# *Grand Rounds*

# The Multidisciplinary Approach to Hemodialysis Vascular Access at The Mount Sinai Hospital

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**Abstract**

A majority of the quarter of a million end-stage renal disease patients nationwide are treated with hemodialysis. Important and frequent causes of morbidity and mortality, when they undergo this procedure, include vascular access infection and thrombosis associated with the use of catheters and, to a lesser extent, grafts. Therefore, an arteriovenous (AV) fistula is the preferred hemodialysis access. A multidisciplinary approach, including nephrologists, vascular surgeons, interventional radiologists, nurses, nephrology fellows, and nephrology physician assistants, meeting together weekly, should improve hemodialysis outcomes by promoting the use of AV fistulas. The specific roles of the interventional radiologist, vascular surgeon, nephrologist and other members of the multidisciplinary team are reviewed. Important additional components of this program are Doppler ultrasound for preoperative hemodialysis access vein mapping and screening techniques for early detection of arteriovenous graft stenosis. The use of arteriovenous fistulas in the Mount Sinai outpatient hemodialysis program has increased from 15% to 43% ($p<0.001$) and substantially limited catheter use since 1998, when the multidisciplinary program began.

**Key Words:** Dialysis, AV fistula, graft, catheter, vein mapping, Doppler ultrasound, static venous pressure, thrombolysis, distal revascularization interval ligation.

## Introduction

THE END-STAGE RENAL DISEASE (ESRD) program in the United States has grown 100-fold, to approximately one quarter of a million patients, since Congress approved Medicare coverage of renal replacement therapy in 1972 (1). Although this represents a genuine medical success story, there are some negative aspects. Currently, vascular access procedures and their complications represent major causes of morbidity and mortality for chronic hemodialysis patients, with an estimated annual health care cost approaching $1 billion (2).

The arteriovenous fistula (AVF) is the preferred hemodialysis access with the lowest risk of infection and thrombosis (3). Unfortunately, recent data show only 28% functional AVF and 24% catheter prevalence in U.S. hemodialysis patients (4), in contrast to an 80% AVF prevalence in Western Europe (5). Although several risk factors associated with poor AVF outcomes, such as advanced age, diabetes, African-American ethnicity, obesity, and female gender are well represented in the U.S. dialysis population, this is unlikely to be solely responsible, given the 0–87% AVF prevalence range for individual centers nationwide (5).

A multidisciplinary approach to hemodialysis vascular access should increase the percentage of AVF created, preserve each access site for as long as possible, and limit tunneled and cuffed catheter (TCC) use. The following sections will review the roles of the interventional radiologist, vascular surgeon and nephrologist, and of the multidisciplinary team, in vascular access planning and management.

## Interventional Radiology

The role of the interventional radiologist is to provide and maintain adequate vascular access as long as possible, to avoid delays and/or

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interruptions in hemodialysis therapy. Factors that complicate the management of dialysis access include: the limited number of potential access sites in each patient, the limited lifespan of each site, and the natural occurrence of stenoses/thromboses, particularly in the case of arteriovenous grafts (AVG). The interventional radiologist is essential for the placement, management and removal of TCC and the management of poorly functioning AVF and AVG.

## Tunneled and Cuffed Catheters

TCC provide temporary vascular access, with advantages including ease of insertion and immediate use. Indications for TCC are maturing AVG or AVF, failure of either current access site or peritoneal dialysis, and acute renal failure requiring hemodialysis for more than three weeks (3). These catheters should be preferentially placed in the right internal jugular vein (Fig. 1), since this site confers the lowest complication rate (3). Other placement options include the right external jugular and left internal and external jugular veins. The brachiocephalic vein and collateral veins offer alternative access sites for patients with occluded internal and external jugular veins. Subclavian vein catheterization should be avoided unless there are limited alternatives, because central venous stenoses and occlusions frequently follow catheter placement at this location (3). Femoral, translumbar, and transhepatic vein TCC may also be used only in exceptional circumstances, since these sites are associated with high complication rates. Catheter insertion using real-time ultrasound guides placement and also reduces complications, since venous anatomy varies (3, 6).

