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Vascular access for hemodialysis

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SUMMARY

Establishing and maintaining adequate vascular access is essential to providing an appropriate dialysis dose in patients with end-stage renal disease. Complications related to vascular access have a significant role in dialysis-related morbidity and mortality. The National Kidney Foundation Kidney Disease Outcomes Quality Initiative (K/DOQI) clinical practice guideline for dialysis access was last updated in 2000 and provides a framework for the optimal establishment and maintenance of dialysis access, and treatment of complications related to dialysis access. This paper reviews the 2000 K/DOQI dialysis access guideline as well as updated information published subsequently.

KEYWORDS arteriovenous fistula, arteriovenous graft, dialysis access, end-stage renal disease, hemodialysis

REVIEW CRITERIA

Material for this article was found by searching both the PubMed and MEDLINE search engines using the terms, "dialysis access", "arteriovenous fistula", "arteriovenous graft", "dialysis access and anticoagulation", "dialysis access and thrombosis and stenosis", "dialysis access and infection", "dialysis access and digital ischemia", and "dialysis access and heart failure."

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INTRODUCTION

Vascular access to obtain a functional portal to a patient's circulatory system is vital to delivering adequate hemodialysis therapy. The ideal hemodialysis access would fulfill three criteria. It would have a long use-life, provide an adequate blood flow rate to achieve the dialysis prescription, and have a low rate of associated complications. Currently no form of hemodialysis access perfectly achieves all three criteria; however, the native forearm arteriovenous fistula (AVF) comes closest, with studies showing that this form of access provides the best 4–5-year patency rates and requires the fewest interventions. Following the forearm AVF, in order of preference, are the upper-arm AVF, the arteriovenous graft (AVG) and the cuffed central venous catheter.[1,2]

EPIDEMIOLOGY

In 1997 the Kidney Disease Outcomes Quality Initiative (K/DOQI) was created in an attempt to form a consensus guideline based on both evidence and opinion to improve and standardize renal care, including care related to dialysis vascular access.

The most recent K/DOQI guideline for vascular access was published in 2000; an update of this guideline is expected to be published in 2006. The 2000 guidelines recommend that at least 50% of patients electing to receive hemodialysis for renal replacement therapy should have a native AVF placed, and that 40% of prevalent dialysis patients should have a native AVF. Since the publication of this guideline, numerous studies have shown a graded mortality risk dependent on access type, with the highest risk associated with central venous dialysis catheters, followed by AVGs and then AVFs.[3,4] The Choices for Healthy Outcomes in Caring for ESRD (CHOICE) study examined mortality based on access type in 616 incident hemodialysis patients for up to 3 years of follow-up. In this study, central venous catheters and AVGs were associated with approximately 50% and 26% increased mortality, respectively, compared with AVFs. Increased risk of mortality

was particularly evident in men.[5] Despite these findings and the K/DOQI recommendations, dialysis access data from 2002–2003 analyzed as part of the Dialysis Outcomes and Practice Patterns Study (DOPPS II) showed that only 33% of prevalent hemodialysis patients in the US were being dialyzed via AVFs. In Europe and Canada, 74% and 53% of patients, respectively, were being dialyzed via AVFs.[6]

PATIENT EVALUATION

Proper patient evaluation and dialysis access selection prior to access placement are important to success. Factors such as the characteristics of a patient's arterial and venous systems, cardiopulmonary adequacy, and life expectancy can all influence which access type and location are desirable for a given patient. A thorough physical examination should be performed to help guide additional diagnostic testing prior to access placement.

