J Surg Med. 2020;4(7):550-554.
DOI: 10.28982/josam.769747

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN=2602-2079

Our arteriovenous fistula experiences with grafts in hemodialysis patients

Hemodiyaliz hastalarında greft ile arteriyovenöz fistül tecrübelerimiz

Cengiz Güven [1], Fatih Üçkardeş [2]

[1] Department of Cardiovascular Surgery, Adiyaman University, Faculty of Medicine, Adiyaman, Turkey
[2] Department of Basic Medical Sciences, Biostatistics and Medical Informatics, Adiyaman University, Faculty of Medicine, Adiyaman, Turkey

ORCID ID of the author(s)
CG: 0000-0001-9693-434X
FÜ: 0000-0003-0677-7606

Corresponding author/Sorumlu yazar:
Cengiz Güven
Address/Adres: Adıyaman Üniversitesi Tıp Fakültesi, Kalp ve Damar Cerrahisi Anabilim Dalı, Adıyaman, Türkiye
E-mail: guvencengz@yahoo.com

Ethics Committee Approval: This study has been approved by Adıyaman University Non-Interventional Clinical Research Ethics Committee with the session number dated 1/14/2020 and 2020/1-4. All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.
Etik Kurul Onayı: Çalışma Adıyaman Üniversitesi Girişimsel Olmayan Klinik Araştırmalar Etik Kurulu tarafından 14.01.2020 ve 2020/1-4 tarihli oturum numarası ile onaylanmıştır. İnsan katılımcıların katıldığı çalışmalardaki tüm prosedürler, 1964 Helsinki Deklarasyonu ve daha sonra yapılan değişiklikler uyarınca gerçekleştirilmiştir.

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Published: 7/30/2020
Yayın Tarihi: 30.07.2020

Abstract

Aim: In patients whose life is dependent on hemodialysis, the most suitable vascular access routes are arteriovenous fistulas made with native vessels. However, in patients whose natural vessels are depleted, or not suitable, arteriovenous fistulas can be opened with artificial grafts. Our aim is to examine arteriovenous fistulas opened with synthetic grafts in hemodialysis patients who do not have native vascular access in the upper extremity and share our results.

Methods: Patients who underwent opening of an arteriovenous fistula with a synthetic graft to the upper extremities in Adıyaman University Faculty of Medicine, Cardiovascular Surgery Clinic between December 2012 and December 2018 were examined in this retrospective cohort study. They were screened for age, gender, end-stage renal failure etiology, complications in vascular access site, postoperative follow-up, and duration of use. Primary and secondary patency rates were determined.

Results: It was determined that synthetic grafts were used in 33 (15 males, 18 females) out of 436 arteriovenous fistulas (AVF) opened to 372 patients. The mean age was 59.2 (17) years. Left radiocephalic (RC) straight graft fistula was opened in 2 patients, left brachiocephalic (BC) straight graft fistula was opened in 12, left BC distal loop AVF in 13, right BC distal loop AVF in 1, left brachioaxillary (BA) distal loop AVF in 3 and right BA distal loop was used to open an AVF in 2 patients. Primary cumulative patency rates were as follows: 72% in the 3rd month, 65% in the 6th month, 42.24% in the 12th month. The secondary patency rates were 33.9% in the 60th month, 12% in the 60th month, 96.96% in the 12th and 24th months, 90.28% in the 36th and 48th months, 59.12% in the 60th month and 43.11% in the 72nd month.

Conclusion: In chronic renal failure patients who do not have a natural vascular access routes or whose natural routes have been exhausted, AVFs that are opened to the upper extremities with a synthetic graft are suitable vascular access routes for long-term dialysis.