Catheter malfunction secondary to pericatheter fibrin sheath and thrombus formation is common, often limiting duration of catheter utility. Late catheter malfunction results from thrombosis or fibrin sheath formation. Treatment options include percutaneous fibrin sheath stripping, performed in the interventional radiology suite or thrombolytic TCC instillation (7). The latter is noninvasive and safe, and can be performed in the outpatient dialysis unit, using 1 mg/mL alteplase or 0.4 U reteplase to fill luminal volume. One prospective study of alteplase for catheter malfunction revealed limited efficacy after 3 instillations (8). If thrombolytic therapy fails to restore catheter function, catheter exchange should be considered, after imaging to identify the cause of malfunction.

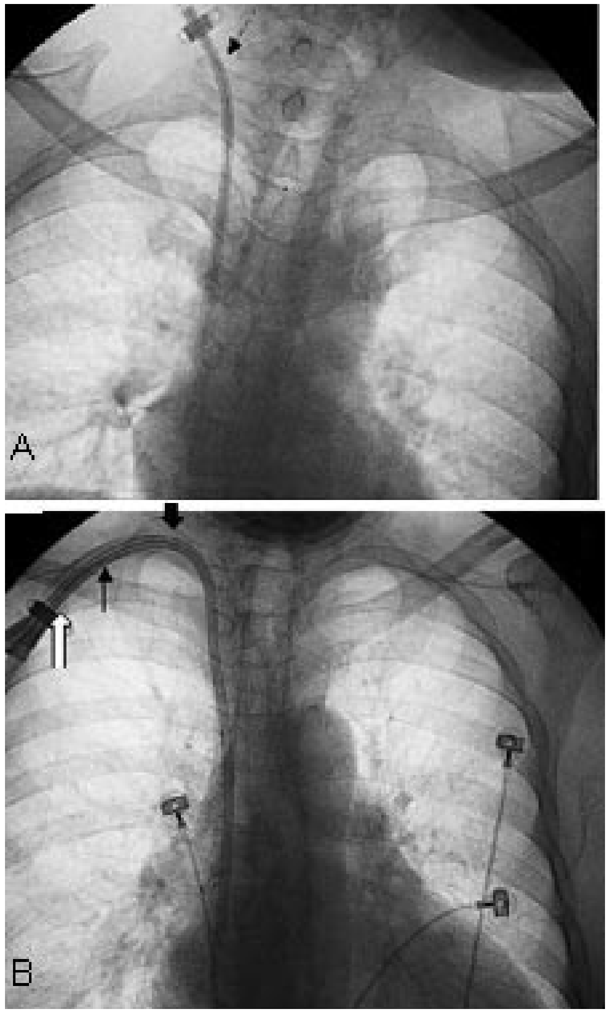


**Fig. 1.** Double lumen hemodialysis catheter types include the right internal jugular vein uncuffed catheter shown in panel **(A)** with venotomy and catheter exit site at the same position (black arrow) and catheter tip in the right atrium. The right internal jugular vein tunneled cuffed catheter (TCC) is shown in panel **(B),** with the approximate venotomy site (wide black arrow), approximate cuff location (thin black arrow), and exit site (white arrow). The subcutaneous tunnel is located between the large arrows and the TCC tip is in the right atrium.

## Arteriovenous Fistulae

Although the AVF is the preferred vascular access (3), the disadvantages of AVF include: 3–4 month maturation, possible need for TCC to initiate dialysis, failure of outflow vein to enlarge sufficiently to allow for repeated cannulation by 16- or 15-gauge needles, and unappealing cosmetic appearance of enlarged veins. The radiocephalic AVF, followed by brachiocephalic AVF, are preferred as optimal sites (3).

