Am J Transl Res 2019;11(2):1058-1065
www.ajtr.org /ISSN:1943-8141/AJTR0087413

Original Article

Outcomes of arteriovenous fistula reconstruction in vascular access dysfunction

Nail Kahraman, Deniz Demir

Bursa Yüksek Ihtisas Training and Research Hospital, Department of Cardiovascular Surgery, Bursa, Turkey

Received October 26, 2018; Accepted December 20, 2018; Epub February 15, 2019; Published February 28, 2019

Abstract: Background: Complications such as stenosis, thrombosis, aneurysmal dilatation, and infection occur in at least one-third of all arteriovenous fistulas (AVFs). Due to these complications, vascular access dysfunction develops in hemodialysis patients. Objectives: We investigated AVF rescue operations, which we performed for the pathologies causing dysfunctional vascular access, and outcomes of these operations by surgeon-performed preoperative ultrasound (US) in our clinic. Design: Retrospective Study. Settings: Bursa Yüksek Ihtisas Training and Research Hospital Cardiovascular Surgery Department, Turkey. Patients and methods: 67 patients who were treated in our clinic due to AVF dysfunction between January 2012 and January 2016 were included in the study. Preoperative US evaluation for dysfunctional AVFs was performed by the surgeon conducting the operation. The patients were divided into 5 groups according to the pathologies such as stenosis, thrombosis, aneurysm, high-flow rate, and deep basilic vein. Main outcome measures: Our goal in all patients with vascular access dysfunction was to maintain the AVF. Sample size: 67 Patients. Results: In Group 1 (16 patients) which had stenosis and underwent AVF reconstruction, the 24-month primary patency rate was 81.3%. In Group 2 (9 patients) which had trombosis and underwent AVF reconstruction, the 24-month primary patency rate was 22.2%. In Group 3 (24 patients) which had AVF aneurysm and underwent AVF reconstruction, the 24-month primary patency rate was 70.8%. In Group 4 (10 patients) which had high flow and underwent AVF reconstruction, the 24-month primary patency rate was 90%. In Group 5 (8 patients) which had deep basilic vein and underwent AVF reconstruction, the 24-month primary patency rate was 75%. Conclusion: Leaving patients with vascular access dysfunction to fate (no intervention) or AVF ligation is always simpler and easier. However, it should not be forgotten that paternity for vascular access are limited in these patients. We think that the primary target is to demonstrate AVF by physical examination and surgeon-performed detailed US and to make it again available for hemodialysis by reconstructing dysfunctional AVF using the most appropriate surgical strategy. Limitations: Retrospective, small sample size.

Keywords: Arteriovenous fistula, stenosis, aneurysm, ultrasound, arteriovenous fistula reconstruction

Introduction

Complications such as stenosis, thrombosis, aneurysmal dilatation, and infection occur in at least one-third of all arteriovenous fistulas (AVFs) [1]. Degenerative changes of the vein wall due to high AVF flow, venous stenosis, and repeated dialysis attempts from the same site may lead to aneurysm formation [2]. Venous stenosis can cause thrombus formation in an aneurysm sac, aneurysmal sac enlargement and ultimately infection, skin atrophy, ulceration, necrosis, and bleeding [3]. Many complex vascular access problems such as aneurysm, thrombus formation, venous stenosis, juxta-anastomotic stenosis, high-flow fistula, arm edema, arm ischemia, and deep basilic vein fistula (which cannot be used due to its proximity to the nerves and arteries) are present in AVF. Ultrasound (US) in addition to physical examination can be used in detecting these AVF problems [4-7].

We investigated AVF rescue operations, which we performed for the pathologies causing dysfunctional vascular access, and outcomes of these operations by surgeon-performed preoperative ultrasound (US) in our clinic.