Keywords: Chronic kidney failure, Hemodialysis, Synthetic graft, Arteriovenous fistula

Öz

Amaç: Yaşamı hemodiyalize bağımlı hastalarda, en uygun vasküler erişim yolu nativ damarlar ile yapılan arteriyovenöz fistüllerdir. Ancak doğal damarları tükenen veya uygun olmayan hastalarda, yapay greftler ile arteriyovenöz fistüller açılabilir**.** Amacımız üst ekstremitede vasküler erişim yolu olmayan hemodiyaliz hastalarında sentetik greft ile açılan arteriyovenöz fistülleri incelemek ve literatür eşliğinde sonuçlarımızı paylaşmaktır.

Yöntemler: Çalışma retrospektif kohort çalışması olarak tasarlandı. Aralık 2012-Aralık 2018 tarihleri arasında Adıyaman Üniversitesi Tıp Fakültesi Kalp ve Damar Cerrahisi Kliniği'nde üst ekstremitelere sentetik greft ile arteriyovenöz fistül açılan hastalar incelendi. Hastalar yaş, cinsiyet, son dönem böbrek yetmezliği etiyolojisi, komplikasyonlar vasküler erişim bölgesi, postoperatif takip ve kullanım süresi açısından tarandı. Birincil ve ikincil açıklık oranları belirlendi.

Bulgular: Toplamda 372 hastaya açılan 436 arteriyovenöz fistülden 33 (15 erkek, 18 kadın) hastaya sentetik greft ile arteriyovenöz fistül (AVF) açıldığı tespit edildi. Yaş ortalaması 59.2 (17) İdi. Hastaların 2'sinde sol radiyosefalik (RC) düz, 12'sinde sol brakiosefalik (BC) düz greft AVF, 13'ünde sol BC distal loop AVF, 1'inde sağ BC distal loop AVF, 3'ünde sol brakioaksiller (BA) distal loop AVF ve 2'sinde sağ BA distal loop ile AVF açıldığı görüldü. Primer kümülatif açıklık oranları; 3. ayda %72, 6. ayda %65, 12. ay %42,24. ayda %33, 60. ayda %12 iken sekonder açıklık oranları 12 ve 24. aylarda %96,96, 36 ve 48.aylarda %90,28, 60. ayda %59,12 ve 72 ayda %43,11 idi.

Sonuç: Nativ vasküler erişim yolu olmayan veya tükenen kronik böbrek yetmezliğindeki hastalarda, üst ekstremitelere sentetik greft ile açılan AVF'ler, uzun süre kullanılabilen diyaliz erişim yolu sağlayan, uygun bir vasküler erişim yoludur.

Anahtar kelimeler: Kronik böbrek yetmezliği, Hemodiyaliz, Sentetik greft, Arteriyovenöz fistül

How to cite/Atıf için: Güven C, Üçkardeş F. Our arteriovenous fistula experiences with grafts in hemodialysis patients. J Surg Med. 2020;4(7):550-554.

Introduction

Hemodialysis is one of the most common renal replacement methods in patients with end-stage renal failure. Despite the modern methods and techniques used, the average life expectancy of these patients is higher than deaths due to malignancy [1].

Arteriovenous fistula (AVF) applications, described and developed by Brescia and Cimino in 1966, remain popular in hemodialysis patients [2].

Some patients are not suitable for creating arteriovenous fistulas with autologous veins. Although various methods are developed for renal replacement in such patients, such as jugular, subclavian, femoral transient or permanent hemodialysis catheters and peritoneal dialysis catheters, they are not as healthy as native vein AVFs [3].

Specially manufactured artificial polytetrafluoroethylene (PTFE) grafts are used for long-term vascular access in patients with or without depletion of autologous vascular access in the upper extremities [4]. In 1976, Baker LD et al. studied PTFE grafts for dialysis, after which the use of these grafts increased gradually [5].

Our aim in this study was to examine the AVFs we opened with synthetic grafts in patients whose veins were depleted due to multiple AVFs or those whose autologous veins were not suitable and share our experiences.