Routine preoperative vascular mapping with Doppler ultrasound to identify suitable vessels prior to AVF placement has been shown to increase numbers of AVFs placed (as opposed to AVGs and central venous catheters) and to improve access outcomes, especially for forearm fistulas, in women and patients with diabetes.[7,8] If the patient has physical findings indicative of, or risk factors for, venous impairment in the target extremity (such as edema, collateral vein development, differential extremity sizes, a pacemaker or previous catheter placement) then venography should be considered, as Doppler ultrasound is generally less accurate for evaluation of central venous structures.[9] Venography using iodinated contrast is, however, relatively contraindicated in a pre-dialysis patient, as contrast nephropathy and acute renal failure can ensue. Alternatively, contrast-enhanced magnetic resonance (MR) venography, which is not nephrotoxic, has been gaining acceptance as a means to accurately assess venous anatomy, including central venous structures, prior to AVF placement.[10–12]

MEASURES TO INCREASE NUMBERS OF NATIVE ARTERIOVENOUS FISTULAS

Every attempt should be made towards timely creation of an AVF in all eligible patients approaching end-stage renal disease (ESRD). 'Fistula First' is a movement founded by the Centers for Medicare and Medicaid in March 2005 that provides resources for nephrologists, vascular surgeons, vascular access coordinators, dialysis facilities, primary care physicians and patients, in order to encourage placement and optimal care of AVFs. Some centers advocate a multidisciplinary approach to vascular access, including a full-time vascular access coordinator as an integral member of the team.[13] The vascular access coordinator facilitates patient education, communication between specialists, access monitoring, outcomes tracking and quality assurance, and can be a cost-effective member of the vascular access team.[14] Evidence-based recommendations were developed by the National Vascular Access Improvement Initiative Working Group and are key to accomplishing the mission of Fistula First (Box 1). In anticipation

Box 1 Clinical and organizational recommendations for increasing arteriovenous fistula (AVF) use and improving hemodialysis patient outcomes (adapted from 'Fistula First Change Package' available at www.fistulafirst.org/tools.htm).

- Review vascular access as part of routine organizational improvement processes: incorporate vascular access into facility-based continuous quality improvement processes, based on a multidisciplinary approach
- Establish processes to facilitate timely referral to nephrologists: reach out to the community of primary care physicians to facilitate education with regard to appropriate referral criteria
- Establish processes to facilitate early 'AVF only' referral to surgeons: when possible, coordinate chronic kidney disease patient care so that patients will be referred early to surgeons specifically for AVF evaluation—including vein mapping where indicated—allowing sufficient lead-time for AVF maturation
- Select surgeons based on best outcomes: identify the surgeons in your community who have skills and interest in AVF placement and track their outcomes
- Use a full range of appropriate surgical approaches: vein transposition techniques allow surgeons to create successful AVFs in a substantially greater number of patients
- Place secondary AVFs in patients with AVGs: evaluate graft recipients for placement of a secondary AVF
- Place AVFs in patients with catheters where feasible: catheter use is associated with increased rates of infection, morbidity, mortality and hospitalization; catheter patients should be evaluated and permanent accesses placed as soon as possible
- Provide cannulation training: prevent fistulae from being destroyed by inexperienced staff
- Establish processes for monitoring and maintenance to ensure adequate ongoing access function: the health-care team should establish a protocol for monitoring and maintenance of AVFs to ensure adequate functionality
- Educate caregivers and patients: dialysis patients and their caregivers need education and resources to support their decision-making about care

