

Efficacy of Infraclavicular Brachial Plexus Block in the Patency of Radiocephalic Arteriovenous Fistula

Radiyosefalik Arteriyovenöz Fistüllerin Açıklık Oranlarında İnfraklavikular Brakiyal Pleksus Bloklarının Etkinliği

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ABSTRACT Objective: Long term patency of arteriovenous fistula is relevant to management of end stage renal failure patient on hemodialysis. Increased sympathetic activity and spasm of radial artery during the surgery may responsible for early occlusion rate. Aim of the study is to investigate the efficacy and the role of preemptive infraclavicular brachial plexus block on prevention of the radial artery spasm and fistula patency. **Material and Methods:** Forty patients were randomized into two groups. Infraclavicular brachial plexus block was performed in Group 1. Another group was considered as a control group (Group 2). In this group AVFs were performed under local anesthesia without infraclavicular blockage. Radial artery diameter (in group 1: before and after infraclavicular blockage, in group 2: only before procedure), fistula blood inflow rate and blood flow velocity were calculated. All AVFs were constructed on the forearm using autologous veins. **Results:** Average fistula blood inflow rate was 214.2±29.4 ml/min in Group 1 and 153.4±26.3 ml/min in Group 2 (p<0.001). While average blood flow velocity of radial artery was 172.1±27.3 cm/sec in Group 1, it was 103.3±12.4 cm/sec in Group 2 (p<0.001). Average radial artery diameter in group 1 2.4±0.4 mm and 2.5±0.3 mm in group 2 (p>0.05). Average radial artery diameter after the completion of infraclavicular blockage 2.9±0.3 (p<0.01). Thrill was found in all Group 1 patients, but there was thrill only 11 of the Group 2 patients (p<0.001). Mean maturation time was 39.4±6.1 days after surgery in Group 1 and 70.2±9.1 days in Group 2 (p<0.001). Adequate vascular access was obtained 17 patients in Group 1 and 10 patients in Group 2 (p=0.042). **Conclusion:** AVF occlusion rate is much more common in early postoperative period. Diminished sympathetic tonus by preemptive infraclavicular brachial plexus block not only increases early patency rate but also increases fistula maturation rate.

Key Words: Brachial plexus; arteriovenous fistula; vascular patency

ÖZET Amaç: Hemodiyaliz bağımlı son dönem böbrek yetmezlikli hastalarda arteriyovenöz fistüllerin (AVF) uzun dönem açıklık oranları fistül bakımları ile ilişkilidir. Artmış sempatik aktivite ve cerrahi sırasındaki radyal arterin spazmı ise erken kapanma oranlarından sorumlu olabilir. Bu çalışmanın amacı preemtif infraklavikular brakiyal pleksus bloğunun fistül açıklığı ve radyal arter spazmının önlenmesi konusundaki rolü ve etkinliğinin araştırılmasıdır. **Gereç ve Yöntemler:** Kırk hasta iki gruba randomize edildi. Grup 1'e infraklavikular pleksus bloğu uygulandı. Grup 2 ise kontrol grubunu oluşturdu. Bu grupta AVF'ler lokal anestezi altında yapıldı. Radyal arter çapı (Grup 1'de infraklavikular blokaj öncesi ve sonrasında, Grup 2'de sadece girişimden önce yapıldı), fistüle giren kan miktarı ve kan akım hızları hesaplandı. Tüm AVF'ler ön kolda otolog venler kullanılarak yapıldı. **Bulgular:** Ortalama fistüle giren kan akım miktarı Grup 1'de 214.2±29.4 ml/dk ve Grup 2'de 153.4±26.3 ml/dk'dı (p<0.001). Ortalama kan akım hızları ise grup Grup 1'de 172.1±27.3 cm/sn ve Grup 2'de 103.3±12.4 cm/sn'di (p<0.001). Ortalama radyal arter çapı Grup 1'de 2.4±0.4 mm ve Grup 2'de 2.5±0.3 mm'di (p>0.05). İnfraklavikular pleksus blokajı sonrasında ortalama radyal arter çapı 2.9±0.3 mm'di (p<0.01). Grup 1'deki tüm hastalarda tril duyulurken, Grup 2'de sadece 11 hastada tril duyuldu (p<0.001). Ortalama matürasyon süresi Grup 1'de cerrahi sonrasında 39.4±6.1 günken, Grup 2'de 70.2±9.1 gündü (p<0.001). Grup 1'deki 17 hastada yeterli vasküler erişim sağlanabilirken, Grup 2'deki 10 hastada sağlandı (p=0.042). **Sonuç:** Erken postoperatif dönemde AVF kapanma oranları daha fazladır. Preemtif infraklavikular brakiyal pleksus bloğu ile sağlanan azalmış sempatik tonus sadece erken açıklık oranlarını artırmakla kalmaz aynı zamanda fistül matürasyon hızını da artırır.

