Interventional Nephrology: When Should You Consider a Graft?

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Summary

The patient’s vascular access is critical in ensuring that hemodialysis is successful, effective, relatively uncomplicated, and consistently reproducible from one treatment to another. The choice of vascular access is dictated by a multitude of factors, some of which are generalizable to a larger system, and others of which are flavored by local experience and expertise; an important fraction is specific to the patient presenting to the clinician at a particular point in time. Some of these factors, such as patient age and sex, are not modifiable; others, like comorbidity, vessel size and urgency of presentation to the renal provider, are manageable and sometimes modifiable. The role of the autologous arteriovenous fistula as the ideal conduit for hemodialysis treatments is well established. The role of the prosthetic graft warrants discussion and investigation to most optimally apply to patients this important alternative within the armamentarium of vascular access.

Background

The superiority of arteriovenous fistula (AVF) as a hemodialysis access in terms of better access survival, decreased access-related infections, decreased need for procedures required to maintain patency, and improved patient mortality has been shown in numerous studies (1–3). This information is the main impetus to the Fistula First Breakthrough Initiative (FFBI), which is widely acknowledged as having played a pivotal role in increasing the current number of prevalent AVFs in this country to over 60% as of April of 2012 (4). Four years after the birth of the National Vascular Access Improvement Initiative, which later became FFBI, the number of prevalent dialysis patient using a fistula as their access rose from 38.6% to 55.0%, but the number of prevalent patients using catheters remained constant at 18%–19% (5). FFBI includes fundamental change concepts that serve to modify current existing practice patterns based on evidence, best practices, or consensus statements of specialty societies. The change concepts target areas of predialysis care and vessel preservation, referral timing and process, fistula creation and maintenance, cannulation, patient and family education, and continuous quality improvement, providing a comprehensive approach to maximizing AVF use. It is hoped that, as the number of AVFs in use increases, our patients would accure these benefits and that overall patient care, quality of life, and survival might improve.

Alongside FFBI, the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) clinical guidelines support AVFs as the optimum vascular access and encourage its preferential creation and use (6). Guidelines issued by other specialty organizations have echoed the preferential placement of fistulae for permanent dialysis access (7–10). The KDOQI guidelines cogently point out that a limitation of AVFs is the period of time between creation and suitability for use, during which maturation occurs that must be taken into account to make sure appropriate planning in anticipation of initiation of dialysis occurs. The guidelines recommend creation of the fistula 6 months before and a prosthetic graft 3–6 weeks before anticipated start of or need for dialysis. This variable period of maturation may, in fact, be an important decision point in choosing the appropriate vascular access for the patient depending on the particular point in which they are introduced to dialysis.

If one were able to develop the ideal hemodialysis vascular access, it would be one that is easy to create, was useable immediately or soon after creation, is consistently painless and simple to use, needs little to no maintenance, has a low risk of infection with a longevity that equals or exceeds the life expectancy of the patient, does not compromise aesthetic or function of other body parts, and is universally applicable to all patients (Table 1). Each of the different vascular access options has some of these elements, but clearly, not one has all. The decision, therefore, as to which access option is best for the patient must take an accounting of these factors and arrive at a conclusion that is patient-specific.

Although there is general consensus that an AVF is the ideal conduit for hemodialysis access, there are clinical scenarios in which one might consider placement of a prosthetic graft instead. Clinical practice guidelines do not substitute for a grounded, informed, and studied clinical decision based on what is appropriate for the patient at the particular time. The clinician should aim to do the right thing to the right patient at the right time.
has been observed that to a functional mature state (16). Interestingly enough, it cultured, they may require more interventions to get them maintained patency and function after they are matured (18). This increased cumulative survival (19). This finding may be reflective of the pathology in the native vein antedating creation, but a detrimental effect of the intervention itself or cellular repair after the intervention cannot be discounted.

