-mm Stimuplex[®] Ultra 360 needle with in-plane technique. Block success was determined with a three-point pinprick scale for sensory block and Modified Bromage Scale^[5] for motor block by the single investigator at 10-min intervals. The time between Modified Bromage Scale being Grade III and the three-point scale being Grade II was recorded. The block was considered unsuccessful when appropriate anesthesia could not be achieved within 30 min. It was decided that the operation was continued by local infiltrative anesthesia in patients with unsuccessful block or filling pain during the

Table 1. Demographic data, patient satisfaction, surgeon satisfaction and primary patency of groups

Properties	Group B (n=30)		Group L (n=30)		p
	n	%	n	%	
Age, median±SD	56.1±12.06		66.17±8.68		<0.001*
Sex	0.002*				
Female	6	25.0	18	75	
Male	24	66.7	12	33.3	
BMI, median±SD	25.94±4.70	2	7.53±4.94	0.21	
Patient satisfaction, median (25-75%)	5 (5-5)		3 (2-3)		<0.001*
Surgeon satisfaction, median (25-75%)	5 (5-5)		3 (3-3)		<0.001*
Primer patency (n=58)	0.65				
Yes	24	53.3	21	53.8	
No	6	46.2	7	46.7	

*: p<0,05 BMI: Body mass index.

surgery and these patients were not included in the study. No sedation was applied to the patients during the surgery. After a 5 to 6 cm skin incision was made, the vein was exposed and ligated at the distal portion. The vein was flushed with heparinized saline only, and systemic heparin was not used. Then, the artery was prepared and the vessel loop was placed around the artery. All anastomoses were performed with end to side fashion and all arteriovenous fistulas were created at distal radiocephalic location. No tourniquet was applied to the extremity to reduce bleeding during surgery. All patients were discharged either on the first postoperative day with prescribed acetylsalicylic acid 100 mg/day PO.

The primary outcome of this study was NIRS values as tissue oxygenation parameters, Secondary outcomes were primary patency of fistula and patient and surgeon satisfaction.

Our patients were closely monitored in terms of complications (Hemidiaphragmatic paresis, Horner's syndrome, vascular puncture, and sensory deficit) that may develop during and after anesthesia.

While surgeon satisfaction was evaluated at the end of the operation, patient satisfaction was evaluated the day after the operation by the Likert satisfaction rating scale.^[6] One month later, it was questioned whether the opened fistula was used in dialysis to determine 1 month's primary patency of the fistula.

Statistical Analysis

The sample size was calculated at 26 for one group when the alpha error was 5%, power was 90%, the effect size was 0.25 in a repeated design of measurements of tissue oxygenation at baseline, 0th, 10th, 20th, 30th, and 40th min (G*Power version 3.0.10) according to the study by Keuler

et al.^[7] Since 1:1 groups will be taken as the block and local groups, the minimum number of patients to be included in the study was 52. Descriptive statistics were presented as frequency (%) for categorical variables and mean±standard deviation (SD) or median with interquartile range (25-75%) for continuous variables. Normal distribution was tested with the Shapiro–Wilk test. Pearson Chi-square or Fisher's exact test were used to comparing categorical variables. Continuous variables between two groups were compared using the Student's t-test or Mann-Whitney U test. Continuous variables in a dependent group were compared with paired sample's t-test or Wilcoxon signed-rank test. A double-sided p<0.05 was considered significant. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) 20 for Windows (IBM Corp., Armonk, NY, USA).

Results

This study was conducted with 60 patients who had arteriovenous fistula operation for renal replacement therapy for end-stage renal failure between July 2019 and July 2020 in Istanbul Medeniyet University Goztepe Suleyman Yalcin City Hospital. Besides the ages of patients were statistically significantly low in Group B (p<0.001), male patients were statistically significantly more in Group B (p=0.002) (Table 1). NIRS values of the hands without arteriovenous fistula operation were similar between the groups (p>0.05). When the hands operated with arteriovenous fistula were compared between the groups, the NIRS values of Group B were statistically highly significant (p<0.001) (Fig. 1). The NIRS values of the blocked extremity showed a statistically increase during the evaluation period (p<0.05) (Fig. 2). NIRS values of both hands were statistically similar in group L (p>0.05).

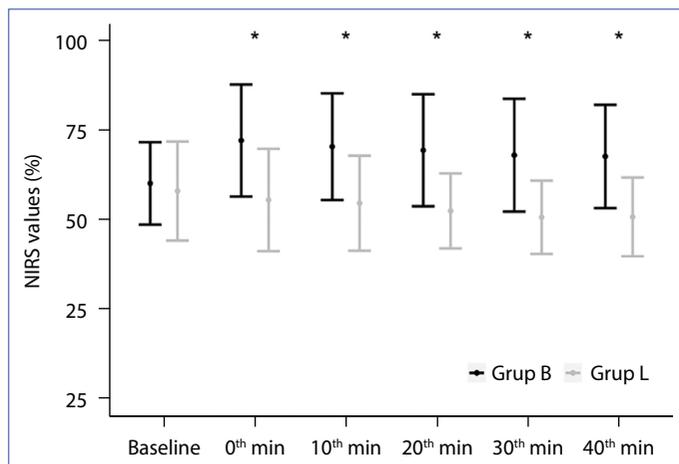


Figure 1. NIRS values of operated extremities between groups.