Materials and methods

This retrospective cohort study started after the approval of Adıyaman University Non-Interventional Clinical Research Ethics Committee was obtained (Date: 1/14/2020, number 2020/1-4). Patients who had AVF opened to the upper extremities between December 2012 and December 2018 were reviewed. None of our patients died during the procedure. However, patients who died during the 6-year follow-up due to comorbid conditions were excluded from the study. The data were gathered electronically from patient files in the hospital registry. Demographic data, surgical complications, physical examination findings, target vascular structures (artery and vein structure where the graft was interposed) were identified and defined. The most frequently used vascular structures, the reasons for the choice of vessel and its differences were investigated technically.

Definitions

Radiocephalic Straight AVF: AVF in which the graft is interposed between the radial artery at the wrist level and the cephalic vein or antecubital vein in the antecubital region (Figure 1A).

Brachiocephalic Straight AVF: AVF where the graft is interposed between the brachial artery in the antecubital region and the region where the cephalic vein pours into the axillary vein (Figure 1B).

Brachiocephalic distal loop AVF: AVF, where the graft is interposed between the brachial artery and the brachial vein in the antecubital region and opened by creating a distal loop (Figure 1C).

Brachioaxillary distal loop AVF: AVF in which the graft is interposed between the brachial artery and the axillary vein in the axillary region and opened by creating a distal loop AVF (Figure 1D).

Primary and secondary patency rates of grafts were recorded. The primary patency rate was defined as the time between the date when the AVF was first opened and when it became dysfunctional for several reasons. Secondary patency rate was defined as the time when the graft was re-functionalized and the time until the second intervention.

Statistical analysis

Statistical analysis to determine patency rates was performed with the Kaplan-Meier method using Graphpad Prism 8.0.2 (La Jolla, CA: GraphPad Software, Inc., accessed at http://www.graphpad.com/scientific-software/prism/). SPSS 22.0 program was used for data analysis. Continuous variable results were reported as mean (standard deviation (SD)). Categorical variables were compared using chi-square homogeneity test and expressed as count and percentage. *P*-value <0.05 was considered statistically significant.

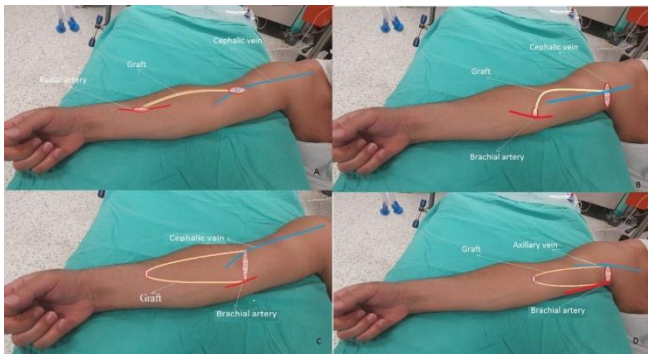

Figure 1: Graft localization. A: Arteriovenous fistula (AVF) with radiocephalic (RC) straight graft, B: AVF with brachiocephalic (BC) straight graft, C: AVF with brachiocephalic (BC) distal loop graft, D: AVF with Brachioaxillary (BA) distal loop graft

Results

The 72-month follow-up results of the patients were examined by scanning patient files. It was determined that a total of 33 patients (15 men, 18 women) had AVFs opened with polytetrafluoroethylene (PTFE) early dialysis grafts to the upper extremity by a single surgical team. The demographic and operative features of the patients are given in Table 1. The mean age was 59.2 (17) years. All patients had at least 3 previous AVFs opened to both upper extremities and none had a chance of native AVF. In AVFs opened with a native vein before the graft, basilic vein transposition was performed. The patients were homogeneously distributed in terms of gender (P=0.273).

Two (6.06%) patients had left-RC AVF, 12 (36.36%) patients, left-BC straight graft AVF, 13 (39.39%) patients, left-BC distal loop AVF, 1 (3.03%) patient, right-BA distal loop AVF, 3 (9.09%) patients, left-BA distal loop AVF and 2 (6.06%) patients had AVF with right BA distal loop graft.