Table 1. Advantages and disadvantages of different vascular access types

<table>
<thead>
<tr>
<th>Access Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Tunneled hemodialysis catheter</td>
<td>Universally applicable</td>
<td>Catheter occlusion</td>
</tr>
<tr>
<td></td>
<td>Multiple potential sites available</td>
<td>Highest risk of catheter and systemic infection</td>
</tr>
<tr>
<td></td>
<td>Immediately useable</td>
<td>Vascular thrombosis/stenosis with loss of future potential arteriovenous sites</td>
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<tr>
<td></td>
<td>Venipuncture not required</td>
<td>Aesthetic concern</td>
</tr>
<tr>
<td></td>
<td>Minimal patient preparation required</td>
<td>Shortest access survival</td>
</tr>
<tr>
<td></td>
<td>Relatively low cost of placement and replacement</td>
<td>Lower blood flow rates</td>
</tr>
<tr>
<td></td>
<td>Provides access over several months</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower burden on cardiac function</td>
<td></td>
</tr>
<tr>
<td>Prosthetic arteriovenous graft</td>
<td>Minimal to moderate maturation time required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>May provide years of access</td>
<td>Prone to higher cost of placement and creation</td>
</tr>
<tr>
<td></td>
<td>Relative ease of cannulation</td>
<td>Higher cost of revision or repair</td>
</tr>
<tr>
<td></td>
<td>May provide opportunity for development and creation of secondary fistula</td>
<td>May develop pseudoaneurysms and/or aneurysms</td>
</tr>
<tr>
<td></td>
<td>Low burden on cardiac function</td>
<td>Moderate risk for infection</td>
</tr>
<tr>
<td></td>
<td>Less prone to dialysis access-related distal ischemia (steal)</td>
<td></td>
</tr>
<tr>
<td>Autologous arteriovenous fistula</td>
<td>Provides longest access survival</td>
<td>Considerable risk for maturation failure</td>
</tr>
<tr>
<td></td>
<td>Lowest risk of access thrombosis</td>
<td>Longest time to mature</td>
</tr>
<tr>
<td></td>
<td>Lowest risk of access infection</td>
<td>May require more preoperative evaluation and testing</td>
</tr>
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</table>

Failure to Mature and Catheter Dependence

Although some fistulas may, indeed, be simpler to create than others, it is the difficult road to functional use that has proven to be vexing and frustrating for many health care providers. Failure of maturation, reported to average about 40% (3,11–14) and be as high as 60% (15), is the fistula’s Achilles heel. The corollary of failure to mature is a longer period of catheter dependence (2,16). It is estimated that each 1 month of catheter use while awaiting fistula maturation increases the patient’s risk of catheter-related bloodstream infection by 9% (2). A sobering observation in a historical cohort of nearly 400,000 patients on dialysis is that septicemia was identified as a precursor to the development of cardiovascular events and death (17). The Dialysis Morbidity and Mortality Wave 2 study showed an almost twofold increase in the risk of myocardial infarction or stroke associated with septicemia or bacteremia (18). Although fistulas require fewer interventions for maintenance of patency and function after they are matured, they may require more interventions to get them to a functional mature state (2). Interestingly enough, it has been observed that fistulas that require two or more interventions to achieve suitability for dialysis had decreased cumulative survival (19). This finding may be reflective of the pathology in the native vein antedating fistula creation, but a detrimental effect of the intervention itself or cellular repair after the intervention cannot be discounted.

In 2010, 82% of incident hemodialysis patients used a catheter, alone or with a maturing fistula or graft, as their vascular access, whereas 64% of incident patients used a catheter alone as their vascular access (5). A retrospective comparison of upper arm accesses showed two times as many days from creation to use corresponding to an increase in the primary failure rate between grafts and brachial-basilic and -cephalic fistulae (2). Congruent to that pattern of increasing time to use, the incidence of catheter-related bacteremia was lowest for grafts and highest for brachial-cephalic fistulae, with the brachial-basilic fistula in between the two others. Another retrospective analysis showed a higher rate of primary failure for upper arm fistulae than grafts (44% versus 20%, P=0.006); they required more interventions before use (0.42 versus 0.16, P=0.04) and were associated with a longer period of time needing a catheter for dialysis (131 days versus 34 days, P<0.001) (16). A final intriguing point of intersection is that mortality from infectious causes in incident patients peaks at the second and third months postinitiation (5), the same period of time in which catheters would still be in use while awaiting functional maturation of the permanent vascular access. A reasonable program to have patients commence dialysis with a mature and functional access, preferably fistulae, is beyond the scope of this discussion but has been the focus of other conversations, and it would have elements that include judicious referrals to nephrologist and surgeon, appropriate patient selection, analysis of competing risks, vessel preservation and mapping, and timely creation and follow-up.

