Dialysis Access Cases

Practical Solutions to Clinical Challenges

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Preface

The practice of any procedural discipline is both a science and an art. In previous textbooks, edited by some of us, we tried to summarize the current state of hemodialysis access science. The purpose of this textbook, on the other hand, is to focus on the art of this medical discipline.

In this book the reader will find a multitude of cases, summarized by masters of the art of vascular access care, who articulate a broad, diverse, and creative vision of their practice. Clinical problems from routine access creation to advanced novel techniques are described in these pages. Thus, the purpose of this textbook is to educate the novice as well as to delight the expert.

Needless to say, we took great inspiration from our patients in putting this work together. Vascular access care requires repeated contact with the same patients on a regular basis. As a result, tremendously close bonds are formed. In some instances, we shared the chapters with our patients who "starred" in the cases. In all instances, we are deeply indebted to our patients for allowing us to use our minds, our hands, and our hearts to help them.

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Part I
Arteriovenous Fistula

Chapter 1
Arteriovenous Graft-Arteriovenous Fistula Conversion (Secondary Arteriovenous Fistula Creation)

Elliot I. Grodstein and Robert R. Redfield III

Abbreviations

AV	Arteriovenous
FFCL	"Fistula First Catheter Last" Coalition
K/DOQI	Kidney Disease Outcomes Quality Initiative
sAVF	Secondary arteriovenous fistula

Case Presentation

A 65-year-old male has been dialyzed for 4 years via a left forearm looped brachio-basilic arteriovenous (AV) polytetrafluoroethylene graft. At the time of access creation, his basilic, median antebrachial, and cephalic veins in his forearm and upper arm were not suitable for construction of a primary AV fistula. Over the past few months, he has had difficulty achieving adequate dialysis flow rates during his Monday/Wednesday/Friday sessions. On exam, he is noted to have a pulse in his graft. He was referred to an interventional nephrologist who performed an angiogram demonstrating a venous anastomotic stenosis of greater than 50% of the luminal diameter (see Fig. 1.1). There was no upper arm or central venous stenosis present. An angioplasty was performed, and the patient was dialyzed for another 2 months until the graft thrombosed. Despite attempts to reestablish flow, the thrombosis could not be corrected. A right-sided internal jugular hemodialysis catheter

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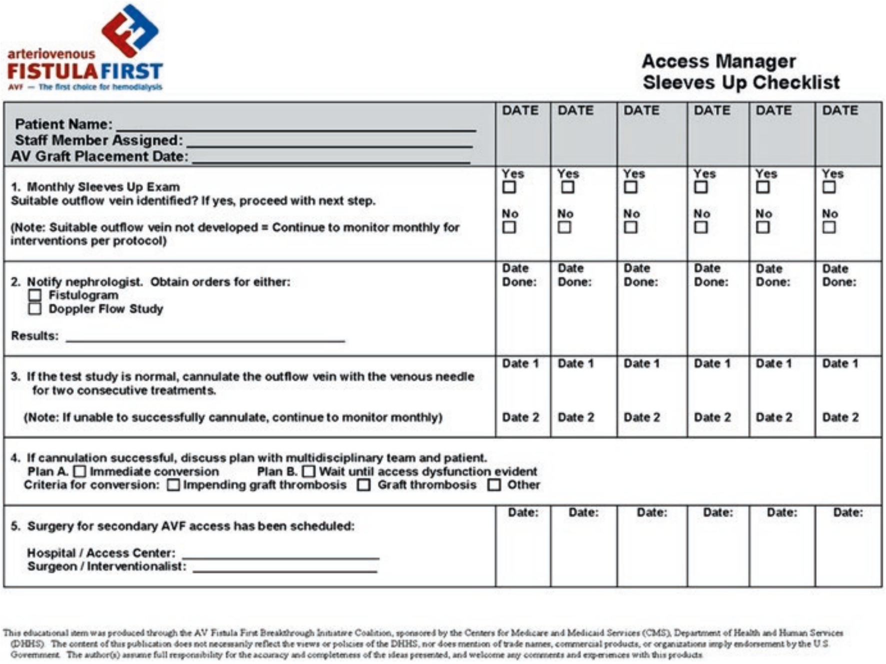
arteriovenous FISTULA FIRST
AVF — The first choice for hemodialysis