Anahtar Kelimeler: Brakiyal pleksus; arteriyovenöz fistül; Fistül açıklık oranı

Brecia MJ and Cimino JE¹ first reported the use of radial artery for arteriovenous fistula (AVF) formation in chronic renal failure (CRF) patients in 1966. Radial artery (RA) and cephalic vein (CV) are still being used in many centers for AVF formation in hemodialysis dependent patients. Since it is a middle sized muscular artery, radial artery is very prone to spasm when harvested for any purpose. This potential reactivity of the muscular layer is particularly very prominent at the distal end where the lumen is smaller. The ratio of media to internal diameter has an extreme significance and requires strategies to overcome perioperative-induced spasm.^{2,3} The effectiveness of different calcium channel blockers and organic nitrates, glyceryl trinitrate⁴ for inhibition or reversal of RA contraction and to increase blood flow were studied in vitro⁵ and in vivo.⁶ Despite these antispastic protocols, radial artery spasm still develops in early postoperative period. Recently preemptive Stellate ganglion blockade has been used in prevention of radial artery spasm.^{7,8}

Successful musculocutaneous nerve block is usually essential in order to provide adequate anesthesia for the creation of an arteriovenous fistula for hemodialysis because this nerve innervates the lateral aspect of the distal forearm. Analgesia of the median and the radial nerve may also be necessary if the exploration of blood vessels is extended distally.⁹

Infraclavicular brachial plexus block (IBPB) prevents or ameliorates the reactivity of the muscular layer of the RA in response to both surgical manipulation during harvesting the artery and to the potent vasoconstrictor mediators released during surgery. Altered calcium and phosphor metabolism in CRF patients would also increase vascular reactivity. Therefore in CRF patients, radial artery is more prone to calcification and vasospasm than normal patients. Increased vascular reactivity in CRF patients may cause early AVF failure. The aim of the study was to evaluate the role of IBPB on prevention of the radial artery spasm and patency of arteriovenous fistula.

MATERIAL AND METHODS

The study protocol was approved by the local Ethics Committee. Forty uremic patients, aged 21 to 68 years, scheduled for creation of an arterio-venous fistula for hemodialysis in the lateral anteb- rachial region gave their written informed consent and were enrolled in the study.

Patients having chronic pain, on chronic opioids, having major neurological conditions and/or peripheral neuropathy, scarring in the infraclavicular area and inability to co-operate with post-operative evaluations, known allergy to local anaesthetics, morphin or fentanyl, coagulopathy and pregnancy were excluded. Also patients with previous antecubital fistulas, cephalic vein occlusion, ipsilateral central vein stenosis, and ipsilateral brachial and radial artery stenosis were excluded from the study. Demographic data of the patients were detailed in Table 1.

The patients received their regular medication in the morning of surgery. They were premedicated with intravenous midazolam before the procedures in both groups. Monitoring consisted of a 5-lead electrocardiogram (ECG), pulse oximetry, and noninvasive blood pressure measurement at 5-minute intervals. All patients received oxygen supplementation.

TABLE 1: Patients' demographic data.

	Group-1 n=20	Group-1 n=20	p-value
Age (yr)	52±17	54±19	0.780
Sex (M/F)	14/6	15/5	
Height (cm)	172±9	170±12	0.672
Weight (kg)	80±19	77±15	0.554
Associated Medical Condition			
Diabetes	10	14	0.40
Hypertension	14	16	0.48
Coronary artery disease	8	6	0.56
Temporary Subclavian cathater	12	14	0.53
Number of Previous AVF	2.8±0.7	2.7±0.6	0.57
Side of procedure			
Left Arm	12	10	0.56
Right Arm	8	10	0.56

Patients were randomized into 2 groups which contain 20 patients to receive either IBPB or control group (only local anesthesia during the surgery procedure). Randomization was based on an investigator-generated code that was sealed in equentially numbered opaque envelopes. The blocks were performed and assessed by the same experienced anesthesiologist. AVF were performed by the same cardiovascular surgeon.

We had a hypothesis that IBPB may increase patency and maturation rate of arteriovenous fistulas on the wrist with respect to the control group.