Patients and methods

Information for the patients who were treated in our clinic due to AVF dysfunction between

Table 1. Demographic features of the patients

	Group 1 n = 16	Group 2 n = 9	Group 3 n = 24	Group 4 n = 10	Group 5 n = 8	*p* value
Age (years)	49.69 (11.97)	52.56 (11.18)	50.33 (11.56)	48.6 (11.13)	41.63 (9.16)	0.820#
Male gender, n (%)	8 (50)	7 (77.8)	16 (66.7)	4 (40)	5 (62.5)	0.410*
HT, n (%)	15 (93.8)	8 (88.9)	22 (91.7)	7 (70)	5 (62.5)	0.143*
DM, n (%)	3 (18.7)	0 (0)	8 (33.3)	3 (30)	3 (37.5)	0.291*

HT, Hypertension; DM, Diabetes mellitus; *Chi-Square, #ANOVA (Tukey HSD: P = 0.158).

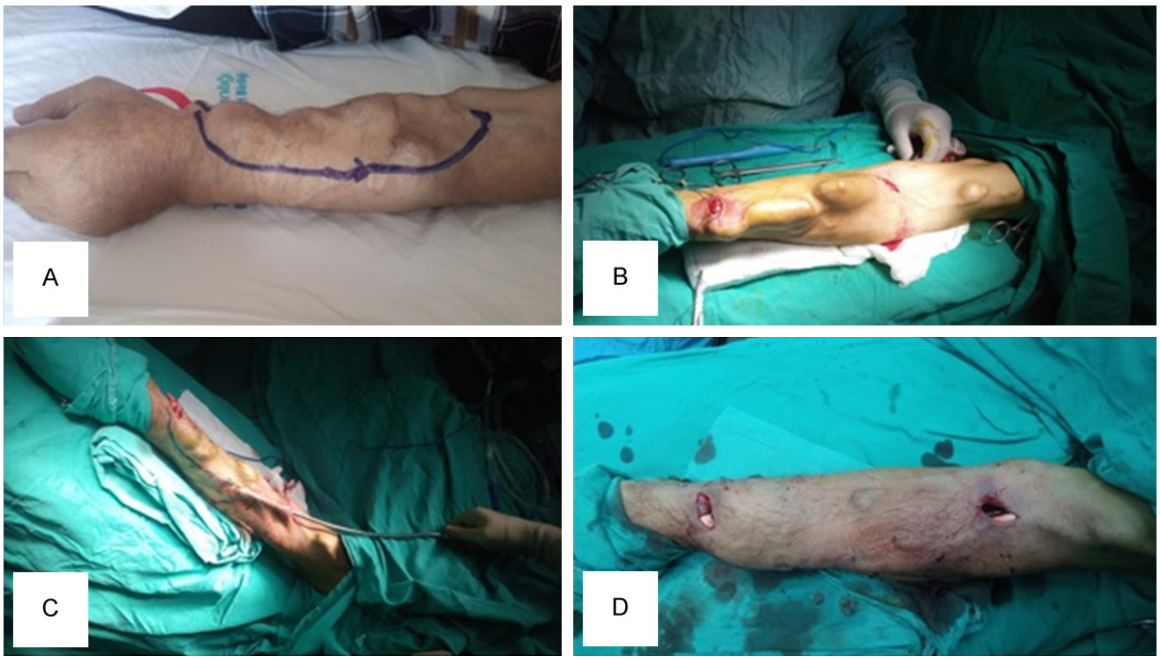


Figure 1. A. Surgical planning with the aid of preoperative US. B. Minimal surgical incisions for AVF reconstruction. C. Creating subcutaneous tunnels for the PTFE graft. D. Completed anastomoses after the PTFE graft being passed under the skin.

January 2012 and January 2016 were obtained from the hospital's database and clinical notes. 67 patients who were admitted to our clinic due to AVF dysfunction and who had surgeon-performed preoperative US were included in the study. The study protocol was approved by the institutional Ethics Committee. The demographic characteristics, comorbidities and perioperative information of the patients were recorded (**Table 1**). Primary patency is duration of successful fistula open without additional intervention after AVF reconstruction. Fistula primary patency rates at 1, 6, 12 and 24 months after AVF reconstruction, postoperative need for central venous catheter, complication development, and functional operation of the reconstructed AVF were evaluated.