There was no homogeneous distribution in terms of graft localization and position (P<0.001). The rate of left forearm AVFs (84.84%) were significantly higher than left upper arm AVFs (6.06%) and right forearm AVFs (9.09%) (P<0.001). The rate of left BC straight AVFs (36.36%) and left BC distal loop AVFs (39.39%) were significantly higher than other graft positions (P<0.001).

It was understood from the file screening that hypertension, diabetes mellitus and glomerulonephritis were the causes of kidney failure (Table 1). Comorbid features of the

patients are summarized in Table 2. The most common accompanying diseases were atherosclerosis and hypertension.

Table 1: Demographic and operative features

	Mean (SD)	*P*-value
Age(year)	59.2 (17)	
	n (%)	*P*-value
Gender		
Male	15 (45.45%)	0.273
Female	18 (54.54%)	
Graft localization		
Left upper arm	2 (6.06)	
Left forearm	28 (84.84)	<0.001
Right forearm	3 (9.09)	
Graft position		
Left RC AVF	2 (6.06)	
Left BC straight graft AVF	12 (36.36)	
Left BC distal loop AVF	13 (39.39)	<0.001
Right BC distal loop AVF	1 (3.03)	
Left BA distal loop AVF	3 (9.09)	
Right BA distal loop AVF	2 (6.06)	
The cause of kidney failure		
Diabetes mellitus	16 (48.48)	
Hypertension	20 (60.60)	0.024
Glomerulonephritis	6 (18.18)	

* Chi square homogeneity test was used, RC: Radiocephalic, BC: Brachiocephalic, BA: Brachioaxillary, AVF: Arteriovenous fistula

Table 2: Comorbid features of patients

	n
Hypertension	20
Diabetes mellitus	16
Coronary artery disease	12
Morbid obesity (BMI >40)	7
Hyperlipidemia	5
Atherosclerosis	24

n: Frequency, BMI: Body mass index

Early and late complications are summarized in Table 3. The most common early complication was edema. It was found that 2 patients were taken for revision and thrombectomy within the early period (first 48 hours) due to bleeding and 3 patients due to graft thrombosis. Two patients presented to the outpatient clinic in the first 3 months with ischemic pain and were followed up with medical treatment. In the eighth month, one of our patients developed steal syndrome (Figure 2) and AVF was closed due to high flow (Figure 3) on Doppler ultrasonography. Another patient developed pseudoaneurysm (Figure 4) and underwent pseudoaneurysm repair (Table 3).

Table 3: Early / late complications and treatment

Early (first 48 hours)	n	Treatment
Bleeding /hematoma	2	Follow-up
Graft thrombosis	3	Thrombectomy/revision
Edema	6	Follow-up
In the first 2 months		
Graft thrombosis	5	Thrombectomy
Infection	1	Antibiotics
Cellulite	1	Antibiotics
Ecchymosis	4	Follow-up
Ischemic pain	2	Medical treatment
Late (6 months-2 years)		
Graft thrombosis	16	Thrombectomy
Pseudoaneurysm	1	Repair
Steal syndrome	1	Closure of AVF

AVF: Arteriovenous fistula

In the 72-month follow-up of the patients, the cumulative primary patency rates were as follows: 72% at 3 months, 65% at 6 months, 42% at 12 months, 33% at 24 months, 12% at 60 months. There was no open fistula at the 72nd month (Figure 5). Cumulative secondary patency rates were 96.96% for 12 and 24 months, 90.28% for 36 and 48 months, 59.12% for 60 months, and 43.11% for 72 months (Figure 6).

