

Basic Strategies for Successful Arteriovenous Fistula Applications: A Three-Year Retrospective Study

Başarılı Arteriyovenöz Fistül Uygulamaları İçin Temel Stratejiler: 3 Yıllık Retrospektif Çalışma

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ABSTRACT Objective: The aim of this study is to share our experience in creating arteriovenous fistulas (AVF) for hemodialysis. **Material and Methods:** The study included 143 AVF cases performed on 131 patients between October 2010 and October 2013. The cases were retrospectively examined in a one-year surveillance period for early and midterm postoperative results. **Results:** Among all, 51.9 % of the patients were male (n=68), with a mean age of 55±12 years. In those 141 procedures, 32 (24.4 %) were performed on the right arm, and 99 (75.6%) were performed on the left arm. Basilic, cephalic and antecubital veins comprised 3 (2.3%), 119 (90.8%) and 9 (6.9%) cases, respectively. Venous anastomosis was carried out in radial arteries in 98 cases (74.8 %), and in brachial arteries in 33 cases (25.2%). The patency rates were 98.5% on the tenth day, 97.7 % after 6 months, and 96.9 % after 12 months. The mean flow rate through the fistulas was 661±34 ml/min after 12 months. **Conclusion:** Identification of the sites of anastomosis through preoperative vascular Doppler ultrasonography at the most distal locations where target arteries and veins are wider than 2 mm, and consideration of the possibility of atherosclerosis or thrombus may increase the success rate of AVFs. A murmur or thrill indicates success of the AVF procedure. Venous dilatation with low pressure using physiological saline prior to anastomosis may increase the chance to obtain a thrill.

Key Words: Arteriovenous fistula; renal dialysis; kidney failure, chronic

ÖZET Amaç: Bu çalışmada hemodiyaliz için oluşturulan arteriyovenöz fistül (AVF) deneyimlerimizi aktarmayı amaçladık. **Gereç ve Yöntemler:** Bu çalışmaya Ekim 2010-Ekim 2013 tarihleri arasında toplam 131 hastada yapılan 143 AVF olgusu dahil edilmiştir. Olgular ameliyat sonrası erken ve orta dönem sonuçları açısından 1 yıllık monitorizasyon periyodu içinde retrospektif olarak incelenmiştir. **Bulgular:** Hastaların %51,9'u erkek (n=68) ve yaş ortalaması 55±12 yıl olarak hesaplanmıştır. Toplam 141 operasyonun %24,4'ü (n=32) sağ kola, %75,6'sı (n=99) sol kola uygulandı. Basilik 3 (%2,3), sefalik 119 (%90,8) ve antekübital ven 9 (%6,9) vakada kullanıldı. Ven anastomozu 98 (%74,8) vakada radial arter ile, 33 (%25,2) vakada ise brakial arter ile yapıldı. AVF'lerin açıklık oranı 10. günde %98,5, 6. ayda %97,7, 12 ayda ise %96,9 olarak gözlemlendi. 12 ay sonundaki ortalama fistül debisi 661±34 ml/dk idi. **Sonuç:** Preoperatif vasküler ultrasonografi ile anastomoz planlanan bölgelerdeki arter ve ven çaplarının 2 mm'den geniş olacağı en distal bölgenin tespit edilmesi, ateroskleroz ya da trombüs varlığının değerlendirilmesi AVF'nin başarı ihtimalini arttırabilir. Üfürüm veya thril AVF operasyonunun başarı göstergelerindendir. Anastomoz öncesinde serum fizyolojik kullanılarak hafif basınç ile venin dilate edilmesi thril alınma başarısını arttırabilir.

Anahtar Kelimeler: Arteriyovenöz fistül; böbrek diyalizi; böbrek yetmezliği, kronik

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End-stage renal failure (ESRF) patients may need dialysis or renal transplantation in order to survive. Based on a report by Brescia et al. in 1996 on the application of subcutaneous arteriovenous fistulas

(AVF) between the radial artery and the adjacent vein, a Cimino fistula has been considered as the best method for vascular access during hemodialysis.¹ In this study, Doppler ultrasonography (DUSG) was used to assess the diameters of veins preoperatively and 6 months after surgery. The veins were also analyzed for presence of postoperative thrill, flow volume at the fistula, postoperative complications, and primary patency rates. Comorbid factors that might have affected the postoperative results were also analyzed.

MATERIAL AND METHODS

The principles of declaration of Helsinki 2008 have been complied in this study. The study included 143 AVF procedures performed on 131 patients between October 2010 and October 2013. History of diabetes mellitus (DM), hypertension, coronary artery disease, congestive heart failure and comorbidities were obtained from patients' files. In general, examinations of the upper extremity's arterial and venous system (Allen and Modified Allen Test, bilateral upper extremity blood pressure measurement, examination of the venous system) were carried out during the procedure as per established guidelines. Although the non-dominant extremity was preferred for vascular access, the dominant extremity was also used for creating fistula when intensive venous thrombosis was observed, or if a hemodialysis catheter was inserted into jugular/subclavian vein in the patient's non-dominant extremity. In addition, temporary internal jugular (contralateral to AVF) or femoral venous hemodialysis catheters were used in patients who required emergency dialysis following the creation of the primary fistula. The patients underwent preoperative color Doppler ultrasonography, and information on atherosclerosis, flow rate, arterial and venous diameters of the vascular structures targeted for anastomosis, starting with the snuffbox region, were recorded on a sheet.