A major problem of AVF is failure to mature in approximately a third to up to half of cases (9). Failure of maturation can be attributed to:

inadequate arterial inflow, outflow vein stenosis, poor surgical anastomosis, and development of collateral veins that delay maturation by siphoning flow (10). The examination of a maturing AVF should focus on the caliber of the fistula and the quality of the thrill. Collateral veins may be obvious on clinical evaluation or detected only by temporary finger occlusion of the AVF (10). Stenoses (inflow and outflow) should be treated with percutaneous transluminal angioplasty (PTA). If PTA fails, surgical revision or new AVF insertion should be considered. Most stenoses occur in the outflow vein at the point of vein mobilization during the initial AVF construction, known as swing-point stenoses (11). The interventional radiology group at Mount Sinai recently demonstrated PTA to be safe, and efficacious in establishing adequate blood flow at swing-point stenoses in non-maturing or poorly functioning AVF (11).

When a mature AVF can no longer sustain adequate blood flow, intervention is recommended to prolong the fistula life (3). Etiologies for poorly functioning AVF are outflow vein stenoses or progressive atherosclerotic disease. The quality of the thrill over the entire portion of the AVF should be the crux of the examination. Failing AVF may present with decreased thrill or pulse alone, elevated venous dialysis pressures, abnormal urea recirculation, decreasing dialysis dose delivery, decreasing flow rates, difficulty in cannulating, or prolonged post-dialysis bleeding (10). However, these findings occur late and are not as sensitive as in AVG screening.

The treatment of thrombosed AVF is more challenging than that of poorly functioning AVF. There is controversy in the interventional radiology community regarding the long-term patency of salvaged thrombosed AVF. A recent report demonstrated excellent results in AVF percutaneous thrombectomy using thromboaspiration, mechanical devices, or thrombolytic drugs in combination with PTA (12).

### Arteriovenous Grafts

After AVF possibilities are exhausted, AVG is the next best option for hemodialysis vascular access (3). The most common cause of AVG failure is the development of intimal hyperplasia at the site of venous anastomosis, which progressively leads to thrombus formation, graft occlusion, and arterial clot extension (3). Other AVG thrombosis etiologies include arterial and mid-graft stenosis, severely impaired cardiac output, hypotension, hypercoagulability, or rarely, excessive external compression. The salvage of thrombosed AVG can be achieved using thrombectomy (mechanical/surgical/balloon), pulse-spray pharmaco-mechanical thrombolysis, and infusion or instillation of thrombolytic agents to restore flow and re-establish patency. Unlike AVF, occluded AVG are more amenable to thrombolysis (which is typically done in combination with PTA) (Fig. 2). Combinations of PTA and 1 unit reteplase plus 4,000 IU heparin or 2 mg tissue plasminogen activator (tPA) plus 3,000 – 5,000 IU heparin have been shown to be efficacious and safe for the treatment of thrombosed AVG (13, 14). This modified thrombolysis and PTA technique allows for a rapid occlusion resolution in the angiography suite. The addition of thrombolytic agents in the management of occluded AVG is particularly important for reducing the risk of pulmonary embolism.

### Central Venous Disease

The clinical signs of central venous disease include the presence of upper extremity edema, facial edema, and collateral veins over the ipsilateral upper arm, neck, and chest wall. The vascular access usually remains patent. Stenoses should be managed primarily with PTA (3). Occlusions and lesions refractory to PTA should be treated with stents. The Mount Sinai interventional radiology program follows occluded central veins after PTA and/or stent insertion every 6 – 8 weeks to maintain patency, monitor for recurrence of symptoms, and assist in the preservation of ipsilateral access function. The frequent recurrence of central venous lesions supports this approach.

## Vascular Surgery

Procedures for hemodialysis access are the most common vascular surgical operations in the United States, representative of the growing number of ESRD patients (15). A recent report found that AVG are used 1.7 times more often than AVF (16), in part as a result of quicker AVG maturation and the high early AVF-failure rate. Upper limb arteries and veins most suitable for vascular access should be selected before the diagnosis of ESRD is established.

