DEBATE

Peter F. Lawrence, MD, Section Editor

The optimal initial choice for permanent arteriovenous hemodialysis access

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POSITION: CURRENT FUNCTIONAL PATENCY RATES OF ARTERIOVENOUS FISTULAS JUSTIFY SELECTIVE USE OF PROSTHETIC GRAFTS

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Chronic kidney disease is a devastating condition that, according to 2008 data, affects 33 million Americans, or 16% of the United States population, with diabetes mellitus replacing hypertension as the most frequent etiology. Paralleling the increase in chronic kidney disease is the number of patients requiring vascular access for hemodialysis.[1] In 2009, the incidence of new patients per year of hemodialysis in the United States was ~106,000 and the prevalence was >370,000.[1]

Since the introduction of the arteriovenous (AV) fistula in 1966 by Brescia and Cimino et al, vascular access procedures have become one of the most frequent operations in the United States. It is estimated that >500,000 vascular access surgeries (including revisions) are being performed annually.[2] This substantial population living with end-stage renal disease has become a major component of Center for Medicare and Medicaid Services (CMS) spending, with the total 2009 Medicare expenditure for hemodialysis patients >$20 billion.[1]

After the release of Kidney Disease Outcome Quality Initiative (KDOQI) guidelines[3] recommending AV fistula as the preferred vascular access for most patients and adoption of the Fistula First Breakthrough Initiative (FFBI), formerly known as the National Vascular Access Improvement Initiative,[4] the number of AV fistulas in prevalent hemodialysis patients increased from 38.6% in 2003 to 55% in 2007, whereas AV graft use decreased from 42.9% to 27.2%.[1] An analysis of vascular access data from the 2008 end-stage renal disease (ESRD) clinical performance project indicates that ~41% of incident patients and 49% of all patients were dialyzed with an AV fistula during their last dialysis session.[5] The first network to achieve the fistula-first goal was the Northwest Renal Network, which as of August 2010, achieved an AV fistula rate of 67.7%.[6] Although the incidence of fistula placement has increased, the need for immediate vascular access through a central venous catheter (CVC) during this same time period changed only slightly, from 18.5% to 17.7%.[1]

The KDOQI and FFBI guidelines rightly promote the increased use of autogenous vascular access because of superior patency rates and lower complication rates than grafts once the access is established.[7] After all, we first established this concept 3 decades ago.[8] Yet many patients do not have suitable venous anatomy to support an AV fistula, with the contemporary result that >50% of AV fistulas fail to attain suitability for hemodialysis.[9] In short, half of all AV fistula operations performed nationwide today fail.

In this discussion, we will point out the rationale for appropriate, selective use of AV grafts and also show where the results of AV fistula must be critically analyzed. Our central point will not be to prove that grafts are superior but that they have an important role in those carefully selected patients in whom an AV fistula simply cannot be constructed successfully. Access-related morbidity remains the major impediment to full rehabilitation of the long-

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term hemodialysis patient.[10] We will emphasize consideration of individual circumstances in deciding on the best operation, including anatomy, patient age, avoidance of CVCs, and anticipated time to begin dialysis. Advocacy for AV fistula must not replace scholarship.

Acknowledged advantages of AV fistulas. Compared with AV grafts and catheters, the rate of infection remains lowest with AV fistulas, at 0.18 per patient-year vs 0.39 for AV grafts and 1.45 for catheters.[1] Once established, AV fistulas also have longer primary patency rates than prosthetic access (Table I). Seven of the 11 studies cited in Table I show significantly higher primary patency for AV fistulas, although not necessarily functional patency. Reviews and meta-analyses comparing AV fistulas with prosthetic access have been limited by few prospective study designs; however, secondary patency rates of AV grafts are similar or close to those of AV fistulas (Table I). In fact eight of the 11 studies report no significant difference in secondary patency between AV fistulas and AV grafts.

Challenges of AV fistulas for hemodialysis. High initial or early failure of AV fistulas to function is a major concern that often leads to prolonged wait during attempts at balloon-assisted maturation.[22] Rates of initial or early failure (nonfunction) range between 20% and 60%.[9,23,24] Early failure of AV fistulas can be defined as those fistulas that do not develop sufficiently to deliver adequate flow rates necessary for dialysis.[24] Primary failure is often due to inadequate maturation or thrombosis and unusually due to ischemia or infection.[24] A recent prospective, multicenter study evaluating 491 AV fistulas placed in 395 patients concluded that the marked difference between AV fistula patency and functional patency rates may be explained by high early failure rates.[24] Dember et al[9] conducted a large multicenter trial involving 877 participants and in the *Journal of the American Medical Association* reported an astounding failure rate of AV fistulas to function satisfactorily for dialysis in 460 of 758 patients (60.7%). This inevitably leads to an increase in CVC dependence.