Figure 2: Steal Syndrome in brachiocephalic (BC) distal loop graft fistula

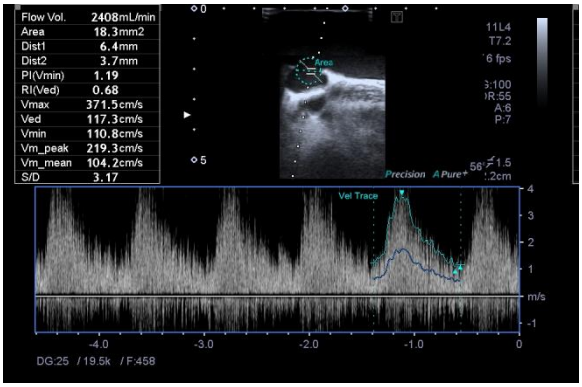

Figure 3: High flow on Doppler ultrasonography in arteriovenous fistula (AVF)

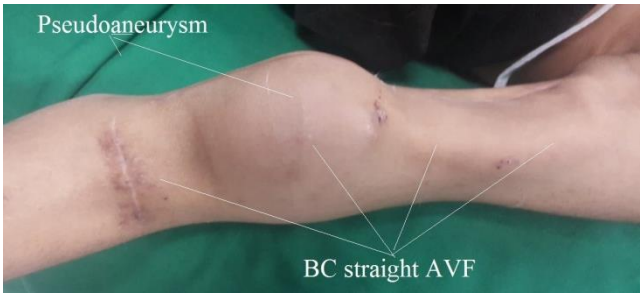

Figure 4: Pseudoaneurysm in brachiocephalic (BC) straight graft arteriovenous fistula (AVF)

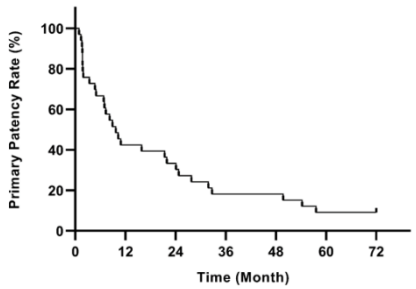

Figure 5: Primary graft patency rates

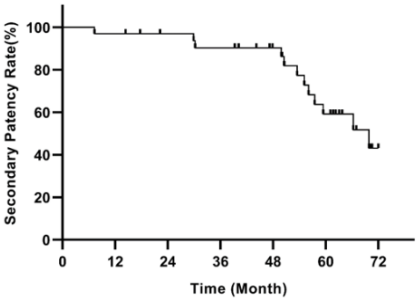

Figure 6: Secondary graft patency rates

The patients in this study consisted of those who had multiple previous AVFs opened to their upper extremities, which all became dysfunctional for several reasons over time, and there was no chance of opening an AVF with other appropriate native veins in the upper extremities. Early dialysis grafts with 4 mm in the arterial side and 7 mm in the venous side were used to prevent ischemia in the hands and fingers. All patients underwent under local anesthesia, 5000 IU heparin was applied before vascular clamps were placed, and no patients were started on prophylactic antibiotics.

Discussion

The preferred vascular access route for hemodialysis is an AVF. For this reason, arteriovenous fistulas, which can be used for a long time for hemodialysis, are vitally important in patients whose lives are dialysis-dependent [6].

However, AVFs cannot be created with native veins in every patient. In the absence or inadequacy of native vessels, artificial grafts can be used for AVF creation in these patients, as needed [7,8].

Patients with end-stage renal disease face multiple AVF openings to the upper extremity throughout their lifetime. The reason for this is that AVFs that open become dysfunctional over time due to thrombosis, infection, and aneurysm. When opening AVFs, the most distal part of the nondominant arm is preferred. RC AVFs created between cephalic vein and radial artery at wrist level are the most preferred routes due to high patency rates [2,9].

Parenteral treatments applied in chronic diseases or repeated multiple vascular interventions for hemodialysis destroy the vessels. For this reason, surgeons have searched for new ways. Microstructured ePTFE grafts with biological structures are the most frequently used artificial grafts for this purpose [10]. These grafts are interposed by passing through a tunnel formed under the skin and forming a straight or U-shaped loop between the artery and vein [11]. While creating AVF with a graft, although there are individual factors, the most preferred artery in the antecubital region is the brachial artery. The most preferred veins include the cephalic vein in the antecubital region and cephalic vein at the axillary region, just before pouring into the axillary vein [11,12].