Because of the extent of the problem of maturation failure, which has been highlighted by attempts to create
more fistulae, predictive algorithms have been postulated that might assist the clinician in assessing the risk of the patient based on clinical parameters of age, coronary and peripheral arterial disease, and race (3) (Tables 1–3). This scoring system was derived from patients of a single dialysis center receiving their first vascular access. Validation of the scoring profile was subsequently performed in five other dialysis facilities.

The scoring system was applied retrospectively to data from 440,000 patients’ CMS (Centers for Medicare and Medicaid Services) 2728 forms that recorded patient characteristics and comorbid conditions, and this information showed that 55% of low-risk patients versus 45.6% of very high-risk patients used a native AVF for their first outpatient treatment (20). Thus, it seems that even patients who may be deemed very high-risk for failure of fistula maturation seem to have done quite well and might have otherwise been needlessly consigned to using a prosthetic graft for vascular access. We eagerly await additional validation of this equation in other studies, with the aspiration that it will prove to be a valuable tool in assisting clinicians in access planning.

### Who Might Benefit from an Arteriovenous Graft? Limited Life Expectancy

Because the highest rates for patients coming into dialysis are for ages 65 years and older (5), age-relevant recommendations for vascular access should merit a high priority in research. Since 2000, the adjusted incident rate of ESRD has grown 12.2% for patients 75 years and older. Although many elderly patients do quite well on dialysis and remain functionally and cognitively intact, there are those patients whose functional status and/or medical comorbidities confer a less than hopeful long-term prognosis. The median survival of incident hemo dialysis patients between ages 65 and 79 years is slightly more than 2 years and less than 1 year for those patients over the age of 85 years (21). One must, therefore, balance the desire for a fistula that has superior long-term outcomes and patient survival with the greater complexity of some fistula surgeries, longer period of maturation, high rate of maturation failure, prolonged catheter use, and increased risk for catheter-related bloodstream infections along with its attendant complications against the patient’s likelihood of survival given the age. In a retrospective analysis of patients receiving fistulae for their first access, most of which were brachial-basilic, access survival (secondary patency) was only 38% at 12 months for 70-year-old patients compared with younger patients (22). In a retrospective study of 212 patients, outcomes of brachial-cephalic and transposed brachial-basilic fistulae and upper arm grafts were compared. Including only those fistulae that matured and were functional, the adjusted relative risk of thrombosis was 2.6 (95% confidence interval [CI]=1.3 to 5.3) for grafts and 0.3 (95% CI=0.1 to 1.1) for brachial-cephalic fistulae compared with brachial-basilic fistulae (2). Another single-center retrospective analysis of 110 patients who had upper arm accesses placed after a failed forearm fistula showed that cumulative survival was higher for fistulas than for grafts when only mature fistulae were included (hazard ratio=0.51, 95% CI=0.27 to 0.94, P=0.03) (16). However, in both of these studies, if primary failures were included, there would be no significant difference in thrombosis rate or cumulative survival of upper arm grafts compared with elbow fistulae (2,16). With patients in whom median survival is poor, one must reflect on the wisdom of a complex surgery, such as a transposed brachial-basilic fistula, with its attendant complications and suboptimal access outcomes. Individualizing dialysis access choice on the grounds of age is no different than the informed choices that physicians make when carving out treatment plans for malignancies in the pediatric or geriatric groups and taking into account patient longevity.

Patients with advanced disease that is severely life-limiting, such as those patients with inexorable progression of malignancy or disseminated infection, would best be served by wisdom and compassion in choosing the appropriate therapeutic alternatives and vascular access.