Given that findings reported in the literature often convey implications for policy recommendations, it is important that limitations pertaining to selection bias be addressed. Specifically, selection bias may present in two forms: (1) in choosing specific outcomes to report, and (2) in choosing patients based on their potential to yield desired outcomes. With regard to the former, numerous studies set as their inclusion criteria only fistulas or grafts that are effectively cannulated.[25] This, in effect, may make outcomes of fistulas appear more favorable because early failures are excluded from analyses. Selection bias also affects patient reporting; for example, an association of lower prevalence of fistulas has been shown for female sex, black race, obesity, increased age, and peripheral vascular disease.[26] Studies concluding that a fistula-first approach should be used for all patients must be critically appraised for the presence of patients who have these factors associated with high primary failure rates. Universal endorsement of a fistula-first approach for all patients may not be in the best interest of patients who may in fact benefit from a selective use of graft for access. As Allon et al[25] stated in 2008 in the *Journal of the American Society of Nephrology*, "Whereas a fistula may be the ideal access choice in a young white man without cardiovascular morbidity, it may be a poor choice in an older black woman with cardiovascular morbidity."

Individual considerations. "Fistula first" is certainly not for everyone. Recognizing the limits of autogenous constructions, nephrologists have identified patients likely to have AV fistulas that would fail to mature.[27] Specific patient characteristics and risk factors predictive of maturation failure in AV fistulas included increased age, peripheral vascular disease, coronary artery disease, race, and diabetes.[24,27] The influence of these factors on high primary failure rates should be taken into consideration when deciding on an initial choice of hemodialysis access.

We believe that each individual should be evaluated critically for the best functional access. Our analysis shows there are circumstances in which an AV graft would be first choice. Table II articulates those clinical situations. Huber et al[16] suggests that patency is only one of the several determinants affecting the choice of the most appropriate access site. These additional factors potentially include life expectancy, patient preference, and number of revisions to maintain access patency, the length of time that temporary catheters are required, and the time until access is sufficiently developed for cannulation.[16] Conservation of proximal access sites for future use is of minimal importance for the ESRD patient with a limited life expectancy. Letourneau et al[28] reported that >50% of patients aged >75 years died <2 years after starting dialysis, with a mean survival of 31 months, and Joly et al[29] found that the median survival of octogenarians undergoing dialysis was 28 months. In this population, the superiority of dialysis quality as well as the lower rate of graft thrombosis in the patient aged >65 years makes a graft a good alternative to an AV fistula.[30]

Recent trends in hemodialysis include an increase in the elderly population requiring dialysis, the prevalence of diabetes, and cardiovascular comorbidities.[31] Each of these independent risk factors can affect the function of a dialysis access. Atherosclerosis in the diabetic patient affecting forearm arteries results in decreased inflow through the fistula. The fragile, thin-walled veins of the older patient often do not become arterialized enough to withstand repeated puncture. In the patient aged >85 years, the limited life expectancy with ESRD may not justify an access any more complex than a cuffed catheter.

Advantages of prosthetic grafts for hemodialysis. One of the major advantages of an AV graft is provision of high flow rates preferred by nephrologists for efficient dialysis.[12] When no veins remain for outflow in the forearm or antecubital fossa, the brachioaxillary interposition AV graft can provide early access without the uncertainty, avoiding a wait that can be as long as 6 months for a transposed basilic vein AV fistula to mature.[32] The 2008 *Journal of Vascular Surgery* guidelines by Sidawy et al[33] recommend using an

Table I. Primary and secondary patency rates in arteriovenous fistulas (*AVFs*) and arteriovenous grafts (*AVGs*) reported (1997-2011)