### Vascular Screening Using Doppler Ultrasound

Three vascular access screening techniques are history and physical examination, Doppler

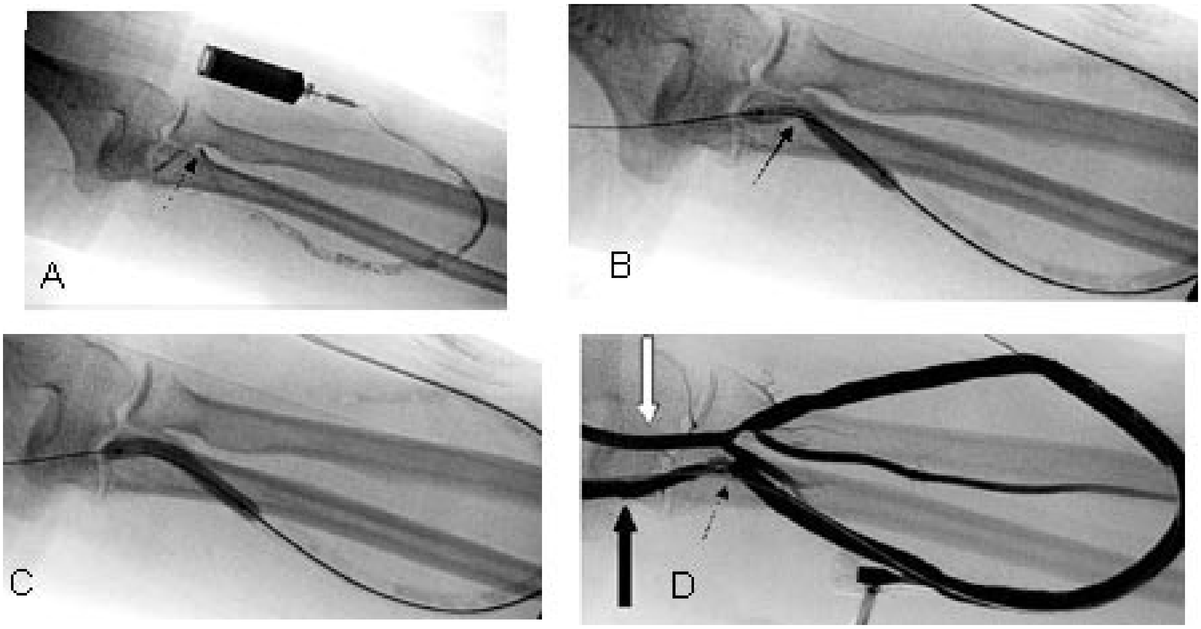


**Fig. 2.** A thrombosed forearm arteriovenous graft (AVG) undergoes percutaneous thrombolysis and angioplasty (PTA). Panel **(A)** demonstrates clot as filling defects within graft. Venous anastomosis is shown by arrow. Panel **(B)** following thrombolysis, PTA is performed at the venous anastomosis. The waist on the balloon identifies the venous anastomotic stenosis (arrow) responsible for AVG thrombosis. Panel **(C)** shows the balloon fully inflated to 18 atm pressure, to facilitate the obliteration of the stenosis. Panel **(D),** the post-procedure angiogram reveals patent inflow/brachial artery (white arrow), AVG, venous anastomosis (thin black arrow) and outflow/basilic vein (wide black arrow).

ultrasound, and venography. Screening should be performed not only before the diagnosis of ESRD is established, but also at any time a patient's access is being revised or replaced. A history of previously failed vascular accesses will limit available sites for access; the cause of a previous failure may influence future access planning. Hemodialysis AVG or AVF should never be placed on the same arm as an existing transvenous pacemaker or an existing subclavian catheter unless there are no other options. Although Doppler studies are reliable for peripheral venous and arterial assessment without contrast, venography is more accurate for evaluating central veins. Cost, invasive nature, and radiocontrast nephrotoxicity in chronic kidney disease (CKD) patients limit venography indications to those access candidates with upper extremity edema, collateral vein development, current or previous subclavian catheter placement, pacemaker placement, previous arm, neck, or chest trauma, and multiple previous accesses (3). For patients who do not have venography indications, preoperative Doppler screening is performed. Vein mapping is superior to clinical examination for identifying veins suitable for AVF construction.