Access Manager
Sleeves Up Checklist

Patient Name: ______ Staff Member Assigned: ______ AV Graft Placement Date: ______	DATE	DATE	DATE	DATE	DATE	DATE
1. Monthly Sleeves Up Exam Suitable outflow vein identified? If yes, proceed with next step. (Note: Suitable outflow vein not developed = Continue to monitor monthly for interventions per protocol)	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
2. Notify nephrologist. Obtain orders for either: ☐ Fistulogram ☐ Doppler Flow Study Results: ______	Date Done:	Date Done:	Date Done:	Date Done:	Date Done:	Date Done:
3. If the test study is normal, cannulate the outflow vein with the venous needle for two consecutive treatments. (Note: If unable to successfully cannulate, continue to monitor monthly)	Date 1 Date 2	Date 1 Date 2	Date 1 Date 2	Date 1 Date 2	Date 1 Date 2	Date 1 Date 2
4. If cannulation successful, discuss plan with multidisciplinary team and patient. Plan A. ☐ Immediate conversion Plan B. ☐ Wait until access dysfunction evident Criteria for conversion: ☐ Impending graft thrombosis ☐ Graft thrombosis ☐ Other						
5. Surgery for secondary AVF access has been scheduled: Hospital / Access Center: ______ Surgeon / Interventionalist: ______	Date:	Date:	Date:	Date:	Date:	Date:

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Fig. 1.1 Sleeves Up Protocol checklist. Courtesy of End Stage Renal Disease National Coordinating Center

was placed. The patient was subsequently referred to a local vascular surgeon for reconstruction of peripheral access. Approximately 4 months later, a contralateral brachiocephalic AV fistula was constructed. The catheter was removed 2 months later, once the fistula matured. In the interim, he was hospitalized once with a methicillin-resistant *Staphylococcus aureus* bloodstream infection. The line was removed and replaced on the contralateral side. He was treated with vancomycin immediately after his hemodialysis sessions for 4 weeks.

Discussion

Unfortunately, as in the case above, AV graft failure is all too frequent, requiring subsequent catheter placementa. The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (K/DOQI) clinical practice guidelines prioritize the construction of autogenous AV fistulae in a distal-to-proximal fashion, always considering the preservation of more proximal surgical sites for future access construction. This emphasis is based on fistula's inherent higher primary and secondary patency rates and, with that, a lower need for interventions and, in select groups, longer patient survival. The K/DOQI guidelines, along with the "Fistula First Catheter Last" (FFCL) Coalition, seem to have changed practice patterns in the

United States [1]. From 1996 to 2007, autogenous fistula access use in the United States increased from 24% to 47%, while prosthetic graft use decreased from 58% to 28%. Still, however, 53% of patients are dialyzed via a central venous catheter or AV graft. To contextualize, in Japan, according to the collaborative international Dialysis Outcomes and Practice Patterns Study, this number is only 9% [2].

In most cases, as in the case above, AV graft failure is followed by a period of catheter placement prior to construction of new access. This cycle often repeats itself leading to unnecessary catheter days and high risks of central line-associated bloodstream infections. To avoid this, the FFCL has advocated for proactive construction of new AV fistulas prior to graft failures, so-called secondary AV fistulas (sAVF). The FFCL recommends nephrologists evaluate every AV graft patient for possible sAVF conversion [3, 4] and has put forth a convenient "Sleeves Up Protocol" to assist with this. The evaluation, which occurs briefly at bedside immediately prior to or after a dialysis session, helps identify suitable outflow vein for immediate conversion to an AVF. Every month, a practitioner should roll the patient's "sleeves up" exposing the entire arm up to the shoulder. Then, the upper arm should be lightly compressed to assess the caliber and prominence of the graft's venous outflow. If the primary outflow vein appears suitable for access, it should be cannulated with the venous dialysis access needle for two consecutive hemodialysis sessions. If there are no issues, a fistulogram or duplex ultrasound of the arm should be performed to confirm the vein's suitability and ensure patent venous drainage back to the right atrium. Assuming both of these tests go well, a prompt sAVF conversion plan should be made (see Fig. 1.1).