Preoperative US (Mindray, diagnostic ultrasound system, Hamburg, Germany) evaluation for dysfunctional AVFs was performed by the surgeon conducting the operation. The detailed physical examination was performed in all patients before the operation. Subsequently, the detailed vascular mapping was performed by assessing arterial diameter, calcification, thrombus, stenosis, aneurysm and fistula flow in all patients by US. The markings indicating the surgical procedure related to AVF in the patients were drawn with a permanent paint pen (**Figures 1A**, **2A**).

The patients with dysfunctional AVF were divided into 5 groups: Group 1: Stenosis > 70% (stenosis at the juxta-anastomotic site and stenosis at the intervention site for AVF). Group 2:

Figure 2. A. Preoperative US mapping of AVF stenosis due to repeated dialysis needle insertion attempts. B. Placement of a PTFE interposition graft following excision of the stenotic segment of the AVF after surgical procedure.

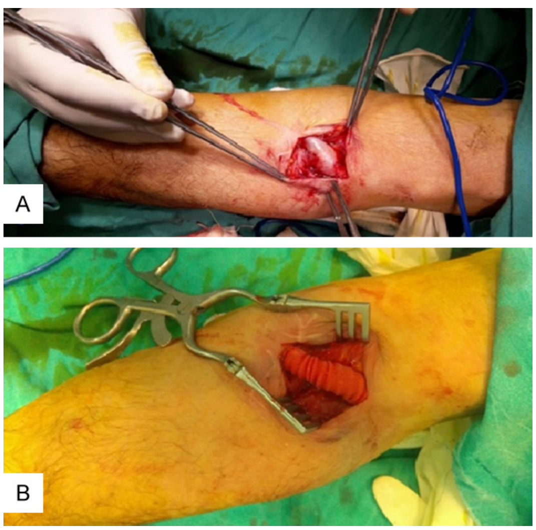


Figure 3. A. Surgical exploration of high-flow AVF. B. Banding procedure with the Dacron graft, narrowing of the fistula.

Thrombosis. Group 3: Aneurysm (an aneurysm with a diameter greater than 4 cm in AVF, pain in the area overlying, rapidly expanding aneurysm (0.2 cm/6 months) and thrombosis of the aneurysm). Group 4: High-flow rate (AVF flow > 1200 mL/min). Group 5: Deep brachiobasilic AVFs (Patients who without basillic vein superficialization in the first brachiobasillic AVF operation).

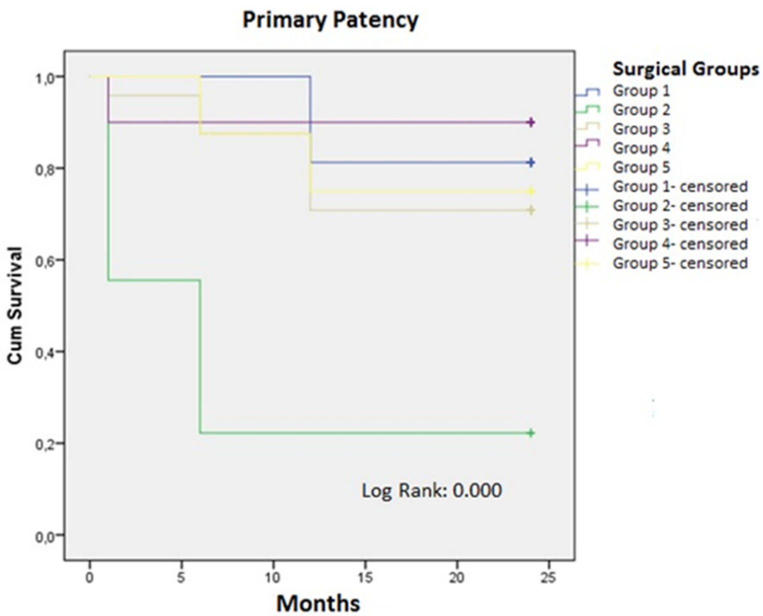
Surgical technique

The patients were operated under sterile conditions in the operating room. Local anesthesia or axillary blockade was performed by considering the extent and duration of AVF reconstruction. Anticoagulation was performed with 5000 IU of standard heparin. Depending on vein wall thickness, 5-0 and/or 6-0 polypropylene were used in anastomoses and sutures. A 6 mm PTFE trilaminate early cannulation graft (Flixene Vascular Graft, Atrium Medical Corporation, USA) was used as a graft material. Surgical procedures that could be performed with the patient's native vessel were preferred as the first option in surgical planning. Minimal surgical incisions were made in order to provide the needle entry site with the longest distance and from different locations that would allow dialysis after the operation.