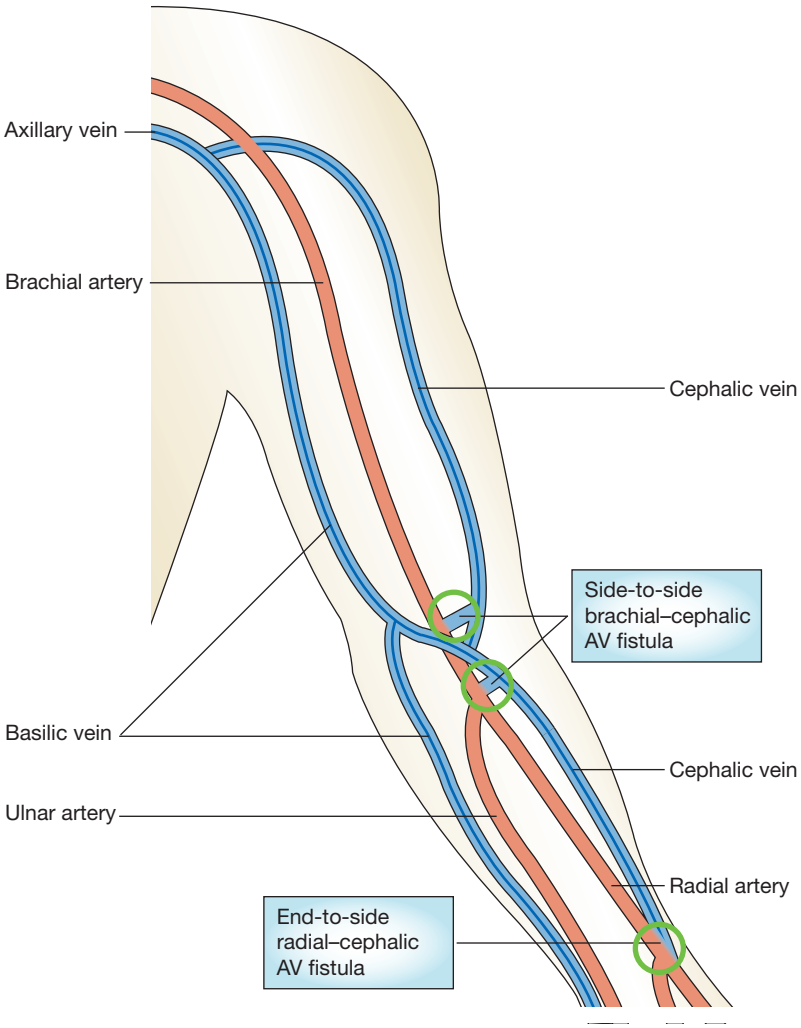

Figure 1 Diagram illustrating end-to-side, radial–cephalic (wrist) and side-to-side, brachial–cephalic (elbow) primary AV fistulas. Abbreviation: AV, arteriovenous.

of future dialysis access placement in patients with advanced chronic kidney disease, every effort should be made to preserve suitable arm veins regardless of arm dominance. Vein preservation involves avoiding blood draws or intravenous catheter placement in the veins of the arm, in particular the cephalic veins, as venipuncture can render the site unsuitable for placement of an AVF. Instead, the dorsum of the hand should be used for blood draws and intravenous lines.

AVFs are typically constructed with an end-to-side vein-to-artery anastomosis. A wrist (radial–cephalic) followed by an elbow (brachial–cephalic) primary AVF placed in the non-dominant arm is the access of choice in patients who will be or are dialysis dependent (Figure 1). A wrist AVF is simple to create, has a lower incidence of vascular steal than an elbow AVF, and preserves more-proximal arm vessels for future access creation.

Hand–arm exercises such as squeezing a rubber ball with a lightly placed tourniquet might expedite the maturation process by increasing blood flow. AVF placement in a patient approaching ESRD should be timed such that fistula maturation is correlated with the anticipated need for starting dialysis therapy. Fistula creation is usually indicated when creatinine clearance is less than 0.4 ml/s (25 ml/min), serum creatinine is greater than 354 µmol/l (4 mg/dl) or within 1 year of anticipated need for dialysis.

TIMING OF FIRST CANNULATION

An AVF is mature and therefore suitable for use when the vein diameter is sufficient to allow successful cannulation and the fistula is able to provide the prescribed blood flow for adequate dialysis. Although the optimal wait-time for maturation of an AVF is unknown, current K/DOQI guidelines recommend that this period is more than 1 month and generally 2–3 months after placement.[2] This recommendation was, however, based largely on opinion and has more recently come into question as perhaps being too long.[15] The DOPPS investigators studied practice patterns regarding the timing of first fistula cannulation at the dialysis facility level.[16] In their study, the relative risks for fistula failure when initial cannulation was less than 4 weeks, 2–3 months or more than 3 months after placement were 0.71 ($P=0.08$), 0.91 ($P=0.43$) and 0.87 ($P=0.31$), respectively. The authors concluded that earlier cannulation of newly placed vascular access at a facility level is not associated with an increased risk of access failure. That being said, the study was observational in nature and susceptible to bias. Randomized clinical trials need to be performed to more definitively address this issue.