### Suboptimal or Inadequate Forearm Vessels or Failed Access

The KDOQI guidelines as well as the guidelines of the Society for Vascular Surgery (8) favor placement of an AVF as far distally as possible, preserving more proximal sites for future use. Additionally, both societies recommend creation of direct or transposed fistulae before consideration

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### Table 2. Clinical use of the scoring system

<table>
<thead>
<tr>
<th>Variable</th>
<th>Points</th>
<th>Score</th>
<th>Variable Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age≥65 yr</td>
<td>+2</td>
<td></td>
<td>Age at time of fistula creation</td>
</tr>
<tr>
<td>PVD</td>
<td>+3</td>
<td></td>
<td>Documented lower extremity revascularization, digit or extremity amputation, or history of claudication and ischemic extremity changes or gangrene</td>
</tr>
<tr>
<td>CAD</td>
<td>+2.5</td>
<td></td>
<td>Documented coronary stenosis by angiography or history of myocardial infarction or previous coronary revascularization by angioplasty, stenting, or bypass surgery</td>
</tr>
<tr>
<td>White Baseline score</td>
<td>−3</td>
<td>+3</td>
<td>Not of black, Asian, aboriginal, or other non-European descent</td>
</tr>
<tr>
<td>Total</td>
<td>+3</td>
<td></td>
<td>All patients are given baseline score of +3 Sum of scores</td>
</tr>
</tbody>
</table>

The total score could range from 0 to 10.5. PVD, peripheral vascular disease; CAD, coronary artery disease. Reprinted from reference 3, with permission.
of a prosthetic graft. There are at least two clinical situations in which the forearm would potentially be abandoned in place of an elbow or transposed fistula in which consideration to a prosthetic graft might have been given: (1) marginal or suboptimal wrist/forearm vessels and (2) failed wrist/forearm fistula.

In a multicenter prospective study, patients with radial arterial diameters between 1 and 2 mm and cephalic vein diameters ≤1.6 mm were randomized to receive either a radiocephalic AVF or a loop brachial artery-to-elbow vein polytetrafluoroethylene graft (11). The primary failure rate in the AVF group was 41%, but the matured fistulae were successfully cannulated for dialysis after 6 weeks. The primary failure rate for the arteriovenous graft (AVG) group was 2%; 1-year primary patency (44 ± 6.2% versus 33 ± 5.3%, P = 0.03), assisted patency (63 ± 5.9% versus 48 ± 5.5%, P = 0.04), and secondary patency (79 ± 5.1% versus 52 ± 5.5%, P = 0.001) rates for the AVG group were superior to those rates of the AVF group. Although thrombosis, surgical thrombectomy, and infections were higher in the AVG group, there was no noted difference in the number of total complications, angioplasties, or total interventions seen. Using the vessel diameter criteria of 2.5 mm for veins and 2.0 mm for arteries as the threshold for suitability of fistula creation (23,24), these patients would not have undergone either wrist fistula or forearm graft creation and would have received either a direct or transposed elbow fistula. Even if one were disinclined to create an AVF in these patients, the option of the forearm graft is reasonable, is not fraught with a high rate of primary failure, can be cannulated fairly easily and soon after creation, and allows a greater number of catheter-free days than might have been the case with an elbow fistula. Serving as a salvage maneuver, it allows use of the forearm for one more access incarneration before proceeding more proximally. The additional advantage of the forearm graft is that it sets the stage for creation of a secondary fistula (25–28). The upper arm basilic and cephalic veins serve as the effluent conduits for the forearm graft and are subjected to the same mechanical and neuro-humoral signals that are involved in fistula maturation (29). Finally, because these veins have already dilated and their walls are thickened, they can be cannulated for dialysis use after conversion to a secondary fistula with no or minimal delay (27). In a similar multicenter study comparing brachial-basilic AVF and a forearm loop graft in patients with failed access or inadequate vessels (30), no difference in access survival was noted, although primary and assisted primary patency in the brachial-basilic fistuulae was better.