In the group with AVF stenosis at the juxta-anastomotic site and at the intervention site for dialysis, native vessels were primarily mobilized. Then, the stenotic segment was resected, and the end-to-end anastomosis technique was performed. If end-to-end anastomosis was not possible despite simple resection and vessel mobilization, the AVF was completed with the interposition of a PTFE graft (**Figure 2A**, **2B**).

In the group with AVF thrombosis, the thrombotic segment underwent thrombectomy with the appropriate skin incisions using the Fogarty embolectomy catheter.

In the group with AVF aneurysm, after the proximal and distal control of the aneurysmatic segment was achieved with approximately 3-5 cm incisions, it was resected. If the juxta-anastomotic site in aneurysmatic AVFs was intact, the non-aneurysmatic arterialized vein segment near the anastomotic line was combined with the PTFE graft using the end-to-end anastomosis technique. Thrombus within the aneurysmal sac was carefully removed. If there was no backflow in the non-aneurysmatic segment, thrombectomy was performed using an appropriately sized Fogarty catheter. The newly anastomosed PTFE graft was passed through the subcutaneous area in the intact region outside aneurysmatic regions to create a new line. A new AVF was created by anastomosing it from the non-aneurysmatic arterialized vein segment in the proximal anastomotic line using the end-to-end anastomosis technique (**Figure 1A-D**).



	Months	1	6	12	24
Group 1	N. at risk	16	16	13	13
	SE	0.000	0.000	0.098	0.098
	Patency rate	100%	100%	81.3%	81.3%
Group 2	N. at risk	5	2	2	2
	SE	0.166	0.139	0.139	0.139
	Patency rate	55.6%	22.2%	22.2%	22.2%
Group 3	N. at risk	23	21	17	17
	SE	0,041	0,068	0.093	0.093
	Patency rate	95.8%	87.5%	70.8%	70.8%
Group 4	N. at risk	9	9	9	9
	SE	0.095	0.095	0.095	0.095
	Patency rate	90%	90%	90%	90%
Group 5	N. at risk	8	7	6	6
	SE	0.000	0.117	0.153	0.153
	Patency rate	100%	87.5%	75%	75%

Figure 4. Kaplan-Meier curves; cumulative primary patency rates for twenty four months.

drain was inserted after bleeding control was achieved. Patients who underwent surgical intervention and debridement in the extensive field underwent elastic bandaging under slight pressure so that the thrill over the fistula site would not disappear.

Statistical analysis

Statistical analysis data were analyzed with the Statistical Package for the Social Sciences (IBM SPSS Statistic Inc. version 21.0, Chicago, IL, USA). Continuous and ordinal variables were expressed as mean ± standard deviation and nominal variables were expressed as frequency and percentage. Chi Square test was used to compare groups for nominal variables. ANOVA test was used to compare groups for continuous variables with normal distribution. Long-term results were analyzed by Kaplan Meier curves, and differences in subgroups were assessed by the log-rank test. For all tests, a p value of < 0.05 was considered statistically significant.

In the group with high-flow AVF, it was narrowed by using a 2-3 cm wide Dacron graft in the AVF with a flow rate of above 1200 ml/min. With the help of intraoperative US, the vessel diameter was narrowed by banding procedure so that fistula flow was about 600 ml/min (**Figure 3A**, **3B**).

In the group with deep basilic vein AVF, the subfascial basilic vein which is not suitable for vascular access due to its proximity to the brachial artery and its deep placement were adapted to vascular access by performing suprafacial transposition with intermittent skin incisions and continuous subcutaneous fascial incisions.