All AVF procedures were performed on the forearm between radial artery and cephalic vein.

SONOGRAPHIC EVALUATION

All sonographic evaluations were performed by using portable doppler ultrasound (LOGIQ Book XP, GE Healthcare, USA). Radial artery diameters were calculated before and after IBPB in Group 1 and only before the surgical procedure in Group 2. Additional radial artery blood inflow rate and blood flow velocity of radial artery were calculated at at the postoperative third hour, postoperative 7th day (end of IBPB procedure) and end of one and three month.

THE INFRACLAVICULAR BLOCK PROCEDURE

The patients were placed in supine position with the neck turned away from the side of the block. The arm to be blocked was placed in adduction. The midpoint of the clavicle and the tip of coracoid process were identified and marked. The area was painted with antiseptic solution and draped. A nerve stimulator (Stimuplex HNSII; B. Braun/McGraw Medical, Inc) and a 102-mm, 18-gauge, insulated stimulating needle and catheter (Contiplex Tuohy continuous nerve block set 18 G. 3.81 cm; B. Braun Melsungen AG, Germany) were used to place an infraclavicular brachial plexus block using the landmarks previously described by Wilson et al.¹⁰ With the patient lying supine and the operative limb by the patient's side, a skin wheal was raised 2 cm medial and 2 cm caudal to the center of the coracoid process. The needle was inserted through the skin

wheal with the bevel pointed toward the patient's head and the long axis of the needle perpendicular to the operating table in all planes. With continuous aspiration and the nerve stimulator initially set at 1.2 mA and 2 Hz, the needle was advanced directly posterior. If the brachial plexus was not identified after 5–8 cm of insertion, depending on patient habitus, the needle was withdrawn to the skin and re-directed either cephalad or caudad in the paramedian sagittal plane until discrete, stimulated motion occurred in any digit(s) with a current between 0.30 and 0.55 mA. Directing the needle tip out of the paramedian sagittal plane was strictly prohibited—neither medially toward the lung nor laterally toward the terminal nerves of the brachial plexus. Flexion or extension at the elbow or wrist that resulted in motion of the fingers, without intrinsic hand or digit motion, was rejected.

For the surgical block, 30 ml of anesthetic solution was injected in divided doses, with gentle aspiration every 3 ml. The block was performed with levobupivacaine 0.5% (Chirocaine®, Abbott, Nycomed Pharma AS, NO-2418 Elverum, Norway). A polyamide catheter was then inserted through the needle so that 3 cm of the catheter was located past the tip of the needle. Early in this investigation, we noted frequent intravascular placement of the catheter if a moderate amount of resistance was encountered during catheter advancement. Therefore, during the remainder of this investigation, when resistance was encountered and when the catheter reached the needle tip, the catheter was held securely in place while the needle was withdrawn over the catheter. This technique left the catheter tip at the original location of the tip of the needle. After being withdrawn roughly halfway to the skin, the needle was held in place, and the catheter was advanced 5 cm. Subsequently, the needle was completely withdrawn over the remaining catheter, leaving 5 cm of catheter "slack" between the skin and brachial plexus.

After negative aspiration, 1 ml of sterile saline (0.9%) was injected into the catheter to ensure its patency. The catheter was then secured with sterile liquid adhesive and sterile tape. An occlusive dressing was placed over the site to retain sterility,

and the catheter further secured to the top of the original dressing with a second dressing.

These patients received 5 mL/h of 0.125% levopivacaine initially, and 8 to 10 mL/h of 0.125% levopivacaine was administered at the same concentration for maintenance in the postoperative 24 hour period. IBPB was performed once a day in the following 7 days to increase fistula maturation and to decrease the risk of thrombosis in early postoperative days.

ARTERIOVENOUS FISTULA SURGERY PROCEDURE

We usually preferred the non-dominant arm, if it had not been used before. All AVF surgery was performed on distal radial artery segment. We did not prefer the snuffbox area in any patients. The forearm was prepared and draped. A 3 cm skin incision was made on the radial artery 3 or 4 cm proximal of styloid process of radius bone. At first the cephalic vein was harvested and dilated with 5 ml isotonic solution, which contains 5000 units of unfractionated heparine. The antebrachial fascia was opened and the radial artery was encircled with silicone rubber strips both proximally and distally. Then radial arteriotomy was completed and the harvested cephalic vein was anastomosed by using 7/0 polypropylene suture in an end to side fashion. Using 1.5 mm probe, patency of anastomosis was controlled in both side of anastomosis. Skin incision was closed with interrupted sutures after adequate hemostasis. Patency of fistula was controlled by exploring thrill on the anastomosis by tactile sense or systolodiastolic murmur by stethoscope. We did not routinely administrate any anticoagulant or antiaggregant medications after surgery.