While AV grafts may spontaneously stop working, graft dysfunction is often predictable. Indicators of venous outflow stenosis include strong pulsatility and shortening or even absence of the diastolic phase of the thrill on exam. In severely obstructed grafts, there may be only a high-pitched thrill during systolic phase. Indicators of outflow problems on dialysis may include low flow rates, high venous pressures, or increased recirculation. There may be persistent post-dialysis bleeding. Other predictors of graft failure include requiring multiple interventions to maintain patency. Cumulative patency at 12 months of angioplastied grafts is around 30–50%, whereas it is only around 10–20% in thrombectomized grafts. Unfortunately, recent studies have shown no benefit to prophylactic treatment of graft stenosis detected on routine angiography. Thus, a preemptive sAVF conversion plan should be considered in patients with graft dysfunction requiring endovascular therapy. Similarly, as AV grafts have a greater rate of infection than autologous fistulae, sAVF is an attractive option to preserve access in patients requiring graft excision from recurrent infections. All of this forms the basis for the FFCL's recommendation that evaluation for sAVF conversion takes place no later than the first signs of AV graft failure. Meanwhile, the impetus is on the surgeon to perform the operation prior to a second intervention for graft stenosis or thrombosis. As such, the prudent surgeon should plan for sAVF conversion while placing an AV graft in a patient with initially unsuitable venous targets (see Fig. 1.2). In fact, in these cases, if a patient is being dialyzed via a catheter, an AV graft can be placed as a bridge to sAVF. Here, an immediate-access graft conduit (e.g., Flixene) is used to