In all patients, necrotic and ulcerated skin tissues were removed if they were present. The

Results

A total of 67 patients underwent AVF reconstruction. The patients were divided into 5 groups according to surgical interventions. Demographic data are showed in **Table 1**. Kaplan-Meier curves; cumulative primary patency rates for twenty four months are showed in **Figure 4**.

Group 1: 16 patients were evaluated in the stenosis group. The patients in this group were operated under local anesthesia. Fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 100%, 100%, 81.3% and 81.3%, respectively (Kaplan-Meier curves, **Figure 4**). No postoperative complications were observed in any of the patients in this group.

Group 2: 9 patients were operated in the thrombosis group. The patients in this group were operated under local anesthesia. Fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 55.6%, 22.2%, 22.2% and 22.2% respectively (Kaplan-Meier curves, **Figure 4**). 1 patient in this group underwent revision due to bleeding. In the postoperative period, 2 patients underwent dialysis catheter placement.

Group 3: The aneurysm group consisted of 24 patients. The aneurysm diameters of the patients in this group ranged from 4-6 cm. While 6 patients were operated under axillary blockade, other patients were operated under local anesthesia. Fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 95.8%, 87.5%, 70.8% and 70.8%, respectively (Kaplan-Meier curves, **Figure 4**). 2 patients in this group underwent revision due to bleeding. In 1 patient, superficial soft tissue infection was seen in the early period. In the postoperative period, 2 patients underwent dialysis catheter placement.

Group 4: 10 patients were evaluated in the high flow group. In these patients, the mean preoperative fistula flow was 1286 (74.02) ml/min, and the mean postoperative fistula flow was 610 (65.19) ml/min. All patients were operated under local anesthesia. Fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 90%, 90%, 90% and 90%, respectively (Kaplan-Meier curves, **Figure 4**). No postoperative complications were observed in any of the patients in this group.

Group 5: There were 8 patients in the deep basilic vein AVF group. All patients were operated under local anesthesia. Fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 100%, 87.5%, 75% and 75%, respectively (Kaplan-Meier curves, **Figure 4**). 1 patient in this group underwent revision due to bleeding. The patients with a preoperative dialysis catheter used their catheters for one month postoperatively and then basilic vein transposition (BVT) AVFs.

Discussion

Local complications such as aneurysm, thrombosis, stenosis, and graft infection as well as systemic complications such as heart failure due to high fistula flow may develop in the late period after arteriovenous fistula surgery. Thrombosis and stenosis are the most common complications [8, 9]. High arteriovenous flow, upstream venous stenosis, and repeated dialysis needle insertion attempts may lead to venous aneurysm formation by causing degenerative changes of the vein wall [2]. The formation of aneurysm and stenosis can be reduced by prolonging the needle intervention area used for dialysis and by performing interventions from different regions. Thrombus within the aneurysmal sac and inadequate hemodialysis may develop due to reduced AVF flow caused by venous stenosis. Complications such as aneurysmal sac enlargement, infection, skin atrophy, ulceration, and bleeding may occur in further stages [3].

Conventional methods for repairing AVF aneurysms include aneurysm resection followed by primary anastomosis or synthetic graft interposition [10]. In recent years, endovascular methods have been successfully used to exclude the aneurysmal AVF sac. Temporary dialysis catheters may be required to meet the need for dialysis in the early stages of these treatments. In patients in whom the aneurysmal sac is excluded by a coated stent graft, skin disorders (such as ulceration, necrosis, and atrophy) that are caused over time by the aneurysmal sac also continue [11]. In our study, the surgical plan was marked on the patient's skin under surgeon-performed preoperative US guidance. Thus, the patients underwent surgical interventions with the smallest incisions and with the least tissue trauma possible. If necessary, debridement and correction were also performed to improve cosmetic impairment on the skin. Thus, the patients were freed from both their pains and ugly looking masses. We found that the 24-month primary patency rates in Group 1 with AVF stenosis and Group 3 with AVF aneurysm were 81.3% and 70.8%, respectively.