SURGICAL PROCEDURE

A single surgeon carried out the AVF procedures in all the patients. AVF was carried out under 2.5x loupe magnification, after applying 2% xylocaine

(Astra Zeneca, London, UK) for local anesthesia. The vein and the artery were isolated through a 3-cm longitudinal incision, which was extended up to 7 cm in patients subjected to basilic vein transposition in a single phase, and vascular diameters were measured with calipers. The patients who had veins smaller than 2 mm, and in case of an unsuitable proximal vein for a primary AVF, the patient was considered as a candidate for AVF with prosthetic graft. Heparin (5000 units) was routinely applied to patients through an intravenous catheter before starting the anastomosis, followed by dilatation of target venous structures by venotomy and subsequent inflation using an injector filled with 5 ml physiological saline. The arteriotomy length was 5 mm for the brachial artery, and 10 mm for the radial artery, regardless of the diameter of the arteries. The AVF anastomoses were performed end-to-side at the snuffbox, radial and high radial, side-to-side between the cephalic or antecubital vein, and the brachial artery in the brachial region, and end-to-side between the basilic vein and the brachial artery, using 7-0 polypropylene and continuous suturing. PTFE graft anastomoses were performed with 5-0 polypropylene sutures. On postoperative AVF examination, presence of thrill was considered as an indicator of success, and the surgical procedure was revisited in cases with venous distension and venous pulsation without thrill. The procedure was finished by placing a mini-vac drain near the anastomosis, and suturing the incision with subdermal 3-0 absorbable and dermal 4-0 polypropylene sutures. Routine antiaggregants or anticoagulants were not prescribed after surgery. The patients that did not have postoperative thrill were administered subcutaneous low-molecule-weight heparin for three days, and prescribed 100 mg acetylsalicylic acid. Hand exercises were advised to all patients during follow up. The estimated fistula maturation period was four weeks, and the patients were allowed to their first hemodialysis after this period.

STATISTICAL ANALYSIS

Continuous variables are displayed as mean \pm standard deviation while categorical variables are dis-

played as frequency and percent. SPSS 20.0 for Windows (Chicago, Illinois, US) was used for descriptive analyses.

RESULTS

A total of 143 procedures were carried out in 131 patients, with 12 patients requiring additional procedures due to inefficient fistulas. Among all, 51.9% of the patients (n=68) were males, and 48.1 % (n=63) of them were females. The mean age of the entire cohort was 55±12 years. Preoperative mean arterial and venous diameters were 3.12±0.96 and 3.43±0.82 mm for males, and 3.0±1.15 and 3.36±0.85 mm for females. The right upper extremity was used in 24.4% (n=32), and left upper extremity was used in 75.6% (n=99) of the procedures. Thirty-three cases were proximal (25.2%), 67 were distal (55 %) and 26 were high radial (19.8%) AVFs. During the study period, there were 72 (55%) first-time AVF creations.

The patency rates of AVFs created in our clinic were calculated as 98.5% on the tenth day, 97.7% after 6 months, and 96.9% at the end of 12 months. The secondary patency rates after 6 and 12 months were 98.5% and 97.6%, respectively. Six percent of the patients (n=8) required a second surgery for thrombectomy while 3.8% (n=5) of them needed an AVF at a higher location. Three patients (2.3%) were subjected to basilic vein transposition. Upon examination of the patients for secondary chronic disease, 93.1% of the patients (n=122) were diagnosed with one or more chronic comorbidities, with the most common secondary comorbidities being diabetes mellitus (63.3 %; n=83) and hypertension (52.6%, n=69) (Table 1).

Since the primary choice for AVF is generally the non-dominant extremity, 75.6 % (n=99) of the AVFs were performed in the left extremity, and 24.4% (n=32) in the right extremity. In some of the cases, multiple needle entries or intravenous catheter attachments in the non-dominant extremity warranted the use of the dominant extremity instead. Basilic vein was used in 3 cases (2.3%), cephalic vein was used in 119 (90.8%) cases, and antecubital vein was used in 9 cases (6.9%). Venous

TABLE 1: Comorbidities of the patients included in the study.