First author (year)	*Study type*	*Access type*	*Initial sample size, No.*	*Time to follow-up, months*	*Primary patency* AVF vs AVG, %	*Secondary patency* AVF vs AVG, %
Hodges[11] (1997)	Retrospective	Autogenous	87	12	43 vs 41 ($P < .7$)	46 vs 59 ($P = .07$)
		PTFE	236			
Matsuura[12] (1998)	Retrospective	Autogenous	30	24	70 vs 46 ($P = .023$)	70 vs 51 ($P = .020$)
		PTFE	68			
Kalman[13] (1999)	Prospective	Autogenous	235	24	54 vs 18 ($P < .001$)	70 vs 60 ($P = .331$)
		PTFE	231			
Gibson[14] (2001)	Retrospective	Autogenous	123	12	56 vs 36 ($P = .001$)	72 vs 58 ($P = .003$)
		Prosthetic	85			
Gibson[15] (2001)	Retrospective	Autogenous (simple)	492	12	56.1 vs 38.2 ($P < .001$)	73.2 vs 71.8 ($P = .24$)
		Prosthetic	1574	24	39.8 vs 24.6 ($P < .001$)	64.2 vs 59.5 ($P = .24$)
Huber[16] (2003)	Systematic review	Autogenous	1849	6	72 vs 58 ($P < .05$)	86 vs 76 ($P < .05$)
		PTFE	1245	18	51 vs 33 ($P < .05$)	77 vs 55 ($P < .05$)
Weale[17] (2007)	Retrospective	Autogenous	71	12	45.3 vs 56.4	53.6 vs 61.7
		PTFE	114	24	40.0 vs 43.2 (overall $P = .579$)	50.9 vs 41.1 (overall $P = .868$)
Kakkos[18] (2008)	Prospective	Autogenous	41	12	46 vs 50 ($P = .62$)	88 vs 81 ($P = .31$)
		Prosthetic	76	18	31 vs 26 ($P = .62$)	84 vs 78 ($P = .31$)
Keuter[19] (2008)	Randomized trial	Autogenous	50	12	46 vs 22 ($P = .005$)	89 vs 85 ($P = .532$)
		PTFE	51			
Sala[20] (2011)	Retrospective	Autogenous	36	1	93.5 vs 80.6	93.5 vs 80.6
		PTFE	40	12	50.4 vs 64.3	50.4 vs 67.7
				24	45.8 vs 46.2	45.8 vs 54.2
				36	45.8 vs 31.6 (overall $P = .719$)	45.8 vs 35.1 (overall $P = .902$)
Morosetti[21] (2011)	Randomized trial	Autogenous	29	6	86 vs 55	86 vs 72
		Graft	28	12	61 vs 32	76 vs 52
				24	60 vs 21 (overall $P < .001$)	66 vs 34 (overall $P = .08$)

PTFE, Polytetrafluoroethylene.

"adequate" artery and vein when performing a transposed AV fistula. If these vessels are not available for access, then a graft is recommended.[33] This has led to a subjective view by the surgeon for what is considered suitable vessel size. Many would agree that the diameter of the artery should be at least 2 mm and the vein at least 3 mm. Studies arguing the superiority of a transposed AV fistula compared with a graft likely select more favorable anatomy. Gibson et al[15] determined that adequate "caliber" for vascular access of the basilic vein was >4.0 mm. Selection bias is evident, in that grafts are only placed in patients with poor anatomy for autogenous vascular access. The transposed brachiobasilic fistula has certain advantages such as its large size and a deeper position that prevents repetitive venipuncture. Nevertheless, recent reports do not show a significant cumulative patency advantage over AV grafts.[34,35] An AV fistula is certainly preferred when there is a likelihood of functional success (perhaps 85%), but all too often, fistulas are constructed without this consideration.[36]

Vascular access by prosthetic grafts offers other advantages, including earlier use, a larger surface area for cannulation, and a lumen more amenable to thrombectomy. In general, a standard AV fistula will need a minimum of 4 to 6 weeks to properly mature. If the vein was not transposed and a second operation is still necessary, an additional month will be needed before cannulation for dialysis. This period is further prolonged if the fistula requires a subsequent radiologic or surgical intervention to achieve maturity (ie, balloon-assisted maturation).[25] In the United States, the median time from fistula placement to its first cannulation is ∼3 months[37] and longer for a transposed fistula. In contrast, AV grafts have been punctured safely within the first day of implantation.[38] This allows for immediate dialysis in critically ill patients with no need for a CVC.

One of the additional advantages of placing an AV fistula is the decreased rate of infection compared with an AV graft. Indeed, the rate of graft infection ranges from 6% to 9%, whereas AV fistulas become infected only 1% to 4% of the time. This advantage, however, is not as straightforward as it may appear at first glance. Almost all patients commencing dialysis have CVCs that remain in place until an AV fistula is functional. On average, the literature quotes the rate of CVC infections at fewer than five episodes per 1000 catheter-days; however, it may run as high as five and one-half episodes per 1000 catheter-days in dialysis patients.[39] The risk of infection may be even greater in the population who are elderly and diabetic. Furthermore, a major underlying concern with chronic CVC use is the rate of central venous stenosis with time.