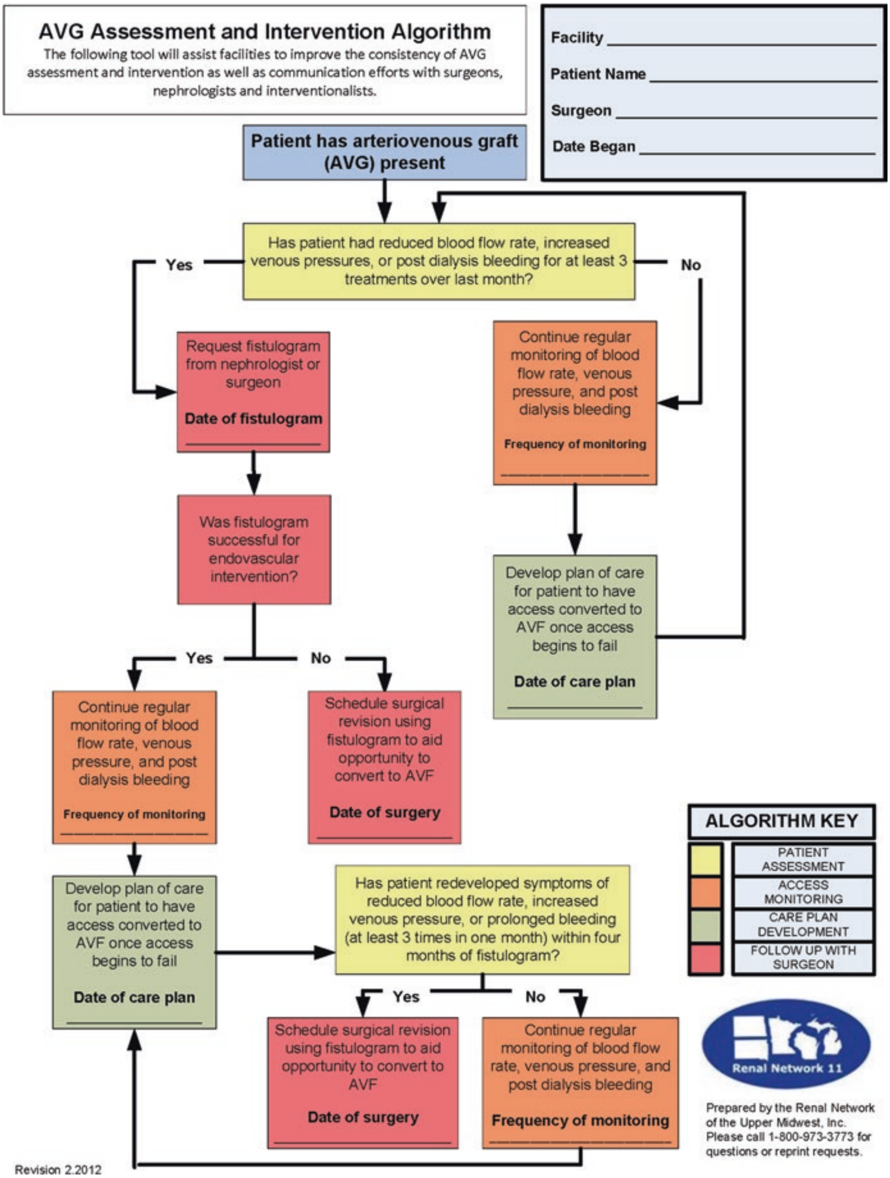

Fig. 1.2 AV graft assessment and intervention algorithm (Reprinted with permission from The Midwest Kidney Network)

allow prompt removal of the catheter. Months later, once the outflow becomes suitable, the graft can be excised and a sAVF constructed.

The classic sAVF, constructed using the main outflow vein from a graft, is termed a Type 1 sAVF. These fistulae can be constructed using below- or above-the-elbow

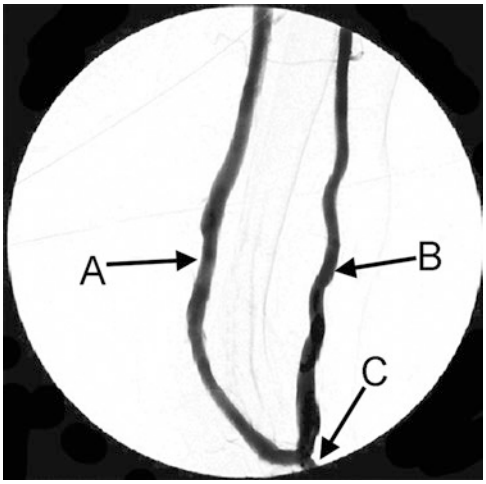

Fig. 1.3 Angiogram of upper arm veins draining a forearm loop graft: (**a**) basilic vein and (**b**) cephalic vein (**c**) venous anastomosis with lower arm AV graft (Reprinted with permission from Beathard [5])

veins following placement of a forearm AV graft. Duplex sonography and contrast venography are essential to both identify outflow veins of sufficient caliber and rule out central venous stenosis. Approximately 75% of patients with forearm AV grafts have vascular anatomy suitable for construction of a Type 1 sAVF (see Fig. 1.3). In the simplest scenarios, the sAVF can be made using arterialized basilic, cephalic, or brachial vein just distal to the previous venous anastomosis. Arterial inflow is typically provided by the brachial or proximal radial artery. Intraoperatively, the AVG is ligated and the outflow vein is mobilized and used for an anastomosis. To gain additional length, venous tributaries flowing into the suitable vein can be mobilized and used for an anastomosis. Frequently, after construction, Type 1 sAVFs are immediately available for dialysis access. A basilic or brachial vein can be transposed to a superficial position at the same time or as a staged approach. Even despite complete graft thrombosis, primary draining veins are often kept patent by tributaries, and a fistula can be constructed (see Fig. 1.4). In these settings, timely Type 1 sAVF construction can avert the need for catheter placement where it would otherwise be necessary.