Although Doppler ultrasound is an invaluable tool for vascular access assessment of the hemodialysis patient, few studies have examined the utility of vascular mapping before hemodialysis access insertion. Silva and colleagues (17) suggest that the inability to predict adequacy of venous outflow based solely on clinical examination, and the consequent use of suboptimal veins and arteries has resulted in high AVF failure rates and increased usage of AVG. This group developed a noninvasive preoperative protocol to increase AVF by identifying veins that were not clinically evident. This group was the first to prospectively demonstrate an increase in AVF construction from 14% to 63% using Doppler ultrasound vein mapping. The preoperative criteria for creating a successful upper extremity AVF were diameters of 2 mm or larger for arteries and 2.5 mm for veins.

Robbin's group (18) compared the original operative plan based on clinical assessment alone versus that using Silva's criteria. Fifty-two of 70 patients who underwent ultrasonographic mapping had vascular accesses placed. Preoperative ultrasonographic mapping resulted in a change in the planned surgical procedure for 16 (31%) of the 52 patients. An AVF rather than the planned AVG was placed in 8 (15%) patients. Overall, 30 (58%) of the 52 patients had an AVF placed compared to 126 (32%) of

395 previous patients who had not undergone preoperative mapping. An additional 17-month prospective series of preoperative Doppler at the same center demonstrated an increase in AVF creation from 34% to 64% when compared to historical controls without consistent vein mapping (19).

Patients who meet the following vein mapping criteria (20, 21), developed by Dr. Teodorescu, are selected for AVF insertion:

1. Cephalic or basilic veins measuring at least 2 mm in diameter in continuity with the deep system.
2. An appropriate artery measuring at least 2 mm in diameter with peak systolic velocity of 50 cm/sec or greater.
3. Patent ipsilateral subclavian vein.

The criteria for preoperative noninvasive screening were developed in l998 by extrapolating lower extremity vein bypass graft data (22). Since success was reported with the use of veins as small as 2 mm, this caliber was adopted as the criterion for the ability to create an AVF. Vein diameter varies with volume status, and therefore a single small measurement was not enough to eliminate the possibility of creating an AVF. Venous duplex ultrasound was performed without the use of a tourniquet, unless veins smaller than 2.5 mm were identified. The ability of a small vein to dilate to a diameter 110% greater or more with tourniquet application was taken as an indication that the vein was suitable for use as a fistula.

An AVF should be created when the glomerular filtration rate (GFR) falls below 30 mL/min (23). The poor patency rate of AVG due to thrombosis may require its creation several weeks before dialysis becomes necessary.

A majority of patients undergoing access Doppler screening meet the above criteria and are thus able to undergo AVF creation. The most common reason for AVG placement is upper extremity veins measuring less than 2 mm in diameter or veins that are calcified. Retrospective series of Mount Sinai's preoperative ultrasound Doppler screening program demonstrate particular benefit in diabetics (20) and obese patients (21), in whom the use of AVF is otherwise infrequent.

### "Steal" Syndrome

An uncommon, 1.8 – 4.3% (24), but potentially devastating upper arm AVG and AVF complication is distal upper limb ischemia, which occurs when the access diverts brachial artery blood flow leading to ischemia of tissues supplied by the arterial vessels distal to the access site. Other risk factors include diabetes and peripheral vascular disease (24). This complication is less common with forearm AV access. Prevention of "steal" syndrome is an important aspect of preoperative vascular screening. Such screening should include measuring the blood pressure in both upper extremities and performing the Allen test bilaterally, as well as taking the appropriate Doppler ultrasound measurement of arterial caliber and peak systolic velocities.

Although the diagnosis of steal syndrome is frequently obvious, angiography before and after occlusion of the dialysis access definitively establishes etiology and assists the surgeon in planning intervention.