Table II. Clinical situations in which an arteriovenous (*AV*) graft would be first choice

- Brachial-axillary AV graft when a patient does not have anatomically suitable veins in the forearm or brachium.
- Forearm AV graft in a patient who requires urgent dialysis and cannot tolerate a prolonged central venous catheter.
- To avoid prolonged central venous catheterization in a patient who has ipsilateral axillosubclavian thrombosis and needs urgent access.
- If there is no site in the upper extremity for AV fistula access.
- An AV graft in the end-stage renal disease patient with limited life expectancy.
- In a patient with clinical risk factors for AV fistula failure that fulfill Lok's criteria.[16]

Patency rates of AV fistulas vs AV grafts. Proponents of the FFBI will often refer to the superior primary patency rates of AV fistulas compared with grafts. Early patency rates at 1, 3, and 5 years have been reported as two-times to four-times greater[19,40,41] (Table I). As we have pointed out, much of the literature reporting patency rates is flawed because of selection bias and removal of patients with early fistula failure. Also of note is that the secondary patency rates between the two groups are remarkably similar (Table I). Although grafts may need more interventions after the initial construction, they have greater salvage rates after thrombosis. In addition, there is also no need for a CVC after salvage. Taken together, even if more interventions are needed to maintain secondary patency of the AV graft, which is now doubtful given the increase in balloon-assisted maturation of AV fistulas, the difference may disappear if CVC insertion and removal to support the AV fistula is accounted for in the calculation.

Conclusions. The debate of whether to construct an AV graft or AV fistula has become somewhat moot. Rather, it is imperative that each individual patient be critically analyzed before any vascular access procedure. Further, maintenance of the vascular access site by a single physician would offer continuity of care and a planned program for future access. The KDOQI and FFBI have made remarkable strides in improving awareness of ESRD and the need for early referral for vascular access. However, the current rate of nonfunctioning AV fistulas, particularly in the elderly population with multiple comorbidities, is too high. Vascular access by a graft should not be abandoned because it may be the last option for some patients and the best option in particular settings. Indeed, the uncertainty in patency definitions, measurement of outcomes, and paucity of prospective studies warrants consideration of a randomized, prospective comparative trial.

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POSITION: EXCELLENT LONG-TERM OUTCOMES FOR AUTOGENOUS ARTERIOVENOUS ACCESS JUSTIFY AN AUTOGENOUS APPROACH FOR MOST PATIENTS

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Although this review specifically focuses on the best initial vascular access, it is worthwhile to briefly review the general consensus opinion of what constitutes the preferred vascular access. Overall mortality, morbidity, and cost considerations unquestionably favor autogenous AV accesses (AV fistulas). Catheter-based dialysis, particularly long-term catheter use, is associated with the worst outcomes in all of these categories, and prosthetic AV accesses (AV grafts) are intermediate. Clearly, catheter use should be minimized. There are, however, well-documented differences between AV grafts and AV fistulas in associated morbidity, such as higher infection rates, decreased access durability requiring interventions for maintenance, shorter access life span, increased incidence of access-related hand ischemia (ie, "steal"), and increased mortality rates and cost for AV grafts.

AV grafts have a significantly higher rate of infection than AV fistulas and, when infection develops, are more likely to result in greater morbidity, require surgical removal of the prosthetic conduit, and hospitalization.[1-4] AV grafts are less durable than AV fistulas and are more likely to need intervention or surgical revision to maintain patency and function.[1-7] These differences in morbidity and patency are reflected in the higher cost for patients using AV grafts for dialysis access.

Overall mortality rates associated with vascular access are highest for catheter-based dialysis, whereas AV grafts had intermediate risk, and AV fistulas the lowest risk.[8,9] Astor et al[10] found annual mortality rates were 16% for catheter patients, 14% for AV grafts, and 12% for AV fistula patients.[10] An analysis of Medicare claims data for infectious mortality by the 2010 Renal Report found antibiotic use among patients who died in the hospital with a catheter or AV graft reached 19% and 18%, respectively. Claims in the hospital for patients with AV fistulas were much lower, at only 9%.[11]

Patients with chronic kidney disease comprise only 7% of the total population, but their care accounts for 22% of all Medicare spending. Currently, ~400,000 patients in the United States receive renal replacement therapy by hemodialysis.[12,13] Total Medicare expenses were nearly $454 billion in 2008, with end-stage renal disease costs reaching $27 billion and hemodialysis expenses of $20 billion. The 2010 Renal Data Report found the per person per year cost for vascular access events were highest for patients with AV grafts, reaching $8683, whereas catheters were the second most expensive at $6402. Access costs for patients with an AV fistula, in contrast, were only $3480, 60% lower than those for AV graft patients. Per person per year total costs were greatest for patients with a catheter, at $90,110, and AV grafts were $79,337. Overall costs for patients with an AV fistula were 28% and 18% lower, respectively, at $64,701. The most common vascular access event in 2010 was replacement of a current access with a catheter, with 0.86 of these events per year for patients already using a catheter, and 0.24 and 0.13, respectively, for patients with an AV graft or an AV fistula.[10]