Patients with previous vascular access loss may be more prone to thrombosis due to anatomic abnormalities, thrombophilic disorders or venous intimal hyperplasia [12]. Seong Cho et al. reported that the US added to physical examination decreased the need for angiography in hemodialysis patients [13]. Patel et al. recruited 48 patients with AVF aneurysm into their study and evaluated these patients by fistulogram 90% of these patients underwent percutaneous angioplasty. While 56% of the patients had one venous outflow stenosis, 44% had two or more stenoses requiring intervention. While 64% of the patients underwent a single-stage open repair, 36% underwent a two-stage treatment. 23% of the patients require a permanent dialysis catheter until the fistula was ready to be used surgically. In this study, Patel et al. consequently reported that all AVF aneurysms were effectively treated and that the patients maintained dialysis access patency when they were improved. They also reported that the use of a catheter in patients with multiple aneurysms would reduce the need for dialysis catheters [10].

In our study, surgical planning in addition to physical examination was performed by surgeon-performed US. The incision regions on the patient's skin and the localization line of AVF graft newly created during reconstruction were marked. In patients undergoing graft interposition, it was performed by creating a tunnel from a new localization in the outer zone of the aneurysmatic area. Preoperative angiography was not performed in our study group. All patients underwent physical examination and surgical planning under surgeon-performed US guidance. In Group 2 (AVF thrombosis), we found that fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 55.6%, 22.2%, 22.2% and 22.2%, respectively. We think that the possible reasons for this may be predisposition to thrombosis and subclavian vein and superior vena cava stenosis in cases where complete evaluation with US is inadequate. We think that angiographic examinations may contribute to diagnosis and AVF success in a limited number of patients, particularly in patients with thrombosed AVFs (Group 2). However, we consider that physical examination and surgeon-performed US are sufficient in the other patient groups. In addition, the PTFE graft material we used could be used for dialysis 24 hours after the operation. As a result of the surgical interventions we performed, we needed a new dialysis catheter in 4 (4/67) of our patients in total (group 2 two patients, group 3 two patients). The greatest advantage of this low rate for patients is that many patients are protected from complications due to a new catheter intervention.

The advantage of US imaging for the planning of vascular access in hemodialysis has been emphasized in many studies [14, 15]. In one study, a patient with two different patent AVFs was evaluated. This study has indicated that outcomes of vascular access surgery may improve with surgeon-performed preoperative US [16]. The detailed preoperative fistula mapping in vascular access dysfunction may allow optimal surgical intervention and contribute to the success of fistula reconstructions. In addition to physical examination performed by the surgeon conducting the surgery in dysfunctional AVFs due to various reasons, US mapping of the AVF is very important in defining the complex anatomy. We consider that surgeon-performed US will be effective in determining the optimal surgical approach among many different surgical techniques. In addition to all these, it can reduce the need for new dialysis catheters because it allows early re-dialysis from the vessel intervened with minimal incisions.

In our country, AVF is generally evaluated and reported by radiology specialists. Many surgeons perform surgery planning according to these reports. As in our study, all vascular structures are observed and assessed without intermediaries in the evaluation of fistula with surgeon-performed US. Thus, the surgeon can anatomically dominate dysfunctional AVFs and designs more easily the optimal minimal surgical plan for the patient. We think that US mapping of the fistula performed by the surgeon and the presence of a previously maturated fistula line were effective in high fistula patency rates. Because we believe that a distally opened AVF (radiocephalic) can help the maturation of proximal vessels in new fistulas being opened from proximal in the future or in fistula pathologies requiring reconstruction. For this reason, we should consider reconstruction options for fistula rescue in AVF dysfunction.

Fistula ligation in AVF dysfunction is the easiest and most common procedure. However, the revival of dysfunctional AVF has great value for hemodialysis patients who already have limited vascular reserve. Ligation is the simplest method for the treatment of distal ischemia due to arteriovenous fistula in high-flow fistulas. However, it causes the loss of the fistula that can be reused with the necessary correction. The narrowing of the arteriovenous fistula with banding technique both improves the distal perfusion and maintains the use of a functional fistula. However, the risk of developing thrombosis after narrowing is high [17]. In our study, we determined that the 24-month patency rate in 10 patients undergoing banding was 90%. We performed banding procedure with a small incision of 2-3 cm (**Figure 3B**). Thus, our patients could use their AVFs after this procedure.