ARTERIOVENOUS GRAFTS

If a native AVF cannot be established, a secondary alternative is to place a synthetic AVG made of polytetrafluoroethylene (PTFE) or polyurethaneurea (PUU). Although an AVF is preferred, an AVG has some advantages including a large surface area, easy cannulation, shorter maturation time and relatively simple surgical placement. Opinion-based recommendations

in the 2000 K/DOQI guidelines are that PTFE AVGs should not routinely be cannulated until 14 days (and preferably 3–6 weeks) after placement. The Vectra® (Thoratec Laboratories Corporation, Pleasanton, CA) is a PUU AVG that, according to the product website, has "graft-sealing properties" and does not require tissue ingrowth into the graft, permitting immediate use after placement. Glickam *et al.* compared PTFE and PUU grafts in 142 patients in a multicenter, randomized, prospective, controlled study that examined (among other things) graft survival, time to early cannulation, and hemostasis after cannulation. Results for PTFE and PUU grafts were similar with regard to 12-month primary (36% and 44%, respectively) and secondary (80% and 78%, respectively) patency. Results for hemostasis after cannulation were superior in the PUU group; 53.9% of PUU grafts were cannulated less than 9 days after placement compared with 0% of PTFE grafts.[17] One possible drawback of the PUU graft is interference of graft material with Doppler ultrasound.[18]

An AVG requires on average four times more salvage procedures than an AVF and, despite intervention, the long-term patency of AVGs is inferior to that of an AVF. A synthetic AVG is generally anticipated to last 3–5 years.[19] The K/DOQI Working Group was unable to come to a consensus regarding preferred initial location for AVG placement, stating that this should be determined individually according to each patient's unique anatomical restrictions, the surgeon's skill and the anticipated duration of dialysis. AVGs are most commonly placed in the non-dominant forearm as an antecubital loop graft, or in the upper arm as a curved graft. Grafts using smaller distal vessels tend to experience more frequent thrombosis yet have the advantage of preserving more-proximal larger vessels as potential sites for future access placement. Proximal vessel grafts tend to have better patency and flow, yet limit potential future access sites. In patients who have exhausted all upper extremity access sites, grafts can be placed in the thigh or chest wall ('necklace' grafts) but are associated with higher complication rates. A recent study of femoral AVGs demonstrated poor graft (and patient) survival 1, 2 and 3 years following graft placement (graft survival 41%, 26% and 21%, respectively; patient survival 81%, 68% and 54%, respectively).[20]

CUFFED DIALYSIS CATHETERS

The cuffed, tunneled dialysis catheter is the least preferred angioaccess method because of higher risks of death, thrombosis, infection, permanent central venous stenosis or occlusion, shorter expected use-life and lower blood flow rates than other access types.[21,22] Cuffed catheters do, however, have a defined albeit limited role in hemodialysis. Advantages of cuffed, tunneled hemodialysis catheters include immediate use after placement, no hemodynamic consequences of placement (e.g. no high-output heart failure) and the ability to be inserted into multiple sites. Dialysis catheters are used when awaiting maturation of a recently placed AVF, or in the setting of acute renal failure where renal function is anticipated to recover after 1–3 weeks. In extremely dire situations when all traditional access sites have been exhausted, transhepatic or translumbar (into the inferior vena cava) dialysis catheter access placed via interventional radiology has been used.[23]

The cuffed, tunneled dialysis catheter is inserted with ultrasound guidance and placed using fluoroscopy to ensure that the catheter tip is adjusted to the level of the caval–atrial junction for optimal blood flow. Insertion into the right internal jugular vein is preferential as it is a more direct route to the caval–atrial junction than left-sided placement.[23] Compared with internal jugular insertion, tunneled catheter insertion into the femoral vein is associated with higher rates of infection and recirculation while subclavian insertion is associated with higher rates of central venous stenosis. Central venous stenosis can have the devastating consequence of precluding the entire ipsilateral arm from future dialysis vascular access and should be used only when internal jugular options are not available.