If ischemia occurs, the vascular surgeon must make a clinical decision regarding the optimal technique to restore or improve flow to the ischemic segment. Ligation of the access is the optimal procedure to treat ischemia, but leaves the patient no alternative other than catheter access. Partial limitation of access flow, commonly referred to as "banding," initially preserves the access and improves distal perfusion. However, this procedure severely limits the access patency (25). An important alternative is distal revascularization with interval ligation (DRIL), developed at Mount Sinai by Dr. Harry Schanzer and colleagues (26). This innovative form of bypass surgery has the unique advantage of both preserving access flow and restoring flow to the ischemic segment (25 – 27). Increasingly, DRIL is being recognized as the surgical intervention of choice (27).

### Pseudoaneurysms

Whereas aneurysms are associated with AVF, pseudoaneurysms are an AVG complication. Prevention of progression is achieved by avoidance of needle insertion into the area of pseudoaneurysm or aneurysm. Indications for pseudoaneurysm resection and insertion of an interposition graft include rapid expansion in size, size exceeding twice the AVG diameter, possible or impending rupture, compromised overlying skin, and infection (3).

## Nephrology

The nephrologist is uniquely responsible for the management of the patient with renal failure, both before and after the initiation of dialysis therapy. However, the development of an access plan for the patient well in advance of dialysis is best accomplished in a multidisciplinary fashion. Patients with CKD should be considered for hemodialysis access, peritoneal dialysis, and transplantation, when their glomerular filtration rate (GFR) is less than 30 mL/min (23). According to the National Kidney Foundation's recent Clinical Practice Guidelines for CKD, patients should be prepared for dialysis at this level of GFR, using the updated Modification of Diet in Renal Diseases (MDRD) equation (28). This simplified equation uses age, race, gender, and serum creatinine to determine GFR (29). Early referral to a nephrologist is associated with decreased TCC prevalence at the time of dialysis initiation (30). Ten guidelines for dialysis access are listed in the Table.

## Catheters

Catheters are consistently the dominant culprit for bacteremia (31). *Staphylococcus aureus* is the most common bacteremia in this setting, causing endocarditis in 12% of patients in one prospective series (31). Infection is the second leading cause of death for dialysis patients (1). Therefore, limiting the use of catheters is an important infection control measure.

**TABLE**
*Ten Hemodialysis Access Guidelines*

1. Discourage use of TCC as permanent access in individual patients.
2. At programmatic level, aim to limit TCC to less than 10% of hemodialysis population.
3. Limit uncuffed catheter use to 3-week duration if internal jugular, 1-week duration if femoral.
4. Avoid subclavian TCC and uncuffed catheters, to reduce the risk of subclavian vein stenosis/occlusion, unless options are limited.
5. Avoid the peripherally inserted central catheter (PICC), which promotes vein thrombosis and/or sclerosis in chronic kidney disease and hemodialysis patients.
6. Refer established CKD patients with GFR less than 30 mL/min for vascular access if hemodialysis is the choice for renal replacement therapy.
7. Consider peritoneal dialysis and renal transplantation for all CKD patients with GFR less than 30 mL/min, and for all hemodialysis patients, particularly during access failure.
8. Preserve selected access arm both preoperatively and after intervention, by avoiding venipuncture, BP monitoring, and finger-stick glucose testing.
9. Reassess patients for AVF at every instance of new access placement.
10. Screen all hemodialysis candidates using Doppler ultrasound vein mapping to promote AVF.

Catheter malfunction secondary to thrombosis or more complex fibrin sheath formation is common and an important cause of patient frustration and inadequate dialysis dose delivery. Prevention with instillation of heparin in the catheter ports after dialysis is the most commonly employed measure. One randomized trial showed that 2 mg tPA was superior to 2,000 IU heparin for TCC priming between hemodialysis sessions and that it can be used as an expensive but more effective alternative to conventional heparin in selected patients (32). Oral warfarin 1 mg daily or mini-dose was not efficacious in a prospective, randomized, placebo-controlled trial for prevention of TCC malfunction in hemodialysis patients, in contrast to trials in oncology patients with catheters (33). There are no randomized trials to date to support the use of warfarin therapy to prevent dialysis access malfunction in the absence of a documented hypercoagulable state.