In a previous study, it has been recommended that the radial artery diameter is 1.6-1.9 mm and the radial vein diameter is 2-2.4 mm, although uncertainties regarding US parameters that predict the success of a fistula are present. Moreover, it has been argued that preoperative US is the best imaging method to plan the operation for vascular access in a radiocephalic AVF and to predict its success [18].

In another study conducted on aneurysm repair by Cingöz et al., they found that the 3-year patency rate was 100%. They have suggested that high fistula patency rate is due to the use of a short segment graft 37 (11) mm [19]. In our study, complicated AVF anatomy, vascular pathologies, and newly created fistula mapping were marked on the patient' skin by surgeon-performed preoperative US. In our patients, a 5-30 cm long graft was used. In Group 3 (AVF aneurysm), we found that the 24-month primary patency rate was 70.8%. In Group 1 (AVF stenosis), we found that the 24-month primary patency rate was 81.3%. The 24-month primary patency rate was 22.2% in Group 2 (AVF thrombosis), 90% in Group 4 (high-flow AVF) and 75% in Group 5 (deep basilic vein AVF), respectively. Among these groups, we found the lowest 2-year primary patency rate (22.2%) in the thrombectomy group. The 2-year primary patency rates in the other groups ranged from 70.8% to 90%. These results suggest us that the demonstration of the pathology by surgeon-performed US and the appropriate surgical planning made for this give favorable outcomes in the treatment of patients with dysfunctional AVFs and limited vascular structures.

Basilic vein transposition (BVT) is a technically challenging surgical procedure. The maturation period is relatively longer, and there is a higher risk of developing wound complications. In a study conducted in 56 patients undergoing BVT, it was found that the average maturation time of AVF was 74 days (range 12-265 days) and that there was poorer maturation in BVT fistulas in patients over 60 years of age. In addition, it was determined in the same study that 21 (38%) patients had maturation failure and that the 1-year primary and secondary patency rates were respectively 35% and 47% [20]. In our study, we performed BVT in 8 patients in Group 5. BVT made AVFs are brachiobasilic AVFs that actively operate but cannot be used for vascular access due to their deep placement. We transposed the basilic vein to the subcutaneous level in order to provide successful and regular dialysis intervention through these dysfunctional AVFs. In these patients, fistula primary patency rates at 1, 6, 12 and 24 months after surgical reconstruction were 100%, 87.5%, 75% and 75%, respectively. The patients with a preoperative dialysis catheter used their catheters for one month postoperatively and then reconstructed AVFs. When compared with the other study, the 24-month patency rate in our patients was higher. We think that the reason for this difference is that brachio-basilic AVF was created in the past period in our patients and they had a completely maturated fistula.

In conclusion, our primary goal in all patients with vascular access dysfunction was to maintain the AVF. Leaving patients with vascular access dysfunction to fate (no intervention) or AVF ligation is always simpler and easier. However, it should not be forgotten that sources for vascular access are limited in these patients. Rather than creating a new fistula from a different localization, the primary target is to reveal the vascular access pathology in the AVF by physical examination and surgeon-performed detailed US. The number of patients is limited, however reconstruction of dysfunctional AVFs with the optimal surgical planning using minimal incisions is often possible for the surgeon who understands the vascular access pathology in the AVF.

Disclosure of conflict of interest

None.

Address correspondence to: Nail Kahraman, Bursa Yüksek Ihtisas Training and Research Hospital, Department of Cardiovascular Surgery, Bursa, Turkey. E-mail: nailkahraman1979@gmail.com

References

[1] Salahi H, Fazelzadeh A, Mehdizadeh A, Razmkon A, Malek-Hosseini SA. Complications of arteriovenous fistula in dialysis patients. Transplant Proc 2006; 38: 1261-1264.

[2] Rajput A, Rajan DK, Simons ME, Sniderman KW, Jaskolka JD, Beecroft JR, Kachura JR, Tan KT. Venous aneurysms in autogenous hemodialysis fistulas: is there an association with venous outflow stenosis. J Vasc Access 2013; 14: 126-130.