Vascular access in the United States. The Dialysis Outcomes and Practice Pattern Study (DOPPS) in 2002 demonstrated a great disparity among vascular access patterns and outcomes between the United States and other developed countries.[14] This was addressed by the National Kidney Foundation-Kidney Disease Outcomes Quality Initiative (KDOQI), the CMS-sponsored National Vascular Access Improvement Initiative/Fistula First Breakthrough Initiative (FFBI), and the Society for Vascular Surgery (SVS) Clinical Practice Guidelines for the Surgical Placement and Maintenance of Arteriovenous Hemodialysis Access.[1-3] All endorse use of an autogenous access whenever possible. The groundbreaking KDOQI Guidelines covered all aspects of dialysis care and categorized vascular access options into three basic surgical AVF divisions: radial-cephalic, brachial-cephalic, and brachial-basilic vein transposition. FFBI and the SVS guidelines extensively reviewed the many specific surgical options for creating and maintaining a successful access, further categorizing, from simple to complex, the numerous options for construction of functional AV fistulas.

The initial KDOQI and FFBI improvement goal in the United States was set for an AV fistula prevalence rate of 40%.[1,2] The emphasis on education and changing practice patterns led to reaching the goal before the target date, and the FFBI was initiated, with both organizations increasing the AV fistula goal to 66%. Vascular access surgeons in the United States are well on the way to meeting this higher goal (Fig). Overall and long-term catheter rates (catheters present >90 days) have improved. AV graft rates in the United States have plummeted as AV fistula rates have steadily increased. This experience has dramatically exceeded the expectations of many physicians in the United States who believed that even the initial goal of 40% AV fistulas would be impossible to reach. These data show that functional AV fistulas are feasible in most patients and that the rates of improvement suggest more progress can be expected. Several authors have reported establishing a successful autogenous vascular access for nearly all patients.[15-17]

Much of our vascular access practice is composed of complex patients referred from other regions and states. In a previous report of our access experience in 921 consecutive patients, an autogenous access was created in all patients, with a cumulative (secondary) patency rate of 91% after 24 months.[16] Our primary medical center's outpatient dialysis unit most recently reported monthly access numbers were 81% AV fistulas (4% awaiting catheter removal), 4% AV grafts, 2% long-term catheters, and 13% of patients new to dialysis awaiting referral, evaluation, or scheduling for access creation. Our surgical group is responsible for most but not all of the patients in this unit. We are now focusing on strategies to improve the lag time to construction of an AVF for these patients new to dialysis.

Grafts should be avoided in patients with AV fistula options. Past limitations used to justify lower AV fistula rates in the United States, based on patient characteristics, surgeon training, experience, and available continuing education, are no longer valid barriers to hemodialysis patients benefiting from an autogenous vascular access.

Placing a forearm vascular access AV graft should especially be avoided, as recent guidelines have suggested.[3] If a surgeon chooses to place an AV graft in the forearm, a substantial outflow vein must be present to provide adequate outflow and maintain AV graft patency. The outflow vein must be the deep communicating (perforating) into the brachial system, the upper arm cephalic, or the basilic vein. If one of these veins is large enough to support AV graft patency, then that vein should be adequate to construct a direct anastomosis to the proximal radial artery or brachial artery and thereby establish an autogenous access. This will result in a direct, simple AV fistula with the cephalic vein in the arm or a primary (or staged) transposition into the median cubital/basilic vein outflow system or the brachial vein.

Forearm AV grafts notoriously lead to the unfavorable cycle of graft-catheter-graft, with each access failure leading to a new prosthesis and destruction of venous sites otherwise best used for autogenous access construction.[18] Even when the initial surgeon feels he or she is constructing a "first step in a secondary AV fistula," later surgeons or interventionalists will likely use balloon angioplasty, stenting, or skip graft extensions in efforts to prolong the life of the failing forearm AV graft, generally leading to only brief periods of success. These stents and extended outflow bypass segments result in critical loss of autogenous access opportunities. The progressive frequency of these secondary interventions increases the risk of communication failure between surgeon, nephrologist, and interventionalist, resulting in these graft salvage procedures that compromise the potential for a secondary AV fistula construction.[18]

AV grafts placed in the upper arm almost always use the proximal basilic or axillary vein for outflow, with the likely later progression to outflow vein stenosis and occlusion. Repeated angioplasties, stents, and access failure leave the entire extremity problematic for later vascular access possibilities. Such patients are left with multiple failed and embedded AV grafts, although ultrasound imaging may reveal an adequate underlying vein suitable for a direct AV fistula or transposition. These old thrombosed AV grafts complicate the establishment of a new AV fistula.