In cases where the AV graft outflow is not amenable to Type 1 sAVF creation, vein mapping of the ipsilateral arm should be performed with the goal of finding other veins suitable for fistula creation. More frequently, these are patients with upper arm AV grafts, where only a small segment of primary outflow vein exists distally to the axilla. It remains important to still ensure that there is no central venous stenosis. As for termed Type 2 sAVFs, these are not dissimilar from standard primary AV fistulae and must be promptly constructed. The ipsilateral proximal radial artery will often have adequate inflow in an untouched surgical field. Venous targets may be more difficult to find however. Other than the median antebrachial or cephalic veins, in the setting of more proximal obstruction, forearm veins may be used in a retrograde fashion once valves are obliterated. Perforating veins may also be used. Overall, proximal radial artery fistulas have low rates of steal with excellent

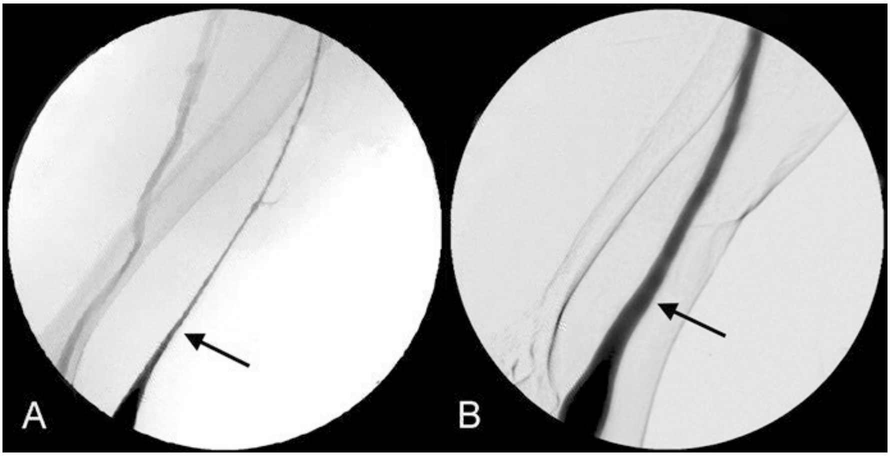

Fig. 1.4 Appearance of the left arm cephalic vein receiving drainage from a clotted forearm AV graft. The cephalic vein is indicated by the *arrow*. (**a**) Appearance when the graft is clotted with no flow or pressure. (**b**) Same vein with flow and pressure after graft was opened (Reprinted with permission from Beathard [5])

2-year secondary patency rates. If however there are no inflow or outflow options on the ipsilateral arm, the contralateral arm must be interrogated for de novo fistula creation. Unfortunately, whereas a failing AV graft will hopefully last long enough to allow for maturation, a failed AV graft will require interim dialysis catheter placement. Therefore, early recognition of graft dysfunction and construction of autologous access are a priority.

Pearls

- New autogenous access sites should be considered prior to AV graft failure to avert the need for hemodialysis catheter placement.
- Primary dialysis providers can evaluate patients for suitability for referral for secondary AV fistula formation quickly, during hemodialysis sessions.
- Secondary AV fistulas can frequently be constructed using the primary outflow of an AV graft, allowing immediate use for hemodialysis.

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Chapter 2
Proximal Forearm Arteriovenous Fistula Creation

Venkat Kalapatapu and Andre Ramdon

Introduction

Worldwide greater than two million patients need renal replacement therapy. The aging population coupled with increasing need of dialysis access leaves surgeons gaining innovative ways to solve this crisis. Guidelines developed by the DOQI and Society of Vascular Surgery advised the creation of autologous fistula due to better long-term patency, fewer re-interventions, lower health-care cost, and low incidence of complications before use of grafts [1, 2]. Fistula first initiative uses distal radiocephalic and snuff box as the first choice, but this is impeded by lack of appropriately sized vessels for fistula creation and relatively high rates of non-maturations (8–40%).