NON-CUFFED DIALYSIS CATHETERS

Emergent or acute hemodialysis access needed for less than 3 weeks can be obtained with a non-cuffed, percutaneous double-lumen catheter inserted at the bedside. These catheters can be inserted in the internal jugular or femoral vein when immediate dialysis is necessary. Like the cuffed catheters, subclavian insertion should be avoided in any patient potentially needing long-term dialysis access because of the possibility of central venous stenosis.[24] These non-cuffed catheters have a finite use-life that should not exceed 3 weeks for internal jugular or subclavian

positioned catheters and 5 days for femoral placed catheters in bed-bound patients. The absence of a cuff renders these catheters even more susceptible to infection by bacteria migrating down the external surface of the catheter.

VASCULAR ACCESS STENOSIS

Venous stenosis leads to diminished blood flow through the access and accounts for 80–85% of access thrombosis; arterial stenosis accounts for 1–2% of access thrombosis. Access stenosis is thought to occur as a result of intimal and fibromuscular hyperplasia in the venous outflow tract. The exact mechanisms of intimal hyperplasia are not currently understood, but are thought to be related to the cumulative effects of inflammation, hemodynamic factors and coagulation.[25] Smooth muscle cell migration and proliferation contribute to neointimal overgrowth into the vascular lumen of the arteriovenous (AV) access. One of the central molecular mediators of vascular proliferation is thought to be $G_{\beta\gamma}$ signaling. In pig models, adenovirus vector-mediated administration of β-adrenergic receptor kinase, which inhibits $G_{\beta\gamma}$ signaling, reduces intimal hyperplasia at the AV anastamosis.[26] Other potential interventions for prevention and treatment of intimal hyperplasia and venous obstruction include *in vivo* seeding with anti-CD3 antibodies to accelerate endothelialization of newly placed AVGs, use of sirolimus-eluting stents, local gene therapy and brachytherapy.[27–30] These modalities have been studied in animal models and are at various stages of transition to human application. Other non-anatomic predisposing factors to access thrombosis include hypotension, elevated hematocrit levels, excessive access compression, hypercoagulable states and hypovolemia.[31]

MONITORING AND MAINTENANCE OF DIALYSIS ACCESS

Patency and function of vascular access is essential to optimal dialysis dose delivery for patients with ESRD. For AVFs, cumulative patency rates are approximately 53% and 45% over 5 years and 10 years, respectively.[32] Vascular access dysfunction significantly contributes to the estimated 11–25% of adult hemodialysis patients who fail to receive an adequate dialysis dose in the US.[33] Between 1991 and 2001 there was a 22% increase in vascular access events in patients undergoing hemodialysis.[34] As a consequence of this increase in dialysis access-related events, up to US$1.5 billion are currently spent annually on vascular access and its associated complications in the US, a staggering 6% of the total Medicare budget for ESRD.[35] Contributing to the financial burden is that dialysis access-associated complications account for 15–20% of hospitalizations among hemodialysis patients.[36,37] K/DOQI recommends regular physiologic monitoring of dialysis access so that early identification and repair of access dysfunction due to stenosis can decrease the incidence of dialysis access failure due to thrombosis.