NIRS: Near-infrared spectroscopy.

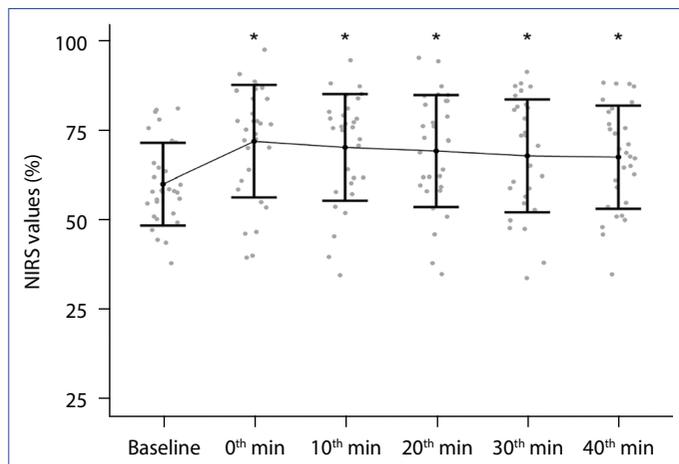


Figure 2. Postoperatif analjezi amaçlı kullanılan ajanlar.

NIRS: Near-infrared spectroscopy.

Patients satisfaction and surgeon satisfaction scores were statistically highly significant in group B ($p < 0.001$). Because one patient was not to be reached and one patient died on the postoperative 23rd day in Group L, primary fistula patency was evaluated in 58 patients and primer patency of patients was similar between the groups ($p > 0.05$) (Table 1). Unsuccessful block did not occur during the study. Arterial puncture developed as a complication while a block was applied to one of our patients. This patient was excluded from the study.

Discussion

Our findings support our primary hypothesis because brachial plexus block, which we applied for anesthesia in arteriovenous fistula surgery, increased tissue oxygenation as indicated by NIRS in the extremity innervated by the plexus. However, the fistula patency examined in the 1st month did not cause any change.

Arteriovenous fistulas in end-stage chronic renal failure provide the best vascular access in hemodialysis treatment with its suitability for long-term treatment, minimal intervention, low morbidity, and mortality rate. Factors such as diameter and quality of veins and arteries, presence of central venous disease, hypercoagulability, and fistula location are important in the formation of arteriovenous fistula.^[8] The continuity of adequate blood flow through the fistula prevents fistula failure from occurring by thrombosis.

The anesthesia method can also directly affect the diameters of vascular structures and change the blood flow perioperatively. Regional and local infiltrative anesthesia applied in suitable patients has fewer perioperative complications compared to general anesthesia.^[9] Arterial and venous spasms observed mostly in local infiltrative anesthesia may cause a decrease in blood flow of newly formed fistula.^[10] Regional anesthesia for arteriovenous fistula surgery represented a theoretically plausible intervention that might reduce early thrombosis and subsequent fistula failure based on the associated intra and postoperative hemodynamic changes.^[11] Brachial plexus block was much better for arteriovenous fistula flow characteristics including diameter, blood flow, and patency as compared with local infiltrative anesthesia.^[12]

Blocks applied from the supraclavicular region, target the truncus and divisions of the brachial plexus. Supraclavicular brachial plexus block, also known as "arm spinal cord," has a rapid onset of action.^[13] We preferred this block because of its easy applicability and rapid onset of effect.

The use of ultrasound while performing the block allows the needle and the administered drug to be seen, thus reducing the risk of unwanted intravenous injection and tissue trauma and also it allows the formation of an effective block at a lower dose.^[14] Gao et al.^[15] suggested that brachial plexus block performed under ultrasound guidance, allowing for more accurate placement of the injection needle as well as the more rapid onset and longer duration of the block, reduced vascular and neurological complications, and minimization of the volume of local anesthetic need. In addition, there are case reports in which mechanical complications can be seen in ultrasound-guided blocks.^[16] For this reason, it was thought that the use of nerve stimulators would be safer addition to ultrasound imaging. It is recommended to use ultrasound and nerve stimulator to increase the success and avoid complications when performing the brachial plexus block.^[17] Nofal et al.^[12] mentioned ultrasound-guided block was a simple and safe technique because there were no complications related to the brachial plexus block technique in their study. In a study by Perlas et al.,^[18] the ultrasound-guided supraclavicular block was

applied to 510 patients who were going to undergo upper extremity surgery, and no clinically symptomatic pneumothorax occurred in any of the patients. However, symptomatic hemidiaphragmatic paresis (1%), Horner's syndrome (1%), unwanted vascular puncture (0.4%), and transient sensory deficit (0.4%) occurred at different rates. While there was not an unsuccessful block in this study, arterial puncture developed in a patient as a complication.