Proximal forearm fistula has become grossly overlooked, likely due to the paucity of published literature, but is still a viable option. This preserves arm vessels for future use and has the theoretical advantage of reduced risk of steal syndrome, ischemic monomelic neuropathy, and high-output cardiac failure.

Proximal Radiocephalic Arteriovenous Fistula

Proximal radiocephalic arteriovenous fistula (pRCF) is an infrequently used option between the proximal radial artery and cephalic vein, first described in 1997 by Gracz et al. [3].

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Fig. 2.1 Proximal radiocephalic fistula (the anastomosis can be to the radial artery at the elbow)

Fig. 2.2 Proximal radiocephalic fistula after failed distal radiocephalic fistula

This is an end-to-side construct through a 4–6 cm longitudinal incision commencing 1–2 cm below the antecubital crease and along the separation between the brachioradialis and flexor carpi radialis muscle. This allows mobilization of the cephalic vein and radial artery for an end-to-side anastomosis. This has a few options for venous outflow from the cephalic veins to the medial antecubital or a perforating vein. If the inflow through the radial artery is unfit, then the medial portion of the proximal incision can be extended to utilize the brachial artery for inflow.

The anastomosis is usually very deep and covered by muscles, which is thought to be protective. A large series of 105 patients reported a 91% primary patency after 11 months of follow-up [4]. A retrospective single-institution review of proximal vs. distal radiocephalic fistula revealed that patients are more likely to have had previous access (47% vs. 18%) and despite this have a low primary failure rate (32% vs. 59%). Cumulative pRCF vs. distal radiocephalic fistula patency was 92% vs. 86% at 1 year [5]. Proximal radiocephalic fistula is an attractive option for non-maturation distal radiocephalic fistula as the cephalic vein is likely more sizable distally and using the radial artery as inflow will limit the risk of steal and preserving the brachial inflow, thus, limiting steal and ischemic monomelic neuropathy (Figs. 2.1 and 2.2).

Basilic Vein Arteriovenous Fistulas in the Forearm

Forearm basilic vein fistula remains an underutilized option for fistula creation, even though advocated for by some authors on the basis of preservation of arm veins with patency rates greater than forearm grafts. The availability of literature with forearm basilic vein is rather scant, and the guidelines continue to exclude this as an option. Basilic veins can be anatomically deep in location making accessibility difficult but more likely preserved due to hidden nature and less susceptibility from multiple needle sticks or even previous access attempts. There are two constructs that can be utilized using either the radial or ulnar artery as the inflow. Both types are suggested to need transposition to allow for dialysis needle access. It is anxiety provoking to create an ulnar-basilic AVF (UBAVF) after a failed distal radiocephalic fistula due to the increased risk of distal ischemia reported to be 28% in one series. UBAVF has much higher failure rates and longer maturity times compared to distal radiocephalic fistula with 1-year patency rates that range from 42% to 70% and a secondary patency rate of 53% [6]. Complication of hand ischemia is 0.4% in one pooled analysis.

Transposed radio-basilic fistula (tRBF) is gaining favor and is particularly attractive after failure of distal radiocephalic fistula with a reported 1-year patency rate as high as 93% in a small series of 30 patients (mostly after a thrombosed cephalic vein) [7–9]. Patency rates are non-inferior to arteriovenous grafts but more importantly without the infectious risk. Additionally, if not matured enough to be used for dialysis, it will contribute to the increased size of arm veins and hence extrapolates to improved outcomes of a more proximal fistula patency at a later date. One study comparing tRBF vs. arteriovenous graft proves fistula first is better with reported patency periods of 16.9 vs. 12.6 months with primary-assisted patency at 1 year 79% and 75%, respectively [9, 10]. Compared to distal radiocephalic fistula, primary patency rates are lower at 1 year (40–54%) and with maturation failure as high as 14% [7, 10]. Shintaro and Natario et al. suggested that low initial patency could be improved with intense observation and surveillance with early introduction of balloon angioplasty to increase as much as 77% [7, 11].