The lower blood flow rates and increased incidence of thrombosis which occur with TCC compared to AVF is often associated with inadequate dialysis dose as measured by urea kinetics. Reducing the use of TCC is one of the simplest ways to enhance dialysis dose delivery in an ESRD population (34). Moreover, a random nationwide study of more than 5,000 hemodialysis patients demonstrated that subjects treated with TCC had an increased adjusted mortality risk (RR 1.7, $p<0.001$ for non-diabetics, and RR 1.54, $p<0.002$ for diabetics) compared to those treated with AVF (35).

## Subcutaneous Port

The recently FDA-approved LifeSite® (Vasca, Inc., Tewksbury, MA) is a novel form of hemodialysis access, composed of two titanium subcutaneous ports and two separate catheters. The system requires special training, experience, and the use of 70% isopropyl alcohol antimicrobial solution instilled in each port after each treatment. Although advantages may include increased blood flow (36), decreased infection rates (36), and better cosmetics than TCC, the exact role of this new access technology is not established. The treatment of port-related bacteremia is complex, requiring daily isopropyl alcohol instillations as well as antibiotic therapy. If treatment fails, device removal is not a trivial procedure.

## AVG Screening

A recent series demonstrated that 77% of AVG required surgical or interventional radiology intervention to maintain patency at one year. Additionally, 45% of AVG permanently failed, requiring replacement in this interval (37). Late referral of patients to interventional radiology when AVG thrombosis was suspected may have resulted in these outcomes. The aim of AVG surveillance is to detect stenosis early, before progression to thrombosis occurs. AVG screening techniques — the responsibility of the nephrologist in the dialysis unit — include history, physical examination, inspection for adequacy of dialysis, dynamic venous pressure evaluation, static pressure (SP) monitoring and access flow measurements. Important physical findings include edema, prolonged bleeding after needle withdrawal (venous hypertension associated with stenosis), and altered characteristics of the AVG pulse or thrill (3). A change in pitch of the thrill or conversion of the thrill to a pulse represents turbulent flow in a stenotic segment. The examination is most useful when performed and evaluated by the same health care worker.

The maintenance of a well-functioning vascular access for hemodialysis is critical. Any stenosis at either the site of the venous or arterial anastomosis, or within the access itself, would impair systemic blood flow rate and/or increase the extent of recirculation of blood to the hemodialysis machine and thereby reduce the efficiency and effectiveness of the dialysis procedure. Such stenosis could lead to ultimate thrombosis of the access. Accordingly, the detection of a significant and progressive stenosis would be important. The least sensitive technique is dynamic venous pressure monitoring that measures venous pressure at blood flow of 200 mL/min during dialysis. A more sensitive diagnostic tool to accomplish this includes periodic monitoring (once or twice a month) and uses intra-access static pressures (SP), a readily available simple procedure. The intra-access pressures are measured using dialysis cannulation needles before the procedure is initiated. At the same time, the systemic mean arterial pressure (MAP) is measured in the contralateral extremity. Significant change in the ratios of the static intra-access pressure to that of the MAP, particularly of the venous pressure ratio, as the access matures and is used has been found by some investigators to be helpful in predicting the extent of a stenosis and the probability of thrombosis (38). Other useful monitoring methods are that of Doppler ultrasonography, the measurement of the extent of recirculation (3, 38, 39), and the measurement of access flow rate by ultrasound velocity dilution technique (40). This latter procedure, not now reimbursed by Medicare, requires special training, and brief interruption of the dialysis. At the present time, few centers use this technique. Angiography of the intravascular access is the most invasive of the various tools and may be required when other less invasive methods yield uncertain conclusions as to the locus, extent and significance of a suspected stenosis.