The detection of early AVG or AVF stenosis and subsequently diminished blood flow is paramount in preventing access thrombosis and failure. Monitoring of an AVF or AVG includes physical examination of the vascular access to detect signs indicative of the presence of pathology and impending graft failure. This access examination, which should be performed at least weekly, includes inspection, auscultation and palpation of all sections of the AVF or AVG. Access flow determines the characteristics of the pulse bruit and thrill. Adequate flows greater than 450 ml/min are indicated by a palpable thrill at the arterial, mid and venous segments of the access.[38] A pulse is indicative of lower flow rates. Intensification of a bruit is suggestive of a stenosis or stricture in that area of the access. Other findings that indicate stenosis include prolonged bleeding after needle withdrawal and persistent swelling of the arm containing the dialysis access.[39] An unexplained decrease in dialysis adequacy (as measured by the *Kt/V* or urea reduction ratio) can signify access stenosis and dysfunction. The weekly measurement and tracking of dynamic and static venous pressures can also help to identify AV access dysfunction by detecting outflow stenosis.

Other techniques for blood flow measurement/monitoring include ultrasound dilution, thermodilution, Doppler ultrasound, ionic dialysance, the glucose pump technique and optodilutional methods.[40–43] Studies indicate that ultrasound dilution yields the most reproducible blood flow measurements, and optodilutional methods the least.[44] Ultrasound dilution has also been shown to be as effective (yet less time-consuming and operator-dependent) than Doppler ultrasound in detecting access stenosis, and is favored by some authors as the screening method of choice.[43,45] For AVFs, the ideal blood flow threshold for performing angiography is undetermined. A reasonable threshold is

500 ml/min, provided that the blood flow rate is not declining, there is no clinical evidence of stenosis and screening is performed every 2 months.[43] For AVGs, the value of blood flow screening is controversial. A recent, randomized clinical trial detected no benefit associated with AVG monitoring using blood flow measurements compared with venous pressure monitoring.[46] More studies need to be performed before regular blood flow monitoring of AVGs can be definitively recommended.

The K/DOQI guidelines recommend an organized monitoring approach with regular assessment of the clinical parameters of the AV access and dialysis adequacy that is tabulated and tracked within the dialysis center as part of a quality assurance/improvement program.

PREVENTION AND TREATMENT OF COMPLICATIONS OF DIALYSIS ACCESS

Arteriovenous access stenosis and thrombosis

Several agents have been studied for the medical prevention of access thrombosis. Data conflict with regard to the safety and efficacy of antiplatelet agents such as aspirin, clopidogrel and dipyridamole. The role of these drugs in the prevention of access thrombosis is currently unresolved.[47,48] Systemic anticoagulation has also been shown to have only marginal benefit in prevention of access thrombosis, but with an unacceptable bleeding rate. Anticoagulation with warfarin should be considered in patients with recurrent access thrombosis or in those diagnosed with a hypercoagulable state such as the antiphospholipid antibody syndrome.[49,50] One promising preventative therapy for AVG thrombosis is omega-3 fatty acids found in fish oil. This therapy was tested in a study of 24 patients, of whom half were randomized to receive 4 g of fish oil and half to 4 g of a placebo oil. In patients receiving fish oil, there was a primary AV access patency rate of 75.6% versus 14.9% in the placebo group at 1 year.[51]

Once venous stenosis of greater than 50% is detected, percutaneous angioplasty is the treatment of choice to prolong graft survival and prevent thrombosis.[52] The procedure is successful in correcting approximately 80% of stenoses, but is less successful with tight lesions that are more than 80% of the luminal diameter. Once angioplasty has been performed, the rate of restenosis is 55–70% at 1 year.[53] Repeat angioplasty can be performed for restenosis. Surgical revision is an alternative to angioplasty for AV access stenosis, but is generally reserved for lesions that are not amenable to angioplasty such as high-grade stenosis. Surgical revision of the stenotic AV access has been shown to yield superior annual patency results compared with angioplasty (65% versus 25%).[54] Surgical revision is, however, limited by the need for hospitalization and extension of the fistula site further up the extremity involved.