Procedurally, tRBF is more difficult with longer operative time but still feasible under local anesthesia. Preoperative duplex ultrasound is important in patient selection and planning of these fistulas. Technique is key: skin sparing with three to four separate incisions for harvest or long elbow-to-wrist incision with a counter-incision over the approximate radial artery after tunneling of available vein. The basilic vein usually runs a little far from the arteries; hence, usually the best positioning during harvesting is flexion at the elbow with forearm supination. General principles of harvesting apply with special care not to injure the vein. The basilic vein after ligation of the side branches forms a high-resistance conduit which is prone to thrombosis [8]. Once the vein is harvested, great care is taken to gently angio-dilate. Some authors prefer to use a 3/4 Fogarty catheter. Meticulous tunneling then allows for subcutaneous access and anastomosis to the radial artery. This moves the vessel away from its native course which can be deep and restrictive with scar tissue formation and healing. Anastomosis is created in an end-to-side construct with

Glowinski et al. suggesting 6 mm as being better than a larger diameter [8]. This can be performed in the forearm from the brachial to the distal radial depending on the suitability with maximizing the entire vein by looping as is needed. Outcomes are dependent on vein size with 3.5 mm vein yielding patency of 93/78/55% at 1, 2, and 3 years, respectively. Use of 2.5 mm veins yields a 1-year patency of 54% [7]. Duplex ultrasound should also demonstrate good inflow with radial artery diameter of >2.5 mm. Silva classified anatomic variants of the basilic vein into three types [9]. Type A (15%) vein is close to the radial artery, and a single incision is needed for harvest and creating anastomosis. Type B (33%) vein is located dorsally, and type C (52%) vein is more volar. Both B and C require separate incisions for harvest and anastomosis, but all will need superficialization for the normal deep position.

Conclusion

Proximal forearm fistula remains an untapped resource for fistula creation, which has escaped the guidelines but is with acceptable patency rates and preservation of arm veins for future use. Additionally, this offers a theoretical reduced risk of steal syndrome, ischemic monomelic, and high-output cardiac failure. This requires a skilled and highly experienced team of surgeons, nephrologists, and dialysis nurses to ensure the success of these accesses. More studies are encouraged to continue for the improvement of these unique proximal forearm fistulas.

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Chapter 3
Fistula with Stenosis of Feeding Artery

Gerald A. Beathard

Case Presentation

The patient is a 75-year-old female with a radial cephalic fistula (AVF) in her left arm. The fistula was created 6 months ago but has not matured adequately for dialysis use. The patient was sent to the vascular access center for evaluation. Physical examination revealed that the fistula was not visible. A soft thrill and bruit, systolic only, were present over the anastomosis. The pulse augmentation was poor (3/10).

The AVF was cannulated in an upstream direction, and a sheath was inserted. A retrograde arteriogram of the anastomosis and lower radial artery was performed. This showed a focus of marked stenosis approximately 3 cm above the anastomosis (Fig. 3.1). This lesion was dilated using a 4 × 4 angioplasty balloon with good results (Fig. 3.2). Blood flow in the fistula was improved. Physical examination was repeated and showed improvement of the thrill and bruit at the anastomosis. Pulse augmentation was improved (5/10) but was not optimal. A guidewire was inserted, passed across the arterial anastomosis, and advanced up to the level of the subclavian artery. An antegrade arteriogram was performed which showed multiple areas of stenosis in the proximal radial artery just distal to the bifurcation (Fig. 3.3). A 5 × 4 angioplasty balloon was inserted over the guidewire and advanced up to the level of the stenoses. These were dilated with good result (Fig. 3.4).