We defined Fistula Maturation as the ability to provide ongoing functional hemodialysis on average 2 months from the access procedure. Adequate vascular access was defined as successful cannulation of superficial arm vein for hemodialysis without excessive effort for cannulation (maximum two or three times).

STATISTICAL ANALYSIS

Results are expressed as the mean \pm SD. The differences between groups were tested for significance

by independent samples t-test, chi-square test and Fisher's exact test as appropriate. Differences were considered significant at $p < 0.05$. Statistical analysis was performed by using the SPSS 15.0 Statistical Package Program for Windows (SPSS Inc., Chicago, Illinois, USA).

RESULTS

At the postoperative third hour average radial artery blood inflow rate on fistula in our study was 214.2 ± 29.4 in Group 1 and 153.4 ± 26.3 in Group 2 ($p < 0.001$). The average peak velocity of radial artery was 172.1 ± 27.3 cm/sec and 103.3 ± 12.4 cm/sec in Group 1 and Group 2 respectively ($p < 0.001$). Results of other measurements related to these parameters were summarized in Table 2. There was not statistically significant difference on cephalic vein size. Thrill was found in all Group 1 patients, but there was thrill only 11 of the Group 2 patients ($p < 0.001$). Systolo-diastolic murmur was auscultated in all Group 1 patients. In Group 2 there was an audible systolo-diastolic murmur in 13 patients ($p = 0.004$). There were not statistically significant differences in both groups' complications except thrombosis in the first 24 hours. Thrombosis developed in one patients from Group 1 and in seven from Group 2 ($p = 0.038$). Hand ischemia was not encountered in both groups. Postoperative patient characteristics were summarized in Table 3.

Patients were followed in the outpatient clinic during postoperative 7-10 days and monthly thereafter until the fistula was mature enough for cannulation. The vascular surgeon and nephrolo-

TABLE 2: Radial artery blood inflow rates (ml/min).

Time Point	Group-1 n=20	Group-1 n=20	p-value
Pre AVF	22.3 \pm 0.3	22.8 \pm 0.3	NS
Postop. 3rd hour	214.2 \pm 29.4	153.4 \pm 26.3	<0.001
Postop. 7th day	279.1 \pm 27.1	190.6 \pm 24.7	<0.001
Postop. 1st month	351.4 \pm 32.3	240.8 \pm 28.9	<0.001
Postop. 3rd month	540.5 \pm 45.8	361.7 \pm 31.8	<0.001

AVF: Arteriovenous fistula

NS: Non significant

Postop.: Postoperative

TABLE 3: Postoperative findings of both groups.

Parameters	Group-1	Group-1	p-value
	n=20	n=20	
Thrill	20	11	<0.001
Sistolo-diastolic murmur	20	14	0.004
Peak velocity of RA (cm/sec)	172.1±27.3	103.3±12.4	<0.001
Cephalic vein size	2.4±0.4	2.5±0.5	0.72
Mean maturation time (day)	39.4±6.1	70.2±9.1	<0.001
Adequate vascular Access	17	10	0.042
Complication			
Hematoma	2	2	1.00
Infection	2	2	1.00
Thrombosis in 24 h	1	7	<0.001
Bleeding	2	1	1.00
Hand ischemia	-	-	1.00

gist decided the adequate maturation of fistula for hemodialysis access on the basis of thrill characteristics and diameters of arm veins. Mean maturation time was 39.4±6.1 days after surgery in Group 1 and 70.2±9.1 days in Group 2 ($p<0.001$). Adequate vascular access was achieved 17 patients in Group 1 and 10 patients in Group 2 ($p=0.040$). Alternative AVF surgery was performed in occluded or inadequate vascular access for hemodialysis conditions. Hematoma was found in two patients in both groups.