In our series, 31 of 33 patients had BC AVF. Twelve of these were straight BC grafts, 14 were distal loop BC grafts and 5 were distal loop BA grafts. Our reason for choosing BA distal loop in the last 5 patients was the intense scar tissue which developed due to multiple AVFs that were opened and thrombosed on the forearm. The antero-lateral part of the upper arm was preferred for comfortable cannulation while creating a loop in this region.

The most common complication in PTFE grafts is venous stenosis and thrombosis due to neointimal hyperplasia [13,14].

Dialysis patients must be dialyzed 2 or 3 times a week. For this purpose, complications such as hematoma, bleeding or pseudoaneurysm may also occur due to repeated needle injections to the grafts [7].

The most common early complications were edema and graft thrombosis in our study series. Three patients underwent thrombectomy in the first 48 hours due to graft thrombosis, 2 of which had AVFs opened with RC straight grafts. Thrombosis was associated with a diameter mismatch between the graft and artery. These two patients were observed to use these fistulas for more than two years (secondary patency rates were 50% at 36 months) after thrombectomy and revision. The other patient had a distal loop BA AVF and the graft was thrombosed due twisting in the loop region. For this reason, we believe that such complications can be avoided if the loop area is formed with a wide angle while the graft is passed through the tunnel created under the skin.

Another important complication that required the closure of AVF in our series was steal syndrome in 1 patient, in whom the fistula was closed because of severe ischemia in the outpatient control at the 8th month. The fistula flow rate was measured at 2408 ml/min on colored venous doppler ultrasonography.

Infection rates in PTFE grafts have been reported between 1% and 13% in various series. This is due to compliance with asepsis-antisepsis rules during nursing care and graft cannulation. In our series, our infection rate was 3%, compatible with the literature [15,18].

Pseudoaneurysm is usually caused by degenerative damage to the graft due to repeated cannulations. This complication presents with difficult cannulation, severe pain, and cosmetic problems. While pseudoaneurysm has not been reported in some studies, it has been reported as 23% in others [17,19,20].

In our study, the rate of pseudoaneurysm was limited to 1 patient (3%), who was underweight and had developmental retardation. Surgical repair of the pseudoaneurysm failed due to graft infection, and the graft had to be removed.

Hematoma and edema may occur in the relevant extremity when the graft is passed through the created tunnel under the skin. For this reason, there are publications defending that cannulation should begin after 2-3 weeks of maturation period [17].

However, all patients in our series were cannulated within the first week. The reason for this was attributed to the feature of the used graft. We used 4x7 mm early dialysis grafts, which allow cannulation within the first week [14].

The rate of thrombosis in artificial grafts is 6 times higher than that of native vein AVFs despite the advances in graft technology [7].

Early thrombosis that develops in PTFE grafts is usually caused by surgical technique. In the late period, it is due to intimal hyperplasia, stenosis in venous anastomosis, poor blood flow, hypercoagulability, inappropriate pressure on the graft after dialysis, hypovolemia, and hypotension. The risk increases in diabetic individuals [21]. The one-year primary patency rates of PTFE grafts are between 46% and 68% in the literature [7,22,23].

The primary patency rates were 100% in the first 3 months in BC straight graft patients in our study, 91.6% at 6 months, 75% at 9 months, and 66.7% at 12 months. This rate was 78.5% in the 3rd month, 71.4% in the 6th, 50% in the 9th and 42.8% in the 12th month in BC distal loop AVF, all of which were coherent with the literature [23]. The primary patency rates were 25% at the 3rd, 6th and 9th months in patients with BA distal loop AVF and there was no open fistula at the 12th month. The secondary patency rates of patients in this group were 60%. The RC straight graft patients had 50% patency at the 3rd and 6th months, and there was no primary open fistula at the 9th month. The cumulative primary patency rates in our series were 72% in the 3rd month, 65% in the 6th month, 42% in the 12th month, 33% in 24th and 12% in the 60th month. There was no open primary fistula in the 72nd month. Our secondary cumulative patency rates were 96.96% at the 12th and 24th months, 90.28% at the 36th and 48th months, 59.12% at the 60th month, 43.11% at the 72nd

month, all of which were similar to those reported in the literature. It would be safe to say that our late results were better. The decreased primary patency rates in the first year, compared to the literature, were related with the low rates in RC straight and BA distal loop graft AVFs. This was because of the low opening rates of RC fistulas due to the incompatibility of radial artery diameter with the graft and difficult cannulation in BA distal loop AVFs [24]. Patients in this group had cannulation problems due to morbid obesity.