**Bridge and Opportunity for Secondary Fistulae in Incident Patients Urgently Starting Dialysis**

Whether because the patient was not adequately introduced to renal replacement or resisted the concept or there was a breakdown in throughput, some patients find themselves needing to commence chronic maintenance hemodialysis in under less than ideal conditions. Many patients need dialysis urgently, and they and their families are easily overwhelmed by the enormity and rapidity of changes. Peritoneal dialysis as an option for chronic therapy may be discussed but may be staggering to comprehend. These patients default to hemodialysis using a central venous catheter as initial access. In a perfect world, they will be mapped, have a fistula created and ready for use within 2–3 months, be catheter-free very soon thereafter, and have a functional low-maintenance vascular access for as long as dialysis is needed. The reality that the patient faces will be different of course. The prosthetic graft has the advantage of a lower primary failure rate (2) and shorter maturation time (16,31), and it could conceivably reduce catheter dependence. Is there a role for an early-stick prosthetic graft as a bridge until the patient has a mature and functional fistula? Thirty-three patients who received an early-stick prosthetic graft were prospectively followed (32). Although primary patency was only 49% at 6 months, it was noted that all grafts were uneventfully accessed for dialysis no later than 72 hours postcreation and in almost 90%, within 24 hours. Although this study is a single-center study and no patients needing urgent initiation of dialysis were included in the study group, the possibility of using an early-stick prosthetic as a bridge to a fistula is a seductive one.

As part of the patient’s comprehensive vascular access plan, a forearm prosthetic graft should have its venous

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**Table 3. An example of the use of the FTM predicted risk categories**

<table>
<thead>
<tr>
<th>Score</th>
<th>Risk Categorya</th>
<th>Clinical Applicationb</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.0</td>
<td>Low risk: 25%</td>
<td>PE ± duplex ultrasound; create AVF</td>
</tr>
<tr>
<td>2.0–3.0</td>
<td>Moderate risk: 35%</td>
<td>PE, duplex ultrasound ± venogram; create AVF</td>
</tr>
<tr>
<td>3.1–6.9</td>
<td>High risk: 50%</td>
<td>Arteriogram + venogram and appropriate preoperative intervention as necessary; create AVF with very close postoperative monitoring (e.g., weekly or biweekly) and anticipate the need for aggressive intervention to facilitate maturation</td>
</tr>
<tr>
<td>≥7.0</td>
<td>Very high risk: 70%</td>
<td>Consider another form of permanent access (e.g., graft); continue to avoid catheter use</td>
</tr>
</tbody>
</table>

All patients with risk factors for central vein stenosis should have a venogram regardless of score. FTM, failure to mature; PE, physical examination; AVF, arteriovenous fistula. Reprinted from reference 3, with permission.

aBecause of the similarity in risks for patients who have fistula primary failure and patients who fail to mature, the risks have been rounded for ease of use.

bThese applications are untested possible applications that will require prospective trial evaluation.
anastomosis in the infracubital area to preserve sufficient native vein length to create a secondary fistula of optimum length, which is true regardless of whether the effluent vein is the basilic or cephalic vein. Additionally, providers must understand that deploying an endovascular stent across the vein–graft anastomosis in the cubital region compromises the length of native vein available for creation of secondary fistula. Assiduous avoidance of stentong across this region, sedulous attention to arm native veins on sleeves-up physical examination, and structured and effective communication between all health care providers and the patient will increase the likelihood of the successful creation of a secondary fistula.

Finally, it is worth mentioning that, in a small prospective study of patients with forearm prosthetic grafts referred for creation of secondary fistulae, 45% of patients transitioned to using the fistula without the need for a catheter (25). Clearly, planning, a heightened sense of awareness, effective communication, and provider and patient engagement are all needed to best time the conversion of a failing graft to a secondary fistula.

Conclusion
In the era of FFBJ and KDOQI, when the fistula has been promoted aggressively and system-wide process changes have been instituted to increase its use in both incident and prevalent patients, it may seem like apostasy to revisit the role of prosthetic grafts as a preferred access option in select instances. Neither FFBJ nor KDOQI interdicts the use of grafts and indeed, acknowledges that there is an important and relevant role for this access type. What is needed is more research into the precise role of the graft in the minority of patients challenged in one fashion or another for whom a fistula would not be the ideal access. Understanding this role and the setting in which it is to be played will reduce needless fistula surgeries and interventions, catheter-dependent days, and all the attendant complications that may arise from these use. Health care should always be patient-centric, and whenever possible, it should directed by evidence and driven by clinical outcomes. A mature and functional fistula remains the access choice for our patients. The appropriate role for grafts as a preferred access remains to be elucidated.

Disclosures
None.

References


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