Following this procedure, the radial cephalic AVF was visible to the level of the elbow. Blood flow in the fistula was good. The thrill and bruit at the anastomosis were systolic and diastolic and of good quality. Pulse augmentation improved to an optimal level (10/10). The AVF was used successfully for dialysis.

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Fig. 3.1 Angiogram showing just anastomotic fistula and artery (Note the stenotic area in the artery approximately 3 cm above the anastomosis (*arrow*))

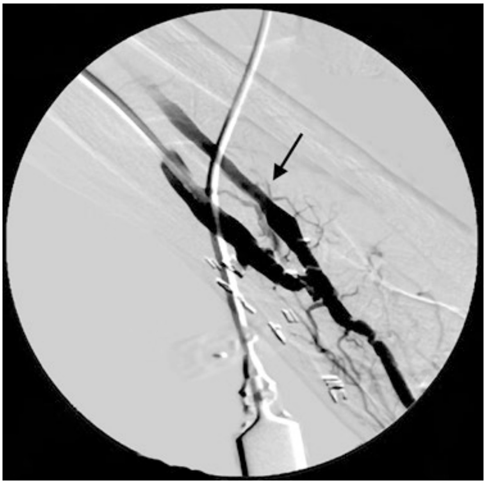

Fig. 3.2 Appearance of artery following treatment with 4 × 4 angioplasty balloon (*arrow* indicates site of previous lesion)

Discussion

The dialysis vascular access should be thought of as a complete circuit starting and ending with the heart. The venous side, the AVF and its draining veins, represents only one-half of the circuit; the other half is arterial. Lesions in this region adversely affect inflow. These may be within any of the arteries that ultimately lead to the access, or they can affect the arterial anastomosis, which is considered to be the arterial component of the access itself. Frequently these two types of lesions are reported together with juxta-anastomotic lesions as inflow stenosis. These lesions can lead to decreased blood flow in the access, which can result in inadequate dialysis if the AVF is functional and failure to mature in a newly created AVF.

Fig. 3.3 Arteriogram showing bifurcation and proximal radial artery. Site of stenotic lesions indicated by *arrows*

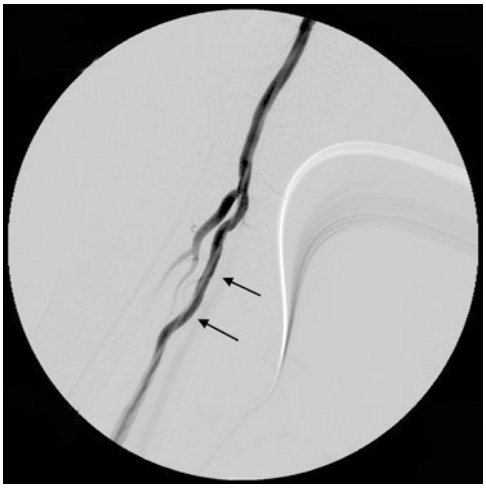

Fig. 3.4 Appearance of artery following treatment with 5 × 4 angioplasty balloon (*arrows* indicate sites of previous lesions)

In a report dealing with a cohort of 101 dysfunctional AVF cases [1], 8% were found to have lesions in the feeding artery, and 21% had stenosis of the arterial anastomosis. There was a higher incidence of inflow stenosis for forearm as compared to upper arm AVFs. Others [2, 3] have reported the incidence of arterial stenosis in these cases at 6–18%.

Inflow lesions are the most common cause of failure of a newly created AVF to mature. These lesions result in decreased fistula blood flow leading to problems of maturation and often early thrombosis. The most common inflow lesion resulting in failure of an AVF to mature is stenosis of the juxta-anastomotic segment of the AVF [2, 4–11]. This makes it the most common lesions associated with this problem; however, stenosis of the inflow artery also occurs and has a similar effect.