We believe that nurses should be able to reach vascular maps during dialysis after the AVF is created with a graft. Otherwise the errors in arterial and venous cannulation will result in inadequate dialysis while the patient is connected to the hemodialysis machine and the patient will require multiple vascular interventions, both of which will decrease the life of the graft.

Our study center is the only one which provides venous access to dialysis patients in the area, along with dialysis services. Surgeries are usually performed by a single surgical team and patient records are kept digitally. Considering factors such as timely and necessary intervention of complications and patient follow-up, we think it is important both to open the patient's fistula and to perform dialysis in a single center.

Limitations

The most important limitation of our study is its single-centered design. Compared to similar studies, the number of patients was sufficient, and we did not find any similar studies in the literature reporting 6-year follow-up results in a single center, which is the strength of our study.

Conclusion

When forming an AVF with a graft, we recommend preferring the brachial artery and cephalic vein in the antecubital region, followed by the cephalic vein in the axillary region. We believe that PTFE grafts can be used with low complications for long-term vascular access with correct surgical technique, appropriate vessel selection and proper cannulation for hemodialysis patients.

References

1. Bozkurt O, Topal C, İnanç M. The relationship between dialysis adequacy and the rate of change in uric acid level by hemodialysis. J Surg Med. 2018;2(3):293-7.
2. Brescia MJ, Cimino JE, Appel K, Hurwich BJ. Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. N Engl J Med. 1966;275:1089-92.
3. Hodges TC, Fillinger MF, Zwolak RM, Walsh DB, bech F, Cronenwett JL. Longitudinal comparison of dialysis access methods: risk factors for failure. J Vase Surg. 1997;16:1009-19.
4. Çekirdekçi A, Rahman A, Burma O, Cihangiroglu M. Polytetraflouroethylene {PTFE) Greftlerle Hemodializ Amaçlı Arterio-Venoz Fistül Uygulamaları. Damar Cerrahisi Dergisi. 2000;3:24-7.
5. Baker LD, Johson JM, Gold farb D:Expanded Polytetraflouroeethylene (PTFE) Subcutaneus Conduit: An İmproved Vascular Access for Chronic Hemodialysis. Trans Am Soc Artif İntern Organs 1976;22:382-7.
6. Albers FJ. Causes of hemodialysis access failure. Adv Ren Replace Ther 1994;1(2):107-18.
7. Beathard GA, Lok CE, Glickman MH, Al-Jaishi AA, Bednarski D, Cull DL, et al. Definitions and End Points for Interventional Studies for Arteriovenous Dialysis Access. Clin J Am Soc Nephrol. 2018;13(3):501-12. doi:10.2215/CJN.11531116
8. Leake AE, Yuo TH, Wu T, Fish L, Dillavou ED, Chaer RA, Leers SA, Makaroun MS: Arteriovenous grafts are associated with earlier catheter removal and fewer catheter days in the United States Renal Data Systempopulation. J Vasc Surg 2015;62:123–7.
9. Gibbons CP. Primary vascular access. Eur J Vasc Endovasc Surg. 2006;31(5):523-9. doi: 10.1016/j.ejvs.2005.10.006. Epub 2005 Nov 17. PMID: 16298148.
10. Kaufman JL. Revisional surgery for hemodialysis access. Sem Dial. 1996;9:41-50.