### Medical Prophylaxis for AV Access

Dipyridamole (41) and fish oil (42) were each demonstrated to benefit AVG patency in small randomized trials. Although aspirin is appropriately prescribed to dialysis patients for prevention of coronary events, aspirin alone showed no benefit in AVG thrombosis prophylaxis in one study (38). Results using the combination antiplatelet therapy of clopidogrel 75 mg and aspirin 325 mg were disappointing compared to placebo, with significantly more bleeding events and a small but insignificant AVG patency benefit in the treated group (43). A majority of patients with isolated, recurrent AVG thrombosis have no demonstrable hypercoagulable state (3). Although warfarin is occasionally used to treat recurrent AVG thrombosis, this therapy did not improve patency compared to placebo, and was associated with significant clinical hemorrhage in a recent prospective, randomized study (44). Warfarin should be reserved only for those patients with a documented hypercoagulable state such as antiphospholipid antibody syndrome, for which benefit is clearly supported (45). Those effected may have other manifestations of hypercoagulability, such as previous miscarriage, pulmonary embolism or deep venous thrombosis. Given the complex pathophysiology of AVG thrombosis, including endothelial hyperplasia at the venous anastomosis, the disappointing results with anticoagulants are not surprising. Even when there was a clear anti-coagulation indication, warfarin therapy was associated with a 10% significant hemorrhage rate in the hypercoagulable hemodialysis patients in the study be LeSar et al. (45). Major weaknesses of prior studies include patient selection from single centers and varying frequencies and methods of AVG stenosis screening. The NIH Dialysis Access Consortium is conducting a multicenter trial to provide more definitive results regarding the safety and efficacy of aggrenox (aspirin 25 mg/dipyridamole 200 mg) in prophylaxis of AVG thrombosis. Although this promising study design overcomes many flaws of previous trials, it prolongs the current and mostly disappointing era of antiplatelet therapy for fostering AVG patency. The next important phase in this area is likely to target neointimal hyperplasia.

Early referral to a nephrologist is also associated with a higher prevalence of AVF at the time hemodialysis therapy is initiated (46). There are very few trials of medical therapy to enhance early AVF patency. The NIH Dialysis Access Consortium is also conducting a randomized, placebo-controlled trial of clopidogrel in AVF maturation. The AVF stenosis screening methods are similar to those for AVG, but are generally less sensitive.

## The Multidisciplinary Team

The Mount Sinai multidisciplinary vascular access team, organized in 1998, comprises nephrologists, vascular surgeons, interventional radiologists, nephrology fellows, a dialysis unit physician assistant, and dialysis unit nurse managers, who meet weekly to review hemodialysis candidates with GFR less than 30 mL/min., patients new to hemodialysis, complex cases, overall access prevalence, and all catheter patients. Major aims of the team are to align goals, foster communication, and share expertise to improve patient outcomes. Such a group here and at other institutions (47, 48) have selected the use of an access coordinator as the focal point in the organization of the team. The nephrologists provide feedback to an interventional radiologist regarding blood flow and dialysis delivery after angioplasty of an AVG venous stenosis. The nephrologists are also able to identify access steal in a particular patient on the basis of the vascular surgeon's targeted clinical examination. The recurrent AVG thrombosis case is reviewed by the team, to determine the optimal intervention (repeat thrombectomy, surgical revision, or new access placement). The team approach also provides opportunities to review AVF options, especially when an AVG requires revision. The multidisciplinary approach and the Doppler screening protocol have increased AVF prevalence from 15% to 43% ($p<0.001$) and reduced TCC prevalence from 44% to 25% ($p<0.001$) as of February 2003. In fact, many individual cases could be used to illustrate the effectiveness of the team approach. Access outcomes are followed prospectively as part of the quality assurance process. While our current practice falls short of the nationwide goal of resorting to TCC in less than 10% of patients, substantial progress has been made in this direction. Recent nationwide data indicate that 28% of the patients are receiving AVF, while 24% are receiving either TCC or uncuffed catheters (4).

## Conclusion

The multidisciplinary approach to hemodialysis access, including weekly conferences, succeeds in aligning aims, facilitating communication and collecting access outcome data prospectively. Most important, when combined with Doppler ultrasound for preoperative vein mapping, it has significantly increased the use of AVF and limited chronic catheter use.

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