The treatment options for AV access thrombosis are surgical thrombectomy or percutaneous thrombolysis, both of which result in patency rates of roughly 90%.[55,56] Following treatment of the thrombus, any predisposing stenotic lesion needs to be detected and treated to decrease the incidence of rethrombosis.[57]

Dialysis catheter thrombosis

Late-developing catheter malfunction can be caused by both intrinsic and extrinsic thrombus formation and should be suspected when extracorporeal catheter blood flow is not sufficient to achieve adequate dialysis. Minimal catheter blood flow rate is 300 ml/min but should optimally be greater than 400 ml/min. Late catheter dysfunction should be treated immediately with a step-wise approach. First, a forceful saline flush should be attempted, followed by instillation of the thrombolytic agent tissue plasminogen activator (tPA). A recent, small study looked at long (>48 h) versus short (~1 h) tPA dwell times for dysfunctional dialysis catheters. The authors found no difference in catheter patency rates between long-dwell and short-dwell tPA infusions (78% patency at subsequent hemodialysis run, 48% patency at 2 weeks). They concluded that tPA, either as short-dwell or long-dwell, is useful in restoring short-term catheter function but fails to maintain long-term patency.[58] If these primary measures do not work, secondary measures include radiographic evaluation of the dysfunctional catheter and further treatment based on the radiographic findings. If a fibrin sheath is present then either a catheter exchange over a guidewire or fibrin sheath stripping can be performed. Other abnormalities such as malposition of the catheter or residual thrombus can be detected and corrected accordingly.

Access infection

Dialysis access infection is a common problem that accounts for approximately 20% of access losses. The most common pathogen is

Staphylococcus aureus, but empiric antibiotic treatment should also cover gram-negative organisms and enterococci. Risk factors for AV access infection include the formation of pseudoaneurysms or perifistular hematomas (caused by improper cannulation), use of the access by the patient for intravenous drug administration, and manipulation of the access via secondary surgical procedures.[59,60] Another potential and often underappreciated source of infection is old, previously clotted AVFs and AVGs.[61] AVGs have a higher infection rate than AVFs, with infection occurring in 5–20% of grafts. Local infections of a graft can be treated with 3 weeks of antibiotics (based on culture results) plus resection of the infected portion of the graft. Extensive infection of an AVG should be treated with complete excision of the graft plus intravenous antibiotics. Infected AVGs less than a month old should also be resected and treated with antibiotics regardless of the extent of the infection.[62]

Infected AVFs occur less commonly and can be treated with 6 weeks of antibiotic therapy alone, in a manner similar to subacute bacterial endocarditis. Removal of the fistula is generally only indicated in the setting of septic emboli.

There are two types of cuffed catheter infections. When the catheter exit site becomes infected—a state characterized by erythema, drainage and crusting—treatment involves local care of exit sites with antimicrobial agents. If tunnel drainage is present, the drainage should be cultured and appropriate antibiotics administered that have staphylococcus coverage. The catheter should not be removed unless the exit-site infection fails to respond to medical therapy. With catheter-related bacteremia in a clinically stable patient, a 36 h trial of empiric antibiotics can be attempted with prompt removal of the catheter after 36 h if there is no response to therapy.[63] That being said, only about 25% of infected catheters can be salvaged with antibiotic therapy.[64] Duration of therapy should be a minimum of 3 weeks for bacteremia with catheter exchange following successful medical therapy.[65] If the catheter is removed, a new permanent access should not be placed until blood cultures, performed after cessation of antibiotic therapy, have been negative for 48 h. A recent meta-analysis by Nissenson *et al.* showed that patients with dialysis-related staphylococcus septicemia had costly (average for index admission US$17,307) and lengthy (average stay 13 days) hospitalizations, which were frequently associated with clinically and economically important complications, including hospital readmission (11.8% within 12 weeks).[66]

Digital ischemia

Patients with diabetes, the elderly and patients with peripheral arterial disease are at increased risk for AV access distal extremity ischemia due to shunting of blood.[67] This complication occurs in 4–20% of patients with AV access. Patients will often complain of sensations of numbness, coldness, tingling and impaired motor function in the distal extremity bearing the AV access.[68] These symptoms might be confused with those of carpal tunnel syndrome, which can develop with increased frequency in long-term dialysis patients as a result of amyloidosis, and in patients with AVFs.[69] Other signs and symptoms include pain during exercise, non-healing ulcers and muscle wasting in the distal extremity.