11. Ergüneş K, Yaşa H, Özelçi A,İlhan G, Gökalp O, Göktoğan T, et al. Hemodiyaliz Gerektiren Kronik Böbrek Yetmezlikli Hastalarda Arteriovenöz Fistül Oluşturmak İçin E-Politetrafloretilen Greft Kullandığımız hastalardaki Klinik Deneyimlerimiz. Damar Cer Derg. 2008;17(2):68-72.
12. Han S, Seo PW, Ryu JW. Surgical Outcomes of Forearm Loop Arteriovenous Fistula Formation Using Tapered versus Non-Tapered Polytetrafluoroethylene Grafts. Korean J Thorac Cardiovasc Surg. 2017;50(1):30-5. doi:10.5090/kjtcs.2017.50.1.30.
13. Roy-Chaudhury P, Kelly BS, Miller MA, Reaves A, Armstrong J, Nanayakkara N, et al. Venous neointimal hyperplasia in polytetrafluoroethylene dialysis grafts. Kidney Int. 2001;59(6):2325-34. doi:10.1046/j.1523-1755.2001.00750.x
14. Besarab A, Kumbar L. How arteriovenous grafts could help to optimize vascular access management. Semin Dial. 2018;31(6):619-24. doi:10.1111/sdi.12718
15. Gilliland M, Brown JS, Pryor L. Nursing Care for Patients with Synthetic Arteriovenous Grafts. Nephrol Nurs J. 2017;44(5):391-8.
16. Maya ID, Weatherspoon J, Young CJ, Barker J, Allon M. Increased risk of infection associated with polyurethane dialysis grafts. Semin Dial. 2007;20:616-20.
17. Kakisis JD, Antonopoulos C, Mantas G, Alexiou E, Katseni K, Sfyroeras G, et al. Safety and efficacy of polyurethane vascular grafts for early hemodialysis access. J Vasc Surg. 2017;66(6):1792-7. doi:10.1016/j.jvs.2017.06.083
18. Ryan SV, Calligaro KD, Scharff J, Dougherty MJ: Management of infected prosthetic dialysis arteriovenous grafts. J Vasc Surg. 2004;39:73-8.
19. Florescu MC, Qiu F, PlumbTJ, Fillaus JA. Endovascular treatment of arteriovenous graft pseudoaneurysms, indications, complications, and outcomes: A systematic review. Hemodial Int. 2014;18:785-92.
20. Balaz P, Bjorck M. True aneurysm in autologous hemodialysis fistulae: Definitions, classification and indications for treatment. J Vasc Access. 2015;16:446-53.
21. Ponce KLP, Tejada-Tayabas LM, González YC, Haro OH, Zúñiga ML, Morán ACA. Nursing care for renal patients on hemodialysis: Challenges, dilemmas and satisfactions. Rev Esc Enferm USP. 2019 Dec 2;53:e03502. Spanish, English. doi: 10.1590/S1980-220X2018011103502. PMID: 31800805.
22. Matsuura JH, Rosenthal D, Clark M, Shuler FW, Kirby L, Shotwell M, et al. Transposed basilic vein versus polytetrafluorethylene for brachial-axillary arteriovenous fistulas. Am J Surg. 1998;176(2):219-21. doi:10.1016/s0002-9610(98)00122-6.
23. Huber TS, Carter JW, Carter RL, Seeger JM. Patency of autogenous and polytetrafluoroethylene upper extremity arteriovenous hemodialysis accesses: A systematic review. J Vasc Surg. 2003;38(5):1005-11. doi:10.1016/s0741-5214(03)00426-9.
24. Bosman PJ, Blankestijn PJ, van der Graaf Y, Heintjes RJ, Koomans HA, Eikelboom BC. A comparison between PTFE and denatured homologous vein grafts for haemodialysis access: a prospective randomised multicentre trial. The SMASH Study Group. Study of Graft Materials in Access for Haemodialysis. Eur J Vasc Endovasc Surg. 1998;16(2):126-32. doi: 10.1016/s1078-5884(98)80153-6.

This paper has been checked for language accuracy by JOSAM editors.
The National Library of Medicine (NLM) citation style guide has been used in this paper.