Conflicting reports regarding outcomes of AV fistulas in the United States. Published experience with autogenous vascular access varies widely throughout the United States. Two major issues are generally noted when objections arise to the published recommendations for increasing the number of AV fistulas: (1) the risk of early AV fistula thrombosis and (2) the potential for delay in maturation, both of which are associated with prolonged catheter dependency when they occur. Examples of the wide variation in reported AVF outcomes include:

1. Radial-cephalic AV (RC-AV) fistula reliability has been questioned, with several older reports finding up to 40% of these fistulas have thrombosed or failed to mature. Although an RC-AV fistula remains our first choice for vascular access, only 10% of patients seen in our complex access referral practice are good candidates for this access site. We reported

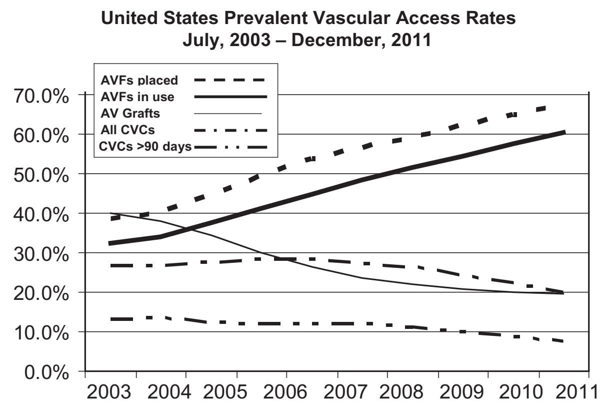

Fig. Prevalent vascular access reported for patients in the United States. *AVF placed,* Patients with an arteriovenous fistula in place; *AVF in use,* patients with an arteriovenous fistula in use; *AV graft,* patients with an arteriovenous graft in use; *CVC >90 days,* patients with a central venous catheter present >90 days; *All CVCs,* all patients with catheter access. Data displayed are from the Fistula First Breakthrough Initiative web site. Available at: http://www.fistulafirst.org/AboutFistulaFirst/FFBIData.aspx. Accessed February 24, 2012.

our experience showing >90% functional cumulative patency after 2 years' follow-up with RC-AV fistulas.[19] This was accomplished when specific preoperative criteria on physical and ultrasound examinations were used to select individuals for this procedure, creating a more proximal autogenous access in patients where an RC-AV fistula was likely to fail. Other authors have reported similar success rates with RC-AV fistulas.[20]

2. Another example of variable reported outcomes is in older patients, generally specified as individuals aged >65 years. Some authors have reported higher failure rates with autogenous access and prolonged delays in maturation compared with younger patients and suggest that AV graft placement might be a better option. We found that targeting an upper arm outflow vein for cannulation was a key element of success in establishing a functional AV fistula for older patients.[21] The skin overlying an upper cephalic or transposed basilic vein has less chronic solar damage and subsequent thinning, in addition to more soft tissue coverage over the vein, making cannulation more reliable and available sooner.[21] In addition, we attempt whenever possible to construct a moderate-flow AV fistula (500-750 mL/min as measured by ultrasound) in older individuals based on proximal radial artery inflow. By using such a policy, AV fistula patency rates were not different in our elderly compared with our younger patient populations. Functional access patency was >90% in our patients aged >65 years at 2 years' follow-up. Other authors have found similar success with autogenous access in older patients.[22] Outcomes in other vascular access patient groups, such as adolescents and children, have paralleled the change in AV fistula rates in adults, with multiple reports of nearly all autogenous dialysis access in younger patients.[23]
3. A multicenter prospective randomized controlled study designed to test clopidogrel in vascular access patients found no benefit in preventing early AV fistula failure. This trial found a surprisingly high 60% rate of AV fistulas that failed to mature and be suitable for dialysis.[24] However, the intervention rate was quite low in this study (an important element for success), and the percentage of failed AV fistulas was among the highest reported in a modern series, at odds with the current national functional AVF rate of 62%.[2,25] More than 70 surgeons participated in the trial, with a wide variation in the number of AV fistulas contributed to the study. These results differ dramatically from other published vascular access outcomes, with early AV fistula failure rates of 5% to 15%.[15-17,20] The wide variation in autogenous access outcomes may be related to surgical training, ultrasound skills, interventional capability, surgical experience, and case volume. Proper initial access site selection is critical. Avoiding early AV fistula failure and minimizing time to access maturation requires a careful preoperative approach, keeping in mind the targeted cannulation zone, final access length, depth, diameter, and flow volume. Minimizing the risk of access-related hand ischemia and arm swelling related to central venous stenosis or occlusion, along with prompt intervention when indicated, are also important parts of the process. A complete working knowledge by the surgeon of the many autogenous access options available is a key element for success.