Tissue oxygen saturation can be evaluated using the reflection and absorption of near-infrared light by NIRS. In addition, NIRS produces information about oxygen supply and demand while characterizing total tissue oxyhemoglobin and deoxyhemoglobin in a quantitative and qualitative manner.^[19] These dynamic values may provide additional information about local oxygen consumption, blood flow, and possibly microcirculation.^[20] Keuler et al.^[7] measured tissue oxygen saturation from the thenar eminences by NIRS monitoring in arteriovenous fistula operation. Similarly, we evaluated tissue oxygen saturation from the thenar eminences of both hands with NIRS. A thenar eminence is a suitable place for measurement of tissue oxygen saturation for the upper extremity due to its distal location, easy accessibility and thin width of the skin over it.

Karahan et al.^[21] measured non-invasive tissue oxygen saturation from the thenar eminence of both upper extremities using the NIRS method in patients who underwent upper extremity surgery with infraclavicular brachial plexus block and found an increase in measurements from 5th min. Keuler et al.^[7] performed supraclavicular brachial plexus block in arteriovenous fistula operation by measuring tissue oxygenation from the thenar eminences by NIRS and found an increase in NIRS values of blocked extremities. Malinzak et al.^[22] reported the increase in tissue oxygen saturations detected by NIRS in the hands performed regional anesthesia in patients operated for arteriovenous fistula in their review. In our study, NIRS values measured from thenar eminences were also higher in the blocked extremity. We think that this occurs as a result of increased tissue oxygenation as a result of vasodilation caused by supraclavicular block.

Studies demonstrated that regional anesthesia performed with a supraclavicular or axillary approach provides better vessel diameter and post-operative graft patency compared to local anesthesia or general anesthesia.^[23] Lam et al.^[24] found that surgeon satisfaction was similar with supraclavicular brachial plexus block and distal peripheral nerve block. Sahin et al.^[25] suggested that brachial plexus block provided higher radial artery and arteriovenous fistula blood flow at both the early and late postoperative periods by producing significant vasodilatation with sympathectomy-like effects compared with infiltration anesthesia.

There was no difference in primary patency also. Terkanlioglu et al.^[26] found higher surgeon satisfaction with regional anesthesia in arteriovenous fistula operation because of veno-arterial dilation and increasing arterial blood flow providing favorable conditions for them. We found higher patient satisfaction in the block group. The delayed feeling of post-operative pain compared to the local group may be the reason for this satisfaction in the block group. We also found higher surgeon satisfaction in the block group and the reason could be attributed to the improvement of intraoperative conditions due to increased blood flow and venodilation, same in literature. For this reason, we think that brachial plexus block can be especially preferred in arteriovenous fistula operations in patients with insufficient vascular diameters.

Elsharawy et al.^[27] reported primer patency with a regional block was approximately 80%. In a study, the primary failure rate was 17% with brachial plexus block and 30% with local infiltrative anesthesia.^[12] Cernevičute et al.^[28] showed that regional anesthesia performed for arteriovenous fistula surgery was associated with improved fistula patency compared with local infiltrative anesthesia in their review. Lo Monte et al.^[29] suggested that axillary-approached brachial plexus block was more effective due to the reduction in peripheral resistance and the increase in local blood flow, thus offering an ideal background for fistula creation and short-term patency. Aitken et al.^[13] found higher primary fistula patency in the block group after 3 months from the fistula formation. Macfarlane et al.^[30] found similar results for primary arteriovenous fistula failure in patients who performed brachial plexus block and local infiltrative anesthesia. Acipayam et al.^[31] examined fistula blood flow by doppler ultrasound at the postoperative 10th month after arteriovenous fistula and found similar blood flow in patients with axillary brachial plexus block and local infiltrative anesthesia. A study included 214 patients undergoing arteriovenous fistula operation, good vasodilatation in the distal arm, and thereby created optimal operable conditions for arteriovenous fistula surgery with supraclavicular brachial plexus block and the functional patency was maintained after 3 months in about half of the subjects.^[32] In our study, the primary fistula patency was similar between the groups in 1st month. In our study, we think that if we had evaluated the 3rd month primary patency, we could have obtained a different result.

There may be a bias in this study. While the randomization was made by the closed envelope method, young and male patients were more group B. Also measuring fistula blood flow while evaluating primary patency could be more accurate and useful for this study.

In our study, it was shown that supraclavicular brachial plexus block led to vasodilation, which was reflected in the increase in tissue oxygenation with the NIRS monitor, making it easier to work in the surgical field during the operation, but it did not have positive effects on the primary fistula patency observed in the 1st month.

Disclosures

Ethics Committee Approval: The study was approved by The Istanbul Medeniyet University, Goztepe Prof. Dr. Süleyman Yalçın City Hospital Clinical Research Ethics Committee (Date: 10/07/2019, No: 2019/0260).

Informed Consent: Written informed consent was obtained from all patients.

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