Severe or acute ischemic symptoms such as absent pulse or a cold extremity are emergencies and warrant immediate medical attention. For severe ischemic symptoms, the treatment is surgical—distal revascularization with interval ligation procedure.[70] Alternatively, a procedure termed 'revision using distal inflow' (RUDI), which involves ligation of the fistula at its origin followed by re-establishment of the fistula via bypass from a more distal arterial source to the venous limb, was found to be effective for treating dialysis steal syndrome in a small sample of four patients.[71] RUDI is a promising alternative to distal revascularization with interval ligation because it places the fistula and not the native arterial supply at risk by ligation and revascularization.

Treatment of mild ischemia is conservative, with symptom-specific therapy such as wearing a glove for a cold hand. Frequent examinations are needed to detect subtle neurological or muscular changes. If the symptoms do not improve, or worsen, surgical intervention is indicated.

Heart failure

AV access placement can predispose to high-output heart failure, especially in patients with a pre-existing cardiomyopathy. The risk is greatest when fistula flow exceeds 20% of cardiac output.[72] Measurement of cardiac output and systemic vascular resistance should be performed after temporary balloon occlusion of the AV

access to confirm the presence of high-output heart failure. Once this is confirmed, surgical narrowing or banding can be attempted to limit AV access flow.[73] This procedure may, however, be complicated by thrombosis, and often does not permanently limit AV access flow.[74] Patients unable to tolerate AV dialysis access might need to either be hemodialyzed with a cuffed catheter or be switched to peritoneal dialysis.

Pseudoaneurysm and aneurysm formation

In AVFs, pseudoaneurysms of the venous limb are much more common than true aneurysms. These can be prevented by rotating the site of needle puncture. Treatment is generally conservative, with observation and avoidance of needle puncture in the aneurysm site. Surgical correction is indicated when the aneurysm involves and compromises the arterial anastamosis. In AVGs, resection and insertion of an interposition graft should occur when there is rapid expansion of the pseudoaneurysm, when the pseudoaneurysm is more than twice the size of the graft, when the pseudoaneurysm threatens the viability of the overlying skin, or if the pseudoaneurysm is infected.[2] AVG pseudoaneurysms that are repeatedly cannulated and are not resected can expand and rupture, resulting in significant hemorrhage.

CONCLUSIONS

Hemodialysis vascular access provides a critical portal to a patient's circulatory system. The functional capacity of the vascular access is a major determinant of how successfully the dialysis dose is delivered. Dialysis access can also be the source of significant morbidity and mortality in the ESRD patient. With close observation and meticulous care, as outlined by the K/DOQI clinical guidelines, potential complications such as access stenosis and thrombosis, infection, digital ischemia, heart failure and aneurysm/pseudoaneurysm can be prevented. When these complications do develop they should be diagnosed immediately and acted upon urgently. The consequences of not doing so can be devastating, ranging from loss of access through significant morbidity to death. Quality vascular access is a precious and potentially limited resource in a patient with ESRD on chronic hemodialysis. Maintaining the vascular access should be of the highest priority for the patient, caring nephrologist and health-care team.

KEY POINTS

- In order of preference (based on duration of patency, and associated complications), types of vascular access for hemodialysis in end-stage renal disease patients are the native forearm arteriovenous fistula (AVF), the upper-arm AVF, the arteriovenous graft and the cuffed central venous catheter
- Complications associated with vascular access included stenosis and thrombosis, infection, digital ischemia, heart failure, pseudoaneurysm and aneurysm
- Consensus guidelines for vascular access were published in 2000 by the Kidney Disease Outcomes Quality Initiative; updated guidelines are expected in 2006
- Vigilant monitoring and rapid intervention are required if complication-related vascular access failure is to be avoided

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