Keys to successful ultrasound mapping of AV fistulas. Ultrasound vessel mapping is a critical component of a successful vascular access practice. Ultrasound in the hands of the operating surgeon offers the greatest opportunity for planning a functional vascular access in addition to postoperative follow-up decision making. The ability to measure and evaluate vessel size, depth, wall characteristics, distensibility (compliance), and subtle areas of stenosis leads to successful AV fistula creation and prompt maturation in most cases. With the ultrasound probe in hand, the surgeon's expectation of constructing a functional fistula is much higher, and access options become much more obvious.[26]

Optimize potential AV fistula options. The successful vascular access surgeon has many options available, including RC-AV fistulas, antebrachial AV fistulas, based on the proximal radial artery inflow or brachial artery inflow, and transposition procedures involving a basilic or brachial vein.[1,3,27-29] Lower extremity opportunities include femoral and saphenous autogenous transpositions in addition to vein harvest and translocation to another extremity in challenging access situations. However, femoral vein harvest and transposition is a major undertaking and associated with a higher risk of complications than seen with other autogenous access procedures.[30,31] Lower extremity vascular access operations often require general anesthesia and are at increased risk for infection, steal syndrome, compartment syndrome, and delayed wound healing.

We occasionally use the saphenous vein for AV fistula revision or inflow proximalization but have often found it problematic when used for cannulation sites. Distal and direct (simple) AV fistulas remain the first recommendation when physical and ultrasound examinations predict success.[19] When an RC-AV fistula is not feasible, our second choice and most common access operation is a proximal radial artery AV fistula using the many venous outflow opportunities at this location.[27] These moderate-flow fistulas minimize the risk of access-related hand ischemia and are less likely to lead to venous hypertension with arm swelling if central venous outflow obstruction develops.[32,33] In addition, the moderate flow rate may be less stressful for patients with congestive heart failure or severe cardiac disease. We reported a cumulative functional patency of 92% at 1 year with this AV fistula procedure.[27] Occasionally, patients with significant ulnar artery occlusive disease are evaluated where the radial artery is the only significant arterial supply to the hand. Using the proximal ulnar artery for AV fistula inflow is appropriate in such patients, preserving flow through the dominant radial artery into the hand.

Basilic vein transposition procedures are best constructed, in our opinion, as primary operations when the vein diameter is ≥4 mm.[28] Basilic veins 2.5 to 4 mm in diameter are often used in our practice in staged operations, with ∼4 weeks between the primary AV fistula construction and the later transposition. Staged basilic vein transpositions have also been recommended by other authors for pediatric and adult patients.[34,35] Most brachial vein transpositions should be completed in two stages.[29] Many transpositions may be created using the proximal radial artery for inflow.[28,29]

Direct (simple) AV fistulas may be created in patients with marginal outflow veins, anticipating that a balloon angioplasty procedure may be necessary for maturation. These interventions generally result in a durable autogenous access. Cannulation of most AV fistulas is expected to be initiated after 4 to 6 weeks. When a marginal fistula is not mature by that time, an ultrasound evaluation of the outflow vein diameter and flow volume measurements may suggest that an additional short period of observation is justified if flow is approaching but has not yet reached 500 to 750 mL/min. Patients with marginal AV fistulas may be monitored longer if serial examinations and ultrasound imaging show steady progress toward successful maturation. However, if flow is significantly lower and the diameter has not increased, the fistula is not likely to mature, and a fistulogram with intervention should be considered. If percutaneous intervention is unsuccessful, surgical revision may be required. AV fistulas in obese individuals may require additional procedures, such as a lipectomy or vein elevation, for reliable cannulation.[36] We generally wait 4 to 6 weeks after the original access creation for these additional procedures.

Coordination and communication of expectations with the patient, the nephrologists, and the dialysis team leads to timely maturation of a functional autogenous access in most patients. Surgical follow-up is recommended for all patients until the vascular access has been successfully used.

Maintaining the autogenous access. Maintenance of an established autogenous access also plays an important role in the long-term success of AV fistulas. Skilled and available interventional support plays a major role in maturing marginal AV fistulas and in the diagnosis and treatment of a dysfunctional access. In some cases, the access surgeon may be capable of providing all needed interventions. If not, the surgeon and an experienced interventionalist must collaborate to achieve optimal patient outcomes. Ultrasound imaging is complementary to contrast imaging in detecting and localizing access problems, providing functional physiologic information, and guiding the interventionalist in planning the procedure along with immediate and subsequent monitoring of outcomes.

The timing and extent of balloon access maturation (BAM) and surgical revision are not clearly defined. Both play important roles in vascular access maturation and maintenance that vary with individual patients, surgeons, and interventionalists. Similarly, the indications for use of bare-metal and covered stents in an autogenous access remain ill defined. Placement of a covered stent in an AV fistula outflow vein for access salvage after BAM rupture is increasingly common. Stenting of *symptomatic* central venous lesions seems justified for recurrent failed angioplasty sites and for those lesions with immediate elastic recoil. Asymptomatic central venous lesions should be left undisturbed.