Comorbidities	Number of patients
Diabetes mellitus + hypertension	39
Diabetes mellitus	29
Hypertension	29
Diabetes mellitus + coronary artery disease	15
Coronary artery disease	7
Chronic obstructive pulmonary disease	2
Hypertension + chronic obstructive pulmonary disease	1

anastomoses were performed on the radial artery in 98 cases (74.8%; five of the cases [3.8%] being snuff-box anastomoses) and the brachial artery in 33 cases (25.2%). End-to-side anastomoses comprised 88.7% of the cases (n=103) while side-to-side anastomoses comprised 21.3% (n=28) of the cases. The mean fistula flow was measured as 661±34 ml/min at the end of 12 months. Postoperative thrill was detected in 93.1% of the cases (n=122).

One patient who underwent basilic vein transposition developed soft tissue infection which was treated with appropriate antibiotic therapy. There were no other complications such as bleeding, steal, swelling or aneurysm requiring surgery during the follow-up, while myocardial infarction that resulted in mortality was seen in two patients.

DISCUSSION

The age at the onset of ESRF has been reported as 54±5 years in the literature.² The mean age of the 131 cases included in our study was 55±12 years. The most common cause of ESRF is DM, with an mean incidence rate of 20%. In the current study, diabetes accompanied chronic renal failure in 83 cases (63.3%). In addition to causing ESRF, diabetes was demonstrated to induce development of early atherosclerosis with increased oxidative stress, while also leading to higher diffusion and severity of atherosclerosis, all of which are negative factors affecting the flow and patency of AVFs.^{2,3} It was previously reported that the rate of blood flow in mature fistulas might exceed 600 ml per minute.^{4,5} In the current study, the mean fistula blood flow rate measured was 661±34 ml/min at

the end of 12 months. Analysis of the patients with fistula flow rates under 600 ml/min revealed presence of DM as comorbidity in all cases, and intimal hyperplasia was observed at the site of anastomosis. For these patients, a second AVF at a higher level was created with a second procedure.

Caplin et al. did not report any significant correlation of arterial and venous diameters with gender: 72% of female and 77% of male patients were eligible for fistula creation.⁶ The current study corroborated those results, and demonstrated no statistically significant difference between arterial and venous diameters with respect to gender.

The patients undergoing hemodialysis with a functional autogenous AVF display longer patency, and a lower risk of complications compared to hemodialysis with dialysis catheters and PTFE AVF grafts. A number of studies have demonstrated the superiority of autogenous AVF over other AVFs.⁷⁻¹⁰ Central venous catheter is the primary method when emergency, and temporary hemodialysis is necessary. However, they are associated with complications such as infection, thrombosis, venous stricture, and proximal vascular injury.^{11,12}

The most common AVF procedure is distal radiocephalic fistula, as initially described by Brescia et al.¹ As a gold standard in vascular access for hemodialysis, this procedure was applied to 51.1% of the cases (n=67) in the current study. Primary AVF failure has been defined as the absence of a well-developed vein accessible for hemodialysis after 12 weeks.¹³ Out of 98 distal fistula cases in the current study, 92 (94%) were successful. In studies that included a very high number of patients, primary failure rate of distal radiocephalic AVF was reported between 15 and 30%.¹⁴ Preoperative evaluation of the vessels with DUSG increases the success rate of autogenous AVF creation, and may improve the results. A randomized study found primary AVF failure rate as 25% in preoperative evaluation, consisting solely of physical examination, while postoperative DUSG evaluation yielded a rate of 6% (p=0.0002).¹⁵ Our results showed primary AVF failure rate as 6%, which is consistent with the literature.

The recommended minimum diameter of the vessel chosen for anastomosis is 2 mm in the litera-

ture.¹⁶⁻¹⁹ In the current study, the most distal location on the vein that was wider than 2 mm as detected by preoperative vascular ultrasonography was chosen for the procedure. Kazemzadeh et al. reported patency rates of 79.5% and 70% at the end of six months and one year, respectively in 245 patients who underwent AVF.²⁰ Patency rates in the current study were 97.7% and 96.9% at the end of six months and one year, respectively. Dilatation of the fistula vein was routinely performed in our study prior to anastomosis by administering physiological saline at low pressure with simultaneous occlusion 4 to 5 cm distally. This process eliminated adventitial strain blocking the flow, thereby facilitating the enlargement of the venous structure and contributing to fistula flow rate. Additionally, the most distal artery and vein wider than 2 mm were selected using preoperative vascular DUSG. Applying these two techniques might have increased our fistula patency rates. Thrombus developed in 42 % of the patients who subsequently required a second surgical procedure. Those rates were reported between 9.4 and 38% in the literature.²¹

CONCLUSION

Arterial and venous diameters wider than 2 mm at the location targeted for anastomosis has been reported to enhance the success rate of AVFs.¹⁶⁻¹⁹ Hence, the creation of AVF in the most distal part of the vessels that reach this diameter may increase the success rate of the procedure, and eliminate the necessity of a second operation. Success of the procedure was directly associated with the detection of thrill on postoperative fistula examination. Dilatation of the vein with low pressure before initiating the anastomosis may reduce adventitial resistance, which may in turn help in the production of a thrill.

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Conflict of Interest

Authors declared no conflict of interest or financial support.

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