DISCUSSION

AVF patency depends on several factors. These factors cannot be optimized by any techniques. Adequate size cephalic veins and radial artery are the major predominant factor that affects the AVF patency. Adequate size vein cannot be found in all patients. The arterial tree has also great importance for patency of AVF surgery. Most patients with CRF have severe calcification in radial artery, which also have negative effect on fistula patency. In addition to these anatomic variations, autonomic disturbance also plays a major role for the patency of AVF.⁷

After AVF construction between the radial artery and accompanying cephalic vein, the peripheral resistance for the radial artery feeding the

fistula is decreased thereby increasing the rate of blood flow.¹¹ Parmar et al.¹¹ in their study, investigated the relationship between the internal diameter of the radial artery feeding the fistula and the rate of radial artery blood inflow and demonstrated associations between early AVF patency and radial artery blood inflow rate. A relatively similar study was designed by Wong et al.,¹² where intra and post operative blood inflow was measured in radiocephalic fistulae. They concluded that intra-operative fistula blood flow did not correlate with the outcome of the operation, probably due to vessel spasm from manipulation. However, blood flow velocities measured noninvasively 1 day after the operation were significantly lower in fistulae that failed early compared with those that were adequate for haemodialysis. Most of the increase in blood inflow occurred within the first 2 weeks of surgery.

Altered calcium and phosphor metabolism in CRF patients would also increase vascular reactivity so radial artery become more prone to vasospasm than normal patients.¹³ Increased sympathetic activity in renal failure patients was shown by Thomsen MB and colleagues. They also showed the beneficial effect of sympathetic blockage with intravenous guanethidine.¹⁴ Mouquet and colleagues also already suggested that sympathetic blockage can be useful for the patency and maturation of AVF. They showed that an axillary plexus block increases blood flow of ipsilateral arm.¹⁵ Infraclavicular brachial plexus block also eliminates the sympathetic tonus on the arm arteries. Flow of radial arteries increases¹⁶ and venous dilatation also obtained by stellate ganglion blockage (SGB).¹⁷ Yildirim et al. also demonstrated that both increased arterial flow and venous dilatation achieved by SGB have favorable effects on radio-cephalic AVF patency.⁷

The infraclavicular approach for brachial plexus block is a better alternative for axillary and/or interscalene approaches in cases where surgery requires an effective block of ulnar, radial, median, musculocutaneous, and axillary nerves.¹⁸ The brachial plexus is envisaged to lie within a closed space formed by its fascial sheath. Continuous anaesthesia

a/analgesia may be obtained by insertion of catheter into this perivascular fascial compartment. The procedure is simple and has few complications, and catheter can be fixed into the plexus sheath for long periods.

Kurt et al.¹⁹ demonstrated that use of continuous brachial plexus blockade technique is particularly warranted during the postoperative period to provide analgesia, sympathetic blockade, and increased blood flow to the injured extremity.

Brachial plexus blokage has also been used to treat vascular insufficiency caused by intravascular injection of drugs, traumatic hand and digit amputation, and prolonged and extensive upper extremity surgery.²⁰ In addition, CPB blockade can be used in treatment of early reflex sympathetic dystrophy.¹⁹

Neither systolic diastolic murmur nor thrill on fistula is significant predictors of early and late fistula patency. Won and associates²¹ found that thrill on the fistula which had been the major intraoperative hallmark for fistula patency, did not correlate with early patency. Thrill can be experienced even in flow of <40 ml/min. Won et al.²¹ suggest that if the flow of AVF is less than 100 ml/min, an alternative fistula should be performed even the surgeon felt thrill on AVF. Generally that fistula will occlude or nonmature in following days. Johnson and associates²² were the first who used intraoperative transitime ultrasonography for measurement of blood flow in various vascular access procedures. They reported that radiocephalic fistu-

las with a flow rate less than 170 ml/min were at risk for early failure and should be watched carefully or allowed to mature longer than 4 to 6 weeks. We have found that IBPB increased both arm and fistula blood flow. Average flow on fistula in our study was 214.2±29.4 in Group 1 and 153.4±26.3 in Group 2 (p<0.001). Increased blood flow may help early and long term patency of AVF. Dictums pointed out that if you find good caliber vein you would be successful. Contrary to this dictum arterial three is much more important than vein. Surgically exposed radial artery is particularly prone to spasm and impairs the blood flow which may cause early fistula thrombosis. IBPB prevents radial artery spasm and increases blood flow of radial artery. We continued IBPB for 7 days in order to avoid rebound phenomena. The time of postoperative IBPB can be debatable in future, but we thought that 7 days of IBPB would increase the possibility of fistula maturation. Fistula maturation time was 39.4±6.1 days in Group 1 and 70.2±9.1 in Group 2 (p<0.001) in our study.

CONCLUSION

According to our clinical observations AVF occlusion rate is much more common in early postoperative period. Increased sympathetic tone may play important role of AVF patency. Diminished sympathetic tone by infraclavicular brachial plexus blocks not only increase early patency rate but also increase, fistula blood flow and fistula maturation rate.

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