[3] Sigala F, Kontis E, Saßen R, Mickley V. Autologous surgical reconstruction for true venous hemodialysis access aneurysms techniques and results. J Vasc Access 2014; 15: 370-375.

[4] Malik J, Kudlicka J, Novakova L, Adamec J, Malikova H, Kavan J. Surveillance of arteriovenous accesses with the use of duplex Doppler ultrasonography. J Vasc Access 2014; 15: 28-32.

[5] Guedes Marques M, Ibeas J, Botelho C, Maia P, Ponce P. Doppler ultrasound: a powerful tool for vascular access surveillance. Semin Dial 2015; 28: 206-210.

[6] Wong CS, McNicholas N, Healy D, Clarke-Moloney M, Coffey JC, Grace PA, Walsh SR. A systematic review of preoperative duplex ultrasonography and arteriovenous fistula formation. J Vasc Surg 2013; 57: 1129-1133.

[7] Ko SH, Bandyk DF, Hodgkiss-Harlow KD, Barleben A, Lane J 3rd. Estimation of brachial artery volume flow by duplex ultrasound imaging predicts dialysis access maturation. J Vasc Surg 2015; 61: 1521-1527.

[8] Mickley V. Stenosis and thrombosis in haemodialysis fistulae and grafts: the surgeon's point of view. Nephrol Dial Transplant 2004; 19: 309-311.

[9] Rahman A, Ozsin KK. Late complications requiring revision of arteriovenous fistulae for hemodialysis. Turk Gogus Kalp Dama 2008; 16: 167-171.

[10] Patel MS, Street T, Davies MG, Peden EK, Naoum JJ. Evaluating and treating venous outflow stenoses is necessary for the successful open surgical treatment of arteriovenous fistula aneurysms. J Vasc Surg 2015; 61: 444-448.

[11] Shemesh D, Goldin I, Zaghal I, Berelowitz D, Verstandig AG, Olsha O. Stent graft treatment for hemodialysis access aneurysms. J Vasc Surg 2011; 54: 1088-1094.

[12] Riella MC, Roy-Chaudhury P. Vascular access in haemodialysis: strengthening the Achilles' heel. Nat Rev Nephrol 2013; 9: 348-357.

[13] Cho S, Lee YJ, Kim SR. Value of doppler evaluation of physically abnormal fistula: hemodynamic guidelines and access outcomes. Korean J Intern Med 2017; 18: 1-8.

[14] McGill RL, Ruthazer R, Lacson E Jr, Meyer KB, Miskulin DC, Weiner DE. Vascular imaging for hemodialysis vascular access planning. Hemodial Int 2017; 21: 490-497.

[15] Lee KG, Chong TT, Goh N, Achudan S, Tan YL, Tan RY, Choong HL, Tan CS. Outcomes of arteriovenous fistula creation, effect of preoperative vein mapping and predictors of fistula success in incident haemodialysis patients: a single-centre experience. Nephrology 2017; 22: 382-387.

[16] Mallios A, Hebibi H, Jennings W. Perioperative ultrasound: a critical element in diagnosis and salvage of complex vascular access dysfunction. J Vasc Access 2017; 18: 359-361.

[17] Özışık K, Okçu O, Dural K, Yıldırım E, Koçer B, Razkan Y, Sakıncı Ü. Correction of steal syndrome of native arterivenous fistulas in hemodialysis patients by banding technique. J Ankara Med School 2003; 25: 175-8.

[18] Pajek J, Malovrh M, Preoperative ultrasound still valuable for radio-cephalic arteriovenous fistula creation? J Vasc Access 2017; 18: 5-9.

[19] Cingoz F, Gunay C, Guler A, Sahin MA, Oz BS, Arslan M. Surgical repair of aneurysm of arteriovenous fistula in patients with chronic renal failure. Kardiochir Torakochirurgia Pol 2014; 11: 17-20.

[20] Rao RK, Azin GD, Hood DB, Rowe VL, Kohl RD, Katz SG, Weaver FA. Basilic vein transposition fistula: a good option forbmaintaining hemodialysis access site options? J Vasc Surg 2004; 39: 1043-7.