Successful resolution of access-related hand ischemia and central venous outflow obstruction are examples of autogenous access salvage opportunities that avoid access ligation or abandonment. The most important element in dealing with hand ischemia is prevention. AV grafts generally require higher blood flow to maintain patency and carry a higher risk of hand ischemia compared with AV fistulas.[37] Salvage of a dysfunctional AV fistula in patients with hand ischemia is feasible in most instances using options such as precision banding over an angioplasty balloon, revision using distal inflow, inflow proximalization, and distal revascularization with interval ligation.[38] Selection of the appropriate salvage procedure depends to a great degree on the access flow volume and the degree and location of arterial disease within the affected limb. Preemptively establishing a safe and functional AV fistula in patients at high risk for hand ischemia is possible using axillary artery inflow.[39] In patients with central venous obstruction and failed attempts at central venous angioplasty, limiting the flow through the AV fistula (eg, "banding") has proven effective in maintaining a functional access and effectively treating the arm swelling in most patients.[40]

Conclusions. Surgical vascular access planning and postoperative maintenance are tied to each individual patient's unique status and circumstance. Some of these situations may be quite complex and challenging. The access surgeon's training, skill, and experience with all autogenous access options will allow most patients to have a successful AV fistula established and maintained. Although our practice has been to create an AV fistula as the initial procedure in each patient, best practice patterns for each individual surgeon will vary based on training, experience, technical skills, availability of interventional support, ultrasound skills, dialysis center proficiency, and specific patient clinical and anatomic opportunities. With the proliferation of national and regional vascular access educational opportunities, a goal of establishing and maintaining an autogenous vascular access for most patients is attainable and should be vigorously pursued.

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SUMMARY

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The role of prosthetic AV hemodialysis accesses (AV grafts) in the current era of the Kidney Disease Outcome Quality Initiative and the Fistula First Breakthrough Initiative remains unresolved. As a direct result of these initiatives, a tremendous amount of pressure has been placed on access surgeons to create autogenous AV accesses (AV fistulas), with a national target rate of 66% (prevalence). Indeed, the prevalence of AV fistulas and, perhaps more importantly, the prevalence of central venous dialysis catheters, have become markers for quality—or lack thereof in the cases of the catheters—among dialysis units. It is unclear whether this AV fistula target is realistic or appropriate, and the anecdotal impression has been that the increased emphasis on AV fistulas has inadvertently resulted in an increased failure-to-mature rate and a prolonged dependence on dialysis catheters. These concerns are underscored by the 61% AV fistula failure-to-mature rate reported by the Dialysis Access Consortium from their National Institution of Health, randomized, controlled trial examining the role of clopidogrel.[1]

The data largely support the superiority of AV fistulas over AV grafts in terms of almost every outcome measure, including patency, morbidity, mortality, and cost. However, the choice of permanent access configurations may not be quite as clearcut or black-and-white as the initiatives suggest. As Dr Wilson and colleagues point out, appropriate comparison of the patency rates mandates inclusion of all accesses that fail to mature, not just those that are successfully cannulated. Accurate patency assessment also mandates comparing comparable patient cohorts, including those deemed high risk for failure after both AV fistula and graft creation, including elderly patients, diabetic patients, women, and amputees. Similarly, the appropriate comparison of the infectious complication rates likely mandates including the catheter-related infections incurred during the fistula maturation period that frequently extends up to 6 months, again potentially diluting or reducing the perceived benefit of AV fistulas. Lastly, AV grafts have several relative advantages over AV fistulas, including an essentially unlimited supply, a shorter maturation period, increased surface area for cannulation, and greater ease of cannulation.

The debate about the role of AV grafts relative to AV fistulas may be somewhat artificial or moot, as suggested by both Drs Jennings and Wilson. AV fistulas and grafts should be viewed as alternative options for providing effective, long-term hemodialysis. A mature AV fistula is the ideal choice for most patients and, fortunately, an AV fistula can usually be created or successfully achieved in most patients, as emphasized in the debate. However, AV grafts are a very acceptable alternative that may be more appropriate for certain subsets of patients. The current challenge is to select the most appropriate access type or configuration for a specific patient to ensure a functional access while minimizing morbidity. It is the hope that the results of the Hemodialysis Fistula Maturation study, a prospective National Institutes of Health-funded observation study of fistula maturation, will help refine the clinical decision making for dialysis access, complementing the adverse findings from its predecessor, the Dialysis Access Consortium. However, it is important to emphasize that maintaining permanent hemodialysis access is a difficult problem that requires committed providers and a